APPENDIX 5
BASIS FOR ESTIMATION OF COSTS

Contents

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1.0 Purpose of Cost Estimate

A cost estimate is an integral component of assessing an irrigation scheme's viability. At each stage of a scheme's consideration the level of understanding, detail and design are improved upon, and the accuracy of the cost estimate increases. Generally, a cost estimate would be completed at each of the following stages:

- Preliminary scheme assessment, accuracy within 50%
- Pre feasibility design, accuracy within 30%
- Feasibility design, accuracy within 20%
- Final design, accuracy within 10 %
- Tendered prices from contractors, accuracy within 5 to 10%

The accuracy of the estimate will often vary significantly from the original preliminary scheme concept stage to receiving a final constructed price. Preliminary scheme assessments of cost often underestimate full scheme costs, and a true estimate of cost is often not obtained until a feasibility design stage is complete. Experience indicates that even when fixed prices from contractors are received, the final scheme cost including commissioning modifications during construction and variations will be above the agreed price.

When assessing an irrigation scheme and undertaking financial viability analysis, consideration of what level of accuracy the price estimate used is, should always be factored into the assessment. This appendix is designed to give guidance to the preparation of cost estimates for developments of the scale involved in open channel and piped distribution systems.

2.0 Sources of Cost Estimates

Construction cost estimates can be prepared by a number of different people or organisations and the basis of the costs estimate derived in a number of ways.

Primary sources of costs estimate often include:

- Scheme engineering designers
- Contractors
- Material Suppliers
- Correlation from schemes already constructed

Scheme organisers should recognise that no one person or organisation is likely to have all prerequisite skills to advise owners in all aspects of large scheme development. It is advisable that input from several people with various skill sets should be obtained throughout the design and costing stage.

3.0 Cost Estimates Integrated with Design

In the initial stages of investigation, the basic layout of a scheme is derived via consideration of factors such as land ownership, availability of easements and topographic constraints etc. Up to and including prefeasibilty level investigation, design iterations to optimise a scheme and or reduce costs are often not completed in detail. At the feasibility stage, however, it is important that consideration of a range of layout options, construction methods and materials is undertaken, as both canal and pipe scheme costs can vary significantly based on what can seem minor assumptions.

Examples of design and construction considerations that could influence scheme costs include:

3.1 Pipe Schemes

- Twin lining pipes in trenches to reduce the need for single large diameter pipes.
- Utilising several pipe material types for different parts of the scheme based on pressure rating, diameter, depth of embedment, surcharging etc.
- Avoiding complicated layouts as the costs of bends and anchor blocks can be a significant portion of the overall scheme cost.
- Pipe layouts can run through productive farm land provided enough ground cover is in place above the crown of the pipe. The layout should not necessarily avoid productive land.
- Vary pipe diameters where only a single pipe diameter is required by design. This allows the ability to ‘nest’ pipes within each other for transport purposes. For example only four 1.2.m diameter pipes can be carried in a shipping container. Sixteen pipes can be carried in one container (weight permitting) if a 1.2 m, 1.0 m, 0.8 m, 0.6 m and 0.4 m pipe are nestled within each other,’
- Varying designs for velocity and friction losses to control excess pressure and avoid expensive pressure control devices.
- Accepting all properties will not receive maximum irrigation equipment operation pressures. Set a minimum supply pressure of 5 m for example to avoid negative pressures issues.
- Scheme layout affects costs. The ALIS case study shows that a ‘long and narrow’ layout can cost more per hectare than a scheme such as the CPW case study which has a more ‘square’ layout overall. These two case studies highlight the effect of the high cost of the large principal pipe line delivery systems.

3.2 Canal Schemes

- Assessing canal seepage losses and the need for earth or artificial linings to reduce it.

- Canal gradients significantly affect the layout and excavation costs of canals based on the site topography. Steepening canals and accepting higher water velocities can often be cheaper than constructing concrete drop structures to control canal velocities but has corresponding high scour protection requirements of the canal invert.
- Designing appropriate canal sections given the local geological conditions and construction equipment to be utilised.
- Culverts, drop structures, gate structures, offtake structures, preliminary and general costs add significantly to scheme costs. In early stages of investigation some of these factors are overlooked.
- Removal of unsuitable materials during construction can be a significant hidden cost.

3.3 Other Variables Potentially Affecting Scheme Costs

Irrigation schemes involving multiple properties typically take several years to implement from first conception through to construction and operation. It is common to see price estimates carried forward without revision for some time and when reassessed the viability of a scheme has changed for a number of factors.

Several commonly occurring changes that may affect price estimates include:

- Changing Resource consent requirements.
- Changing land use and owners may alter scheme design constraints.
- Inflation.
- State of the economy. A busy economy generally means higher contract prices as competition is reduced.
- Scale effects. Typically the larger the project the less the unit costs for scheme construction.

Selection of designers and contractors for the project may affect the cost for a scheme, relevant considerations include:

- Contractor size. Larger firms often have higher fixed overheads and invest in more aspects such as quality assurance documentation, etc. and at times may not be competitive against small firms. Smaller firms can often be more costs competitive but are limited in the size of the projects they could construct. Therefore balancing the size of the project against contractor resources should be considered.
- The method of contract between the owners and the contractor. Contracts are used to define roles, set standards and manage or define risk sharing. The more risk the contractor takes the more expensive the project.
- The design risk scheme. Owners are willing to take based on variations in material suitable for a single purpose, techniques or design.
- Schemes 'over or under engineered' can have significant hidden costs. 'Over' engineered schemes will typically have up front higher costs, but lower ongoing operation and maintenance costs. 'Under' engineered schemes will have hidden and ongoing operational and maintenance costs.

- The experience of pipe installation and earthworks contractors plays a significant role in the scheme overall cost and effective completion of a successful scheme. The value of experienced contractors (and designers) can not be overstated but is difficult to put a price on. Checks on references in tenders should be undertaken to support contractors and marketing claims of suppliers.

There are numerous methods of contract between owners and contractors. In order of decreasing costs the common contract methods are:

- Lump sum price for the completed project. Payment made monthly based on percentage complete.
- Measure and value what is constructed based on designs. Requires a robust design and schedule of rates and quantities.
- Day rates for hire of contractor's personnel and equipment. Requires a robust design but also appropriate supervision. Reduced construction costs are partially offset by increased supervision costs.

Consideration to at least the above issues should be incorporated into cost assessment, design, contract preparation and the contractor selection process.

4.0 Additional Costs Required for Full Budget Estimation

The following lists costs apart from construction that require inclusion in estimates and can contribute a significant portion of the completed costs. Some of these costs are likely to be overlooked in the early stages of investigation.

- Design fees - allow a range of 2% to 8%.
- Surveying - allow a range of 0% to 2%.
- Legal fees including easements - allow a range of 1% to 4%.
- Resource consent fees - allow a range of 1% to 10%.
- Associated studies often for Resource consents - allow a range of 1% to 5%.
- Building consent fees and government levies. Sometimes these can be negotiated down with council under special clauses of the building act. Allow a range of 0% to 1%.
- Contract document preparation - allow a range of 1% to 3%.
- Contract management and supervision - allow a range of 1% to 5%.
- Peer reviews of design - allow a range of 1% to 2%.
- Import duties - allow a range of 0% to 2%.
- Freight of goods - allow a range of 0% to 1%.
- Contingency - allow a range of 0% to 15%.

5.0 Construction Cost Estimation

5.1 Establishing Unit Costs

Establishing quantities and unit costs for construction is the preferred method for estimating the cost of a scheme.

Unit costs are commonly derived from

- Material suppliers
- Designers
- Contractors
- Published data such as the quantity surveyor construction costs handbook, 'Rawlinsons New Zealand Construction Handbook' (published yearly).
- Transposing until costs from previous schemes or rules of thumb. This method is generally only acceptable for preliminary and pre-feasibility level cost estimates.

Depending on the stage of the study, estimating unit costs requires a focus on the critical cost items and those that may vary significantly, for example a canal clay liner that due to local condition is wet of optimum moisture content can lead to significant construction difficulties. The same clay in another region may be dry of optimum and ideal for placement following moisture conditioning.

Line items particularly sensitive to changes in quantity or unit rate should be subject to the closest consideration. Such items generally include:

5.2 Pipe Schemes

- Pipe raw cost
- Pipe bends
- Pipe transport cost
- Pipe trench excavation
- Pipe bedding material
- Pipe haunch material
- Back fill material
- Anchor blocks
- Above ground pipe and supports
- Farm offtakes

5.3 Canal Schemes

- Cut to fill
- Cut to waste of unsuitable materials
- Canal lining costs
- Rock armouring of canal
- Gully crossing including culverts
- Culverts and spillways
- Reinstatement topsoil, fencing etc
- Drop structures

Intake design for both types of schemes is unique to each site. Challenges for design of new river intakes include provision for durability, reliability, sediment control, potential effects on river scour, maintenance, and fish screening.

6.0 Operational Costs

In assessing operational costs the following at a minimum should be considered for new schemes.

6.1 Pipe and Canal schemes

- Director fees
- Insurances
- Rates
- Power, telephones, office administration.
- Rents
- Easement fees ongoing
- Equipment and sundries
- Transport
- Wages
- ACC and other wage associated costs
- Training costs
- Water supply fees

6.2 Pipe Schemes

- Routine valve and farm offtake replacements
- Pump maintenance costs
- Cathodic protection if required
- Pipe lining minor repairs
- Valve blockage

6.3 Canal Schemes

- Rock lining repairs
- Canal lining repairs
- Gate or screen maintenance
- Weed spraying
- Vandal damage

7.0 Maintenance Costs

Maintenance costs are considered non recurring costs that are required to maintain the long term viabilities of infrastructure. Assessing maintenance costs needs to be a through exercise if undertaken at early stages of a project and utilisation of existing scheme unit rates often can provide a reasonable estimate of potential costs. Typical costs may include:

Table 1: Pipe Schemes

Item	Interval
Pipe lining repairs	Infrequent
Jointed pipes seal degradation	Unlikely
Pipe burst requiring replacement	Infrequent
Council or Transit road realignments requiring pipe realignment	Infrequent
Valves, etc	Infrequent
Inspection and material testing	Infrequent
Intake including fish screen repairs	Common

Table 2: Canal Schemes

Item	Interval
Canal rock and lining repairs	Infrequent
Gates and screen damage or replacement	Infrequent
Culvert, drop structures, distribution structure repairs	Infrequent
Intake or fish screen repairs	Common
Canal or head pond sediment removal	Common
Storm damage from excessive inflows	Infrequent
Spillway repairs	infrequent

8.0 Case Study – CPW Piped Scheme

The following sections document assumptions and methods used for a preliminary cost estimate for part of the Central Plains Irrigation Scheme. The area under consideration contains 36,000 Ha of irrigable land. The ground surface is regular, comprising an alluvial terrace gently sloping to the southeast. Subsurface conditions are expected to comprise free-draining gravels overlain by a variable thickness of silty gravel and topsoil. The distance between the offtake at the main distribution canal and the farthest extent of the area considered is approximately 150m vertical height and 28km horizontal distance.

No site visits, survey, ground investigations, or detailed design checks have been undertaken to produce this cost estimate. Published maps, property boundaries and regional geological plans for the area have been reviewed and applicable information incorporated where appropriate.

The preliminary layout of the piped distribution scheme has been developed by Aqualinc Research Ltd utilising “Irricad” pipe network design software.

8.1 General Background

The following notes describe features of the Central Plains Water (CPW) sub area that affected how the price estimate for the scheme was developed.

- Water at the intake has already been diverted to a primary canal between the Rakaia and Waimakariri Rivers. Significant intake work, fish screens or river training are not accounted for.
- The topography is generally flat when compared to other parts of New Zealand. The pipe layout does not involve complicated plan or elevation changes which can significantly affect costs of trenching, bend manufacture and thrust blocks.
- Groundwater into the trench excavation is not considered significant.
- The land is primarily cleared farmland.
- The price estimate is considered a preliminary cost estimate. Scheme layout was developed by Aqualinc Research Ltd utilising "Irricad" pipe software.
- The majority of item estimates are based on a combination of "first principle" unit rates and comparison with other recently constructed schemes. Pipe installed unit costs (the largest component) were developed from first principals.

The scheme layout is shown in Figure 1.

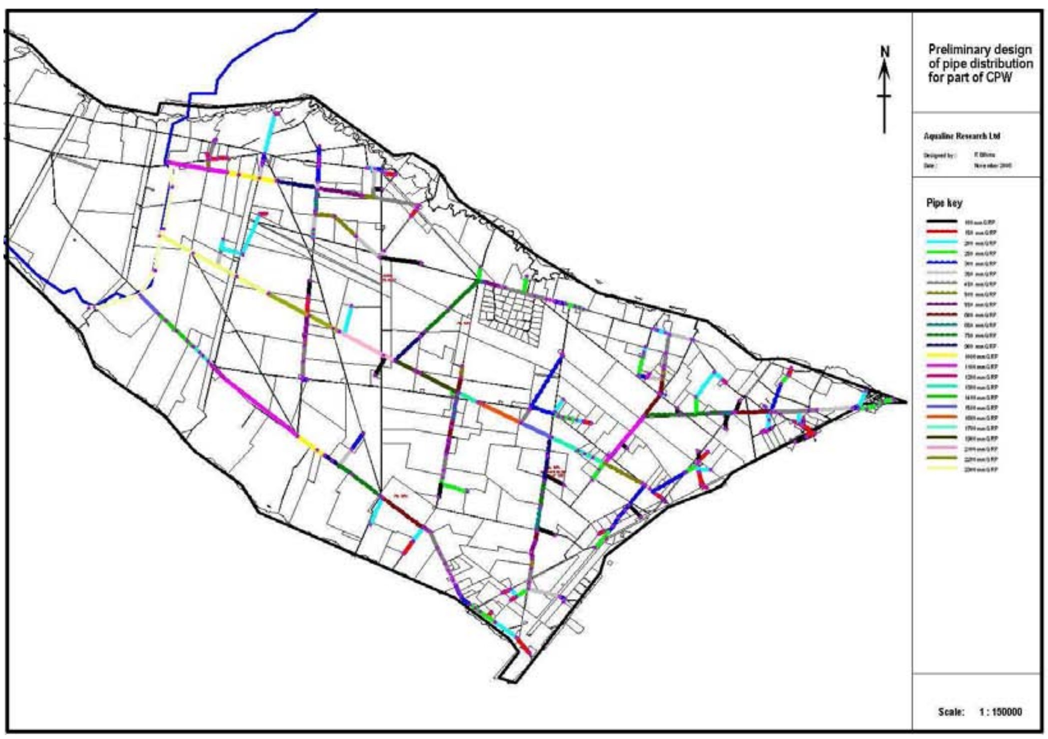


Figure 1: CPW sub area pipe layout

8.2 Preparatory Work

This component covers all scheme evaluation, survey, design, contract preparation and building consent fees. The range considered appropriate is 4% to 8%.

8.3 Construction Management

Contractors, designers and clients will be involved in contract management. Clients will often have the designer involved as the 'engineer to the contract' or for larger projects a specialist project manager may be employed. Modern schemes often employ professional staff or directors and these costs may be reflected in this component. We recommend a range of 4% to 6% for this component.

8.4 Primary Canal Offtakes

These offtakes are unique to the proposed CPW primary canal. The cost of these items was taken from previous projects RILEY has been involved with. Photo 1 shows a similar offtake from a scheme currently under construction.

Photo 1: Example of a typical primary headrace canal offtake structure under construction (2007)

8.5 Primary Distribution Pipe

Unit rates for pipes were supplied by Maskell Ltd, who manufacture and import fibre reinforced pipe (FRP), a 'fibreglass' pipe system. Pipe trench excavation was assumed to allow for 1 m of cover to the pipe crown so full farming of the land above the pipe could be achieved. Pipe bedding, haunch and backfill were assumed as processed from excavated trench materials and excess backfill crowned above the pipe excavation over a 15 m width.

At smaller diameters, HDPE, PVC and PE pipes were utilised as these materials are cheaper on a per unit rate installed.

No specific allowance was made for the pressure rating of the pipe as the variance of this cost was moderate when related to the total installed cost of the pipe. Figure 2 presents a best fit line for estimating the installed cost of a buried irrigation pipeline including excavation and backfill, bedding and haunch material, pipe. This figure was utilised for pricing.

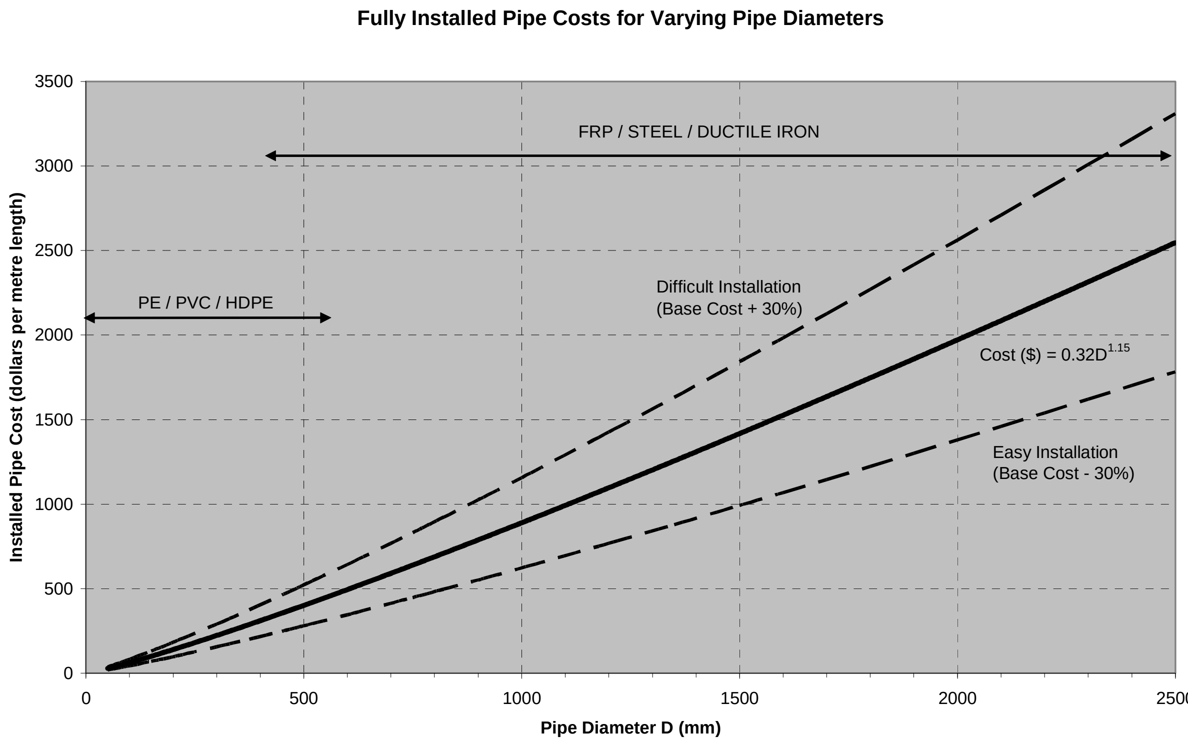


Figure 2: Cost estimates for pipelines

Photo 2 shows FRP pipe currently (2007) being installed in Otago (3000 m length).

Photo 2: 1.1 m diameter FRP pipe (under construction 2007).

8.6 Structures and Fittings

This item includes air valves, flanges, bends, isolating valves, pressure control, drains and manholes, thrust blocks and road or stream crossings. Significant variation in this item can occur and is primarily dependant on topography and sit geology.

The CPW scheme covers an area of 'flat' land. Pipe lengths can therefore be long straights and soil friction can be used to carry longitudinal pipe loads. As there are minimal topographic changes, air relief valves costs will be significantly reduced. The cost component allowed for pipe fittings is at the lower end of the range for these reasons. Proposed schemes in undulating areas will require a higher percentage cost for these items.

In particular we utilize a range for additional items of:

- Flanges and bends – 7% to 17%
- All other items – 0.25% to 1%
- Overall range of 10% to 20% of installed pipe cost

Photo 3: An FRP anchor block under construction (2007).

8.7 Farm Offtakes

The number and size of the offtakes was developed in the 'Irricad' model prepared by Aqualinc Ltd. Costs were supplied by Irrigation and Water Ltd of Christchurch (www.irrigationandwater.co.nz). Costs for these items included:

- Toby boxes
- Thrust supports
- Covers
- Valves
- Flow meters

8.8 Cost Estimate

The total cost estimate for the scheme is $119,283,260 or $3,313.42/Ha. Note this does not make any allowance for ongoing maintenance or operation costs. A breakdown of the component costs estimated for the scheme are presented in Table 3.

Table 3: CPW pipe cost.

	Item	Unit	Quantity	Rate	Total
1	**Preparatory work**				
	Evaluation of service and farm liaison	LS	1	0.50%	$549,202
	Survey	LS	1	0.20%	$219,681
	Feasibility studies through final design	LS	1	3.00%	$3,295,213
	Contract Preparation and Tendering	LS	1	0.50%	$549,202
	Building Consent Fees	LS	1	0.30%	$329,521
	Sub Total			**4.50%**	**$4,942,820**
2	**Construction Management**				
	Contractors Preliminary and General	LS	1	See note	$3,000,000
	Construction management	LS	1	See note	$1,500,000
	Sub Total			**4.10%**	**$4,500,000**
3	**Canal Offtakes**				
	Civil Intake Structures	No	3	$350,000	$1,050,000
	Gates	No	3	$200,000	$600,000
	Sub Total				**$1,650,000**
4	**Primary Distribution Pipe**				
	Pipe Dia (mm)				
	90	m	10,000	$ 57	$573,833
	150	m	11,000	$ 93	$1,020,168
	200	m	17,300	$ 125	$2,161,116
	250	m	12,700	$ 160	$2,030,984
	300	m	14,500	$ 197	$2,851,715
	375	m	11,100	$ 257	$2,852,180
	450	m	14,000	$ 323	$4,518,955
	500	m	6,500	$ 370	$2,403,375
	600	m	12,100	$ 471	$5,700,068
	750	m	4,000	$ 642	$2,566,250
	800	m	9,500	$ 703	$6,681,540
	900	m	5,900	$ 812	$4,791,444
	1000	m	3,400	$ 921	$3,131,054
	1200	m	9,600	$ 1,138	$10,929,373
	1350	m	3,400	$ 1,302	$4,425,644
	1500	m	4,300	$ 1,465	$6,298,828
	1600	m	1,960	$ 1,574	$3,084,320
	1700	m	900	$ 1,682	$1,514,180
	1800	m	0	$ 1,791	$0
	1900	m	2,800	$ 1,900	$5,320,000
	2100	m	2,600	$ 2,118	$5,505,703
	2200	m	3,300	$ 2,226	$7,347,012
	2300	m	3,300	$ 2,335	$7,706,016
	2500	m		$ 2,553	$0
	Scale Factor on pipe	LS	1	100.00%	$93,413,756
	Sub Total Pipe Cost		**164161**		**$93,413,756**
5	**Structures and Fittings**				
	Flanges and bends	LS	1	7.50%	$7,006,032
	Air valves	LS	1	0.25%	$233,534
	Isolating valves	LS	1	0.25%	$233,534
	Pressure Reducing Valves	LS	1	0.50%	$467,069
	Drain points and Manholes	LS	1	0.25%	$233,534
	Concrete thrust blocks and anchor blocks	LS	1	0.25%	$233,534
	Road and Stream crossings	LS	1	0.50%	$467,069
	Sub Total			**9.50%**	**$8,874,307**
6	**Farm Offtakes**				
	250mm diameter	No	146	$ 25,500.00	$3,723,000
	200mm diameter	No	35	$ 18,000.00	$630,000
	150mm diameter	No	29	$ 10,500.00	$304,500
	100mm diameter	No	23	$ 8,300.00	$190,900
	80mm diameter	No	55	$ 7,600.00	$418,000
	50mm diameter	No	19	$ 6,600.00	$125,400
	Sub Total				**$5,391,800**
7	**Misc**				
	Fencing	LS	10.00%	$11	$180,577
	Scheme control systems, power	No	1	$330,000	$330,000
	Sub Total				**$510,577**
	Total				**$119,283,260**
	Irrigable Area	Ha			36,000
	Cost per hectare	$/ha			$ 3,313.42

9.0 Case Study – CPW Open Channel Option

9.1 General Background

Water is to be abstracted from the CPW headrace, and will be delivered to the proposed irrigable area via a primary and secondary open channel network developed by URS Ltd as a result of landholder and current consent discussions. The water will be delivered to each property using an off-take pond point (turnout) suitable for a pipe pumped offtake. A small area of the scheme is to be irritated by a small pipe network to avoid the need for a tertiary canal network.

Figure 3 presents the canal system layout for the CPW sub area.

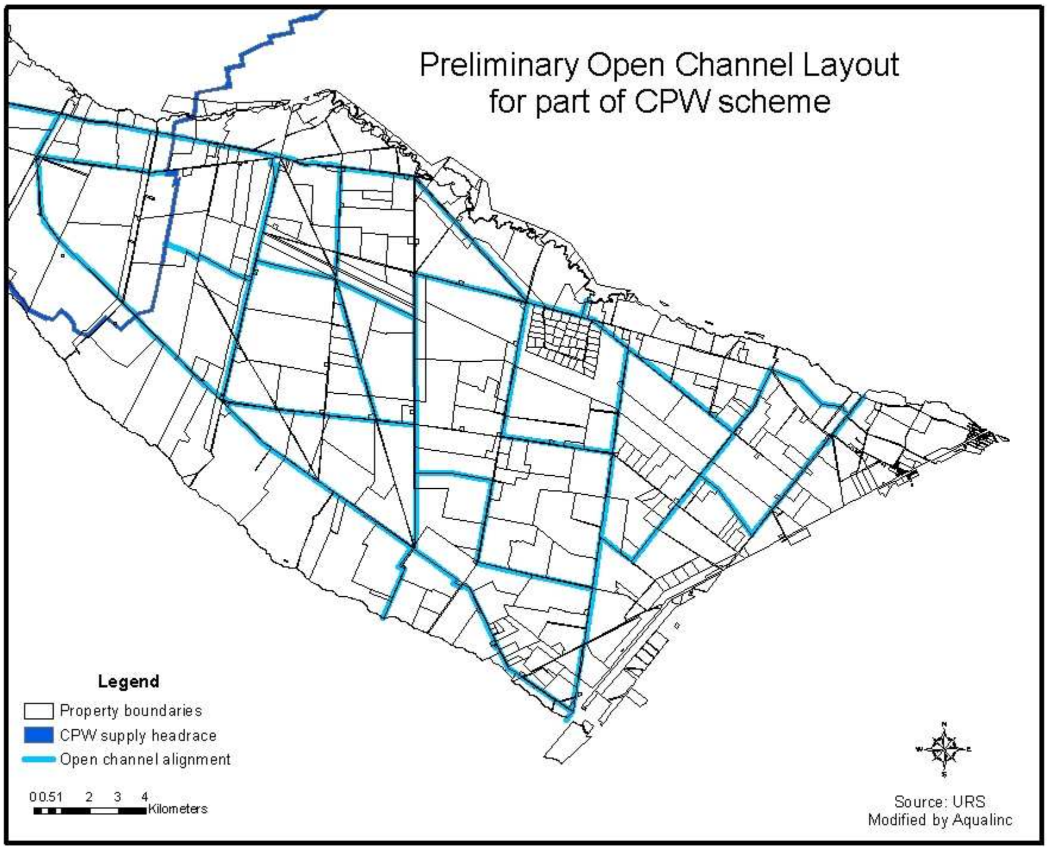


Figure 3: CPW sub area canal scheme layout

To irrigate all comparable land as with the CPW case pipe scheme study additional tertiary or pipe networks were required to achieve a comparable delivery and cost comparison. It was elected for minimal land disturbance that piping to farms for these small areas would be utilised for design. Figure 4 presents the canal scheme layout with sub catchment pipe areas to service all properties.

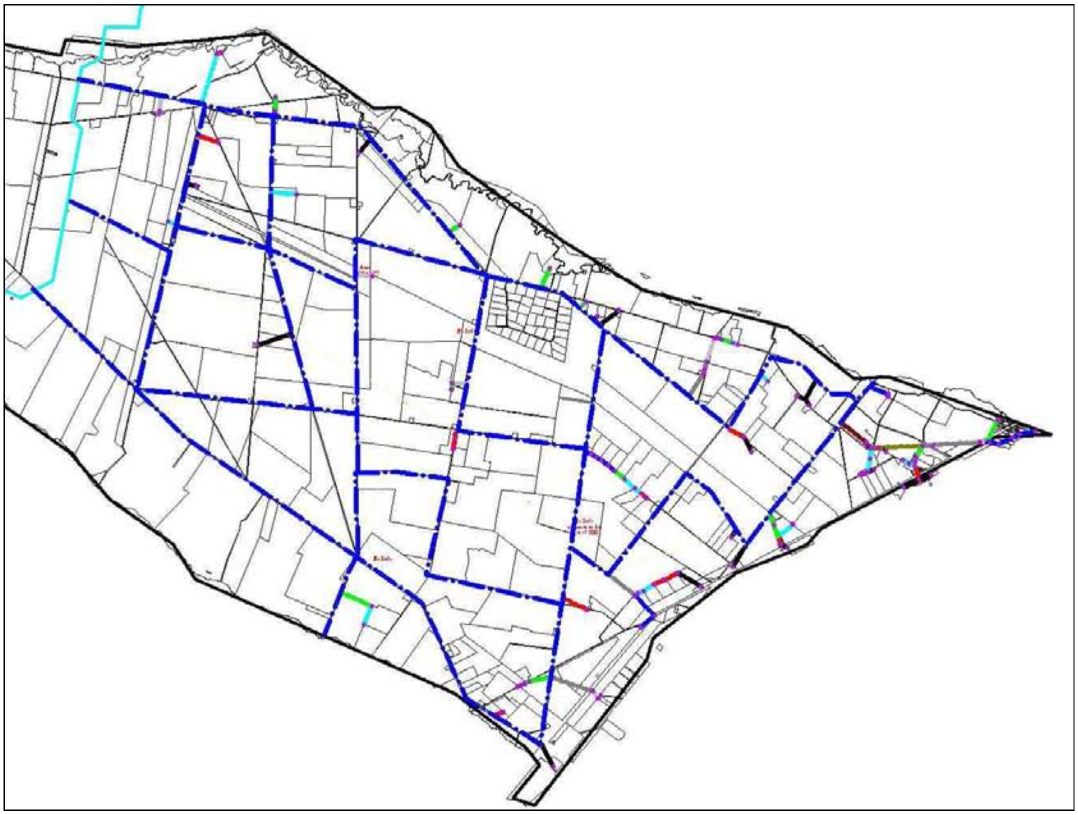
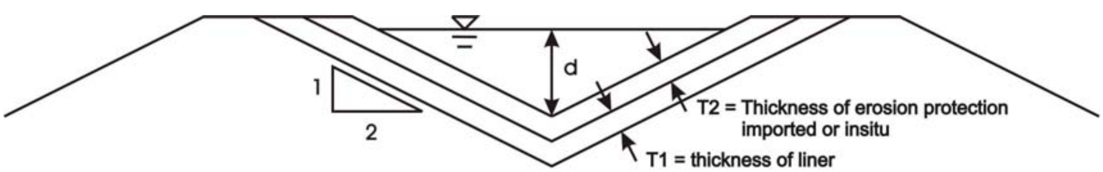


Figure 4: Location of additional pipe to supply properties from the open race.

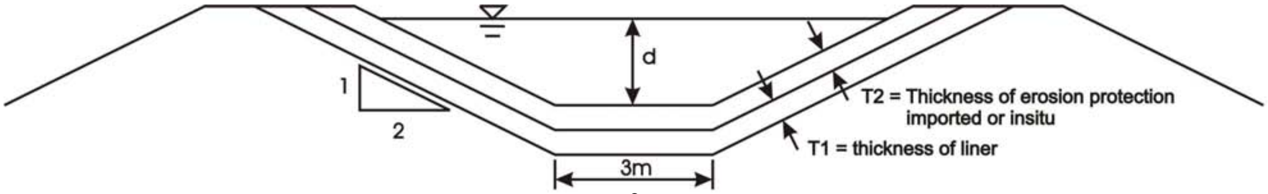
The following sections describe how costs were derived for the scheme area.

9.2 Canal Design Cross Sections

Two different cross sections were designed to suit the required maximum flow rate of each canal section as shown on Figure 5 below. A triangular cross section was used for lengths of canal with flow rates of less than $2m^3/s$. A trapezoidal profile was used for sections with canals with flow rates in excess of $2m^3/s$. These two options were chosen from a construction perspective allowing for digger or grader excavation of small canals and for larger canal flow design sizings to allow economical construction by earth moving equipment.



Triangular cross section for flows less than $2m^3/s$



Trapezoidal cross section for flows greater than $2m^3/s$

Figure 5: Design canal cross sections utilised.

9.3 Canal Layout

The canal layout was developed by URS Ltd as shown in Figure 3. The following steps were then completed to develop the preliminary design to price:

- Code each canal section
- Determine canal section sizing based on canal gradients as assessed from 1:50,000 contours plans.
- Calculate erosion liner requirements based on canal velocities
- A each distribution point determine gate requirements
- Determine culverts for road crossings
- Develop a bill of quantities.

Table 4: Canal network details for structures

Canal Code	Canal Flow	Length	Slope	Culverts Required		Distribution Control gate		
	m3/s	m	(1:~)	900 mm	1600 mm	Large	Medium	Small
L2B	3.6	712	7119			1		
L3G	6.3	3729	7458		1	2		
L1E	5.4	2847	5695			2		
L3D	0.4	102	1017	1				1
L2J	0.5	3797	759	1				1
L2G	0.6	3966	793	1				1
L3N	0.3	1932	483	1				1
L2C	0.9	4407	630				1	
L2E	0.6	4000	400	1				1
L2H	0.6	5559	371	1				1
L3M	0.7	8305	395	2				1
L3P	3.5	813	813					
L3K	1	5288	353	3			1	
L3J	7	1864	932		1	2		
L1G	4.1	1695	565					
L2K	1.7	8814	367	1				
L3O	2.8	6203	365		1			
L1I	1.5	10000	222	2			1	
L3I	8	3050	610		1			
L2I	1.3	5573	232	1			1	
L3H	2.5	4780	208		3		2	
L1B	8.4	373	373		2			
L1D	3	5288	182			1		
L3L	8.5	5424	339		3			
L1H	2.6	2712	151	1		1		
L2F	1.8	2847	142	2		1		
L2A	4.5	4237	193			1		1
L2D	3	2915	133		1	1		
L1F	3.6	1390	139		2			
L3Q	16.5	339	339					
L3F	9	678	226		1	2	1	
L1K	8	8678	202		1			
L3C	9.2	8610	221		3			
L1C	5.4	8746	146		1	2		
L1J	5.4	136	136		1	2		
L1A	7.5	4407	138			2		
L3E	8.8	2068	148			4	2	
L3B	8.6	2407	142		1			
L3A	8	3593	100			2		1
TOTAL		152284		18	23	26	9	9

9.4 Canal Geology and Design Impacts

No site-specific testing or investigation of the soil grading curves for design purposes was completed. As an initial assessment of the potential for erosion of the canal base and sides, typical practical size distribution curves for the materials anticipated on site were checked for erosion with the proposed canal gradients and water velocities. It was found that the local materials would likely erode at the URS proposed canal gradients and flow rates, and that specific gravel or cobble erosion protection measures would be required for many of the proposed canal sections.

For low gradients along the canal route (i.e. flatter than 1:400) it was assumed that the lining and armour material could be sourced on site. For steeper gradients the armour material would need to be imported.

Based on the above, a table of estimated per metre costs of earthworks and erosion protection was created for each canal flow and gradient.

9.5 Liner Material

The URS Ltd design incorporates no liner material for seepage control. The RILEY preliminary design has concluded that a liner material is likely to be required. The thickness of both the liner and erosion protection (T1 and T2 on Figure 5) was assumed to be 0.5 m. Cost estimates for lining and erosion protection were then derived for steep and flatter canal gradients as shown on Table 5.

Table 5: Cost applied for erosion protection and liner

Canal Grade	Cost Erosion protection	Liner (Available on site)
Low Gradient (flatter than around 1:400)	\$ 3 / m^3 (Site erosion protection)	\$10 / m^3
Steep Gradient (steeper than around1:400)	\$20 / m^3 (Imported erosion protection)	\$10 / m^3

Table 6 is a summary of the average cost of the liner, erosion protection and earthworks for different canal conditions as defined above.

Table 6: Average cost for different canal conditions

Canal Type	Total Length (m)	Liner and Erosion Protection (\$/m)	Earthworks (\$/m)	Total (\$/m)
Steep Gradient Canal 1 to 3.5 m^3/s	50522	\$150	\$30	\$180
Steep Gradient Canal 3.5 to 9.2 m^3/s	54440	\$181	\$74	\$255
Low Gradient Canal 0.3 to 1 m^3/s	37356	\$52	\$15.	\$67
Low Gradient Canal 3.5 to 9.2 m^3/s	9966	\$91	\$136	\$227

9.6 Intake Structures

The main canal offtakes are proposed as structures penetrating a canal embankment with energy dissipation at the end. Photo 4 shows an offtake structure suitable for the CPW sub area under constructed in 2007.

Photo 4: Offtake drop structure.

9.7 Road Crossing and Culverts

The number of road crossings was estimated from existing maps and a plan of the proposed scheme extensions. Preliminary culvert diameters were calculated based on the required maximum flow at each road crossing. Prices for crossings were based on similar structures currently under construction.

9.8 Distribution Control Gates

Control gates are required at nodes where a single canal divides to service two or more separate areas. The number of nodes requiring control gates was obtained from the proposed scheme extension plan as shown on Figure 1. Per unit costs were obtained for three automated Rubicon Flume Gates gate sizes to suit the required flow rate at each node. The Rubicon gates are fully automated and include flow gauging. Full details of the Rubicon gates can be obtained at the web site www.rubicon.com.au. Photo 5 presents a series of Rubicon gates being installed.

Photo 5: Rubicon gates under construction.

9.9 Drop Structures

Only one drop structure was required on a particularly steep canal section. Photo 6 Shows a USBR Type 2 drop structure for a 2.5 cumec flow constructed in 2007.

Photo 6: Drop Structure

9.10 Cost Estimate

The total cost estimate for the scheme is $62,404,533 or $1,733/Ha. Note this does not make any allowance for ongoing maintenance or operation costs. A breakdown of the component costs estimated for the scheme are presented in Table 7.

Table 7: Cost estimate for CPW sub area canal network

	Item	Unit	Quantity	Rate	Total
1	**Preparatory work**				
	Evaluation of service and farm liaison	LS	1	1.25%	$677,970
	Survey	LS	1	0.50%	$271,188
	Feasibility studies through final design	LS	1	4.50%	$2,440,692
	Contract Preparation and Tendering	LS	1	1.00%	$542,376
	Building Consent Fees	LS	1	0.30%	$162,713
	Sub Total			7.55%	**$4,094,939**
2	**Construction Management**				
	Contractors Preliminary and General	LS	1	6%	$2,714,660
	Construction management	LS	1	See note	$1,357,330
	Sub Total				**$4,071,991**
3	**Primary Canal Offtakes**				
	Civil Intake Structures incl gates	No	3	$ 450,000.00	$1,350,000
	Sub Total				**$1,350,000**
4	**Primary Distribution Canals**				
	Low gradient canal 0.3 to 1 cumec capacity	m	37356	$ 90.00	$3,362,040
	Low gradient canal 3.5 to 9 cumec capacity	m	9966	$ 130.00	$1,295,580
	High gradient canal 1 to 3.5 cumec capacity	m	50522	$ 170.00	$8,588,740
	High gradient canal 3.5 to 9 cumec capacity	m	54440	$ 200.00	$10,888,000
	Sub Total				**$24,134,360**
5	**Additional Distribution Pipe (to properties not adjacent to race)**				
	Pipe Dia (mm)				
	100	m	8720	$ 57	$500,354
	150	m	5150	$ 93	$477,611
	200	m	7500	$ 125	$936,900
	250	m	6740	$ 160	$1,077,861
	300	m	4920	$ 197	$967,616
	350	m	2800	$ 257	$719,460
	450	m	5330	$ 323	$1,720,417
	500	m	1580	$ 370	$584,205
	600	m	1250	$ 471	$588,850
	Sub Total		**43990**		**$7,573,274**
6	**Pipe Fitting**				
	Flanges and bends	LS	1	15.00%	$1,135,991
	Air valves	LS	1	0.50%	$37,866
	Isolating valves	LS	1	0.50%	$37,866
	Drain points and Manholes	LS	1	0.75%	$56,800
	Concrete thrust blocks and anchor blocks	LS	1	1.00%	$75,733
	Road and Stream crossings	LS	1	1.00%	$75,733
	Sub Total			**18.75%**	**$1,419,989**
7	**Structures and Fittings**				
	Control Gate – Small	No	9	$ 33,000.00	$297,000
	Control Gate – Medium	No	12	$ 50,000.00	$600,000
	Control Gate – Large	No	17	$ 90,000.00	$1,530,000
	Road crossing culvert 0.9m diameter	No	21	$ 14,000.00	$294,000
	Road crossing culvert 1.6m diameter	No	20	$ 80,000.00	$1,600,000
	Small on-farm bridge crossings	No	75	$ 25,000.00	$1,875,000
	Additional large Riprap in locally steepened areas and around structures	m³	12000	$ 80.00	$960,000
	Bywash with energy dissipation to river discharge	No	4	$ 100,000.00	$400,000
	Sub Total				**$7,556,000**
8	**Farm Offtakes**				
	Off-canal stilling bay and coarse screen	No	237	$ 12,000.00	$2,844,000
	Small drop structures for water level raising at gates	No	119	$ 5,000.00	$592,500
	250mm diameter	No	146	$ 25,500.00	$3,723,000
	200mm diameter	No	35	$ 18,000.00	$630,000
	150mm diameter	No	29	$ 10,500.00	$304,500
	100mm diameter	No	23	$ 8,300.00	$190,900
	80mm diameter	No	55	$ 7,600.00	$418,000
	50 mm diameter	No	19	$ 6,600.00	$125,400
	Sub Total				**$8,828,300**
9	**Misc**				
	Fencing	m	304568	$ 10.00	$3,045,680
	Scheme control systems and telecoms	LS	1	$ 330,000.00	$330,000
	Sub Total				**$3,375,680**
	Total				**$62,404,533**
	Irrigable Area	Ha			36,000
	Cost per hectare	$/ha			$1,733

10.0 Case Study – Ashburton Lyndhurst Sub Area Pipe Scheme

The following sections document assumptions and methods used for a preliminary cost estimate for part of the Rangitata Diversion Race (RDR) Irrigation Scheme. The area under consideration contains 3,200 hectares of irrigable land. The ground surface is similar to that considered for the CPW sub area, comprising a gently sloping alluvial terrace. Subsurface conditions are expected to comprise free-draining gravels overlain by a variable thickness of silty gravel and topsoil. The distance between the offtake at the RDR and the farthest extent of the area considered is approximately 190m vertical height and 25km horizontal distance.

No site visits, survey, ground investigations, or detailed design checks have been undertaken to produce this cost estimate. Published maps, property boundaries and regional geological plans for the area have been reviewed and applicable information incorporated where appropriate.

The area under consideration already has a functioning canal-based irrigation scheme. The motivation for assessment of a piped alternative includes elimination of seepage losses and supply of full or partial pressure at irrigation offtakes. The preliminary layout of the piped distribution scheme has been developed by Aqualink Research Ltd utilising “Irricad” pipe network design software.

10.1 General Background

The following notes describe features of the Ashburton Lyndhurst Sub Area Pipe Scheme that affected how the price estimate for the scheme was developed.

- The scheme already possesses a functioning primary canal between the Rangitata and Rakaia Rivers. Significant intake work, fish screens or river training are not accounted for.
- The topography is generally flat when compared to other parts of New Zealand. The pipe layout does not involve complicated plan or elevation changes which can significantly affect costs of trenching, bend manufacture and thrust blocks.
- Groundwater into the trench excavation is not considered significant.
- The land is primarily cleared farmland.
- The majority of item estimates are based on unit rates as pre-feasibility level design has not been completed. Several suppliers were contacted for input. Pipe unit costs (the largest component) were developed from first principals.
- The scheme did not run along existing irrigation races. The layout was optimized for pipe cost minimisation.
- The existing race alignment would be infilled after pipe construction and returned to productive farm land.

The scheme layout is shown in Figure 6.

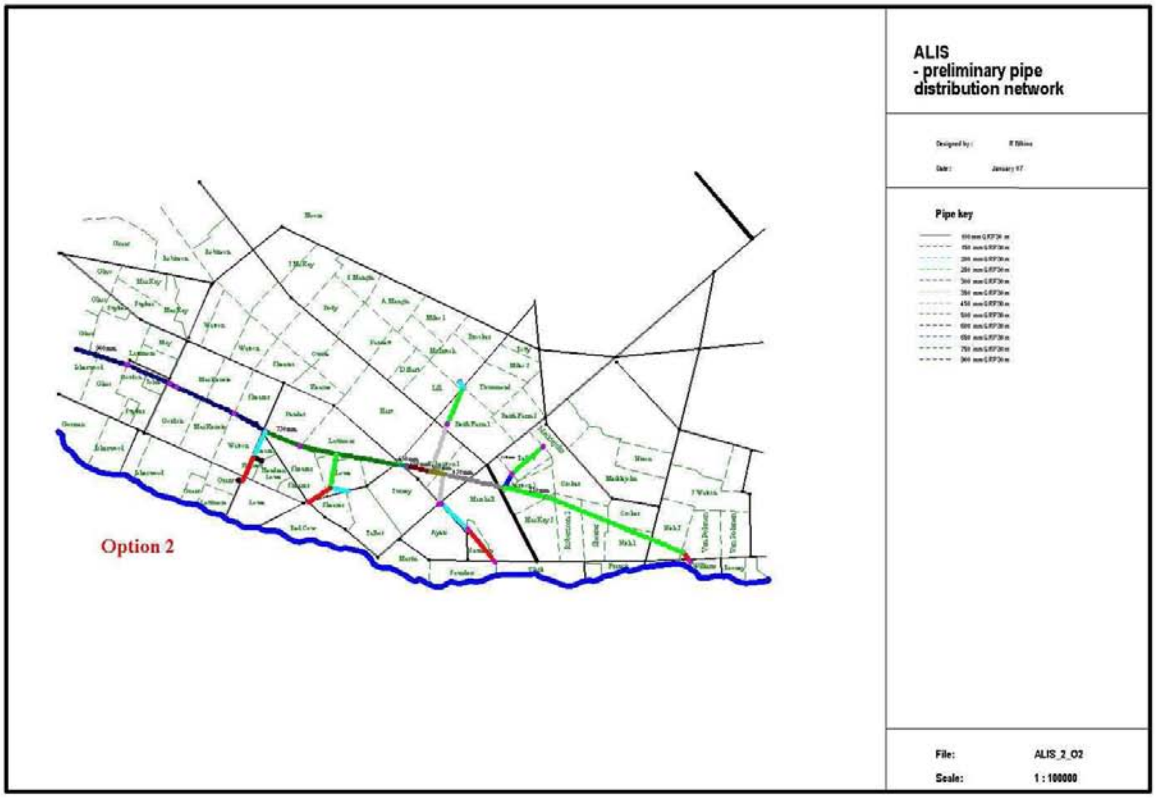


Figure 6: ALIS sub area pipe scheme.

10.2 Preparatory Work

This component covers all scheme evaluation, survey, design, contract preparation and building consent fees. The range considered appropriate is 4% to 8%.

10.3 Construction Management

Contractors, designers and clients will be involved in contract management. Clients will often have the designer involved as the 'engineer to the contract' or for larger projects a specialist project manager may be employed. Modern schemes often employ professional staff or directors and these costs may be reflected in this component. We recommend a range of 4% to 6% for this component.

10.4 Primary Canal Offtakes

The cost of these items was taken from previous projects RILEY has been involved with.

Unit rates for pipes were supplied by Maskell Ltd, who manufacture and import fibre reinforced pipe (FRP), a 'fibreglass' pipe system. Pipe trench excavation was assumed to allow for 1 m of cover to the pipe crown so full farming of the land above the pipe could be achieved. Pipe bedding, haunch and backfill were assumed as processed from excavated trench materials and excess backfill crowned above the pipe excavation over a 15 m width. Pipe values from Figure 2 were utilised for pricing.

At smaller diameters, HDPE, PVC and PE pipes were utilised as these materials are cheaper on a per unit rate installed.

No specific allowance was made for the pressure rating of the pipe as the variance of this cost was moderate compared to the total installed cost of the pipe. These pipes were routed for the shortest length rather than skirting around properties or roads.

10.5 Structures and Fittings

This item includes air valves, flanges, bends, isolating valves, pressure control, drains and manholes, thrust blocks and road or stream crossings. Significant variation in this item can occur and is primarily dependant on topography and sit geology.

The ALIS scheme covers an area of 'flat' land. Pipe lengths can therefore be long straights and soil friction can be used to carry longitudinal pipe loads. In addition, as there are minimal topographic changes and air relief valves etc will be significantly reduced. The percentage figures given are considered to be at the lower end of the estimate from the above reasons. Proposed schemes in undulating or topographically challenging areas will require a higher percentage cost for these items.

In particular we utilize a range for additional items of:

- Flanges and bends – 7% to 17%
- All other items – 0.25% to 1%
- Overall range of 10% to 20% of installed pipe cost

10.6 Farm Offtakes

The number and size of the offtakes was developed in the 'Irricad' model prepared by Aqualine Ltd. Costs were supplied by Irrigation and Water Ltd of Christchurch. Costs for these items included:

- Toby boxes
- Thrust supports
- Covers
- Valves
- Flow meters

10.7 Cost Estimate

The total cost estimate for the scheme is $12,864,732 or $4,020.23 /Ha. Note this does not make any allowance for ongoing maintenance or operation costs. A breakdown of the component costs estimated for the scheme are presented in Table 8.

Table 8: Cost estimate for CPW sub area canal network.

	Item	Unit	Quantity	Rate	Total
1	**Preparatory work**				
	Evaluation of service and farm liaison	LS	1	0.00%	$0
	Survey	LS	1	0.50%	$58,244
	Feasibility studies through final design	LS	1	3.00%	$349,463
	Contract Preparation and Tendering	LS	1	0.50%	$58,244
	Building Consent Fees	LS	1	0.00%	$0
	Sub Total			**4.00%**	**$465,951**
2	**Construction Management**				
	Contractors Preliminary and General	LS	1	See note	$500,000
	Construction management	LS	1	See note	$250,000
	Sub Total			**6.44%**	**$750,000**
3	**Canal Offtakes**				
	Civil Intake Structures	No	1	$100,000	$100,000
	Gates	No	0	$0	$0
	Sub Total				**$100,000**
4	**Primary Distribution Pipe**				
	Pipe Dia (mm)				
	90	m	350	$ 57	$20,084
	150	m	2,640	$ 93	$244,840
	200	m	2,220	$ 125	$277,322
	250	m	7,720	$ 160	$1,234,582
	300	m	460	$ 197	$90,468
	375	m	1,990	$ 257	$511,337
	450	m	1,540	$ 323	$497,085
	500	m	330	$ 370	$122,018
	600	m	890	$ 471	$419,261
	750	m	3,360	$ 642	$2,155,650
	800	m		$ 703	$0
	900	m	5,140	$ 812	$4,174,241
	Scale Factor on pipe	LS	1	100.00%	$9,746,889
	Sub Total Pipe Cost		**26641**		**$9,746,889**
5	**Structures and Fittings**				
	Flanges and bends	LS	1	7.50%	$731,017
	Air valves	LS	1	0.25%	$24,367
	Isolating valves	LS	1	0.25%	$24,367
	Pressure Reducing Valves	LS	1	0.50%	$48,734
	Drain points and Manholes	LS	1	0.25%	$24,367
	Concrete thrust blocks and anchor blocks	LS	1	0.25%	$24,367
	Road and Stream crossings	LS	1	0.25%	$24,367
	Sub Total			**9.25%**	**$901,587**
6	**Farm Offtakes**				
	250 mm diameter	No	7	$ 25,500.00	$178,500
	200 mm diameter	No	7	$ 18,000.00	$126,000
	150 mm diameter	No	5	$ 10,500.00	$52,500
	100 mm diameter	No	6	$ 8,300.00	$49,800
	80 mm diameter	No	1	$ 7,600.00	$7,600
	50 mm diameter	No	1	$ 6,600.00	$6,600
	Sub Total				**$421,000**
7	**Misc**				
	Fencing	LS	10.00%	$11	$29,305
	Scheme control systems, power	No	1	$50,000	$50,000
	Infill canal	LS	1	$400,000	$400,000
	Sub Total				**$479,305**
	Total				**$12,864,732**
	Irrigable Area	Ha			3,200
	Cost per hectare	$/ha			$ 4,020.23

10.8 Cost Sensitivity

Assessing the risk appetite that developers of a scheme are willing to accept can significantly affect the price paid for construction; operation and maintenance costs; and the replacement period between parts of the scheme infrastructure as it wears out. Risk is not discussed in detail in this report, but an inherent assumption is made that developers will assess it at all levels and for all components of a scheme whether specifically, or by intuition in the decision making process.

To assess the influence of RISK and decision making, the ALIS case study was subject to a second phase of pricing to determine if capital cost could be reduced by altering RISK assumptions. The focus was to reduce the costs given in section 10.8. The following lists altered assumptions for assessing the revised costs.

- There is minimal design and a larger portion of ‘contractor’ design is utilized.
- A small contractor is utilized
- A simple form of contract is used with even risk sharing
- The project is not tendered
- There is a significant portion of the project management undertaken by the scheme developers and the contractor.
- Cheaper pipe materials are utilised, PE in place of FRP.
- Fencing and infilling of the canal for example are not undertaken.

The construction price calculated was approximately $8,500,000 m or $2656/ha. The price was cross checked and confirmed by a contractor. The revised price is approximately 35% lower than that given in Table 8 and comparable to the 30% estimated variation in price estimates expected as presented in Section 8.5.

10.9 Cost Sensitivity

Assessing the risk appetite that developers of a scheme are willing to accept can significantly affect the price paid for construction; but also it can significantly affect operation and maintenance costs, and the replacement period for parts of the scheme infrastructure as it wears out. Risk is not discussed directly in this report, but an inherent assumption is made that it will be.

To assess the influence of RISK and decision making the ALIS case study was subject to a second phase of pricing to determine if capital cost could be reduced by altering RISK assumption. The focus was to reduce costs given in section 10.8. The following lists altered assumptions.

- The project is not tendered
- There is minimal design and a larger portion of ‘contractor’ design is utilized.
- A small contractor is utilized
- There is a significant portion of the project management undertaken by the scheme developers.
- Cheaper pipe materials are used, PE in place of FRP.

- Fencing and infilling of the canal are not undertaken.

The construction price obtained was $8.5 m or $2656/ha. The price was checked and confirmed by a contractor. The revised price is approximately 35% lower and comparable to the 30% estimated variation presented in section 8.5.

11.0 Lessons Learned From Case Studies

11.1 General Cost Estimation

- The accuracy of cost estimation and reliance put on values should be reflective of the level of investigation or design the scheme is at.
- In early stage investigations scheme costs are underestimated. Often hidden costs and requirements are only considered at later stages.
- A number of unexpected costs often become exposed in detailed design.
- Effort to complete several design iterations is recommended to optimise schemes as significant savings can be made with efficient designs.
- The method of 'contract' with contractors affects scheme cost. Contracts are a risk sharing device and the more risk a contractor takes the greater the cost.
- Suppliers and contractors are often willing to assist with pricing components of projects.

11.2 Piped Schemes

- Pipe scheme cost is generally similar nation wide dependent on pipe material utilized. Alternative pipe types often come with specialized installation systems that have comparable final installed costs.
- For large schemes, often effort is put into sourcing materials from less expensive countries with minimal representation in New Zealand. Experience indicates the cost of pipes made outside New Zealand is not significantly cheaper than local products for comparable material properties. Low quality pipes can be sourced internationally (up to 50% cheaper) but carry a corresponding risk factor.
- Pipe sizes less than 600 mm can often utilize several material types. Above 600 mm the range of materials is more limited including supplier choice. Optimising pipe diameter during design can save significant costs.
- The pipe scheme case studies will provide an approximate scheme cost independent of scheme location in New Zealand. The spreadsheet was developed for gravity water supply at the intake. Pump schemes may alter pipe designs based on transient effects and the velocity versus friction loss design of the pipe.
- For schemes with frequent topographic variation a significant proportional cost will be bends and anchor blocks.
- Contractors for pipe scheme construction is limited when compared to canal construction due to specialist skills often required, such as ticketed welding or installation techniques.
- The layout of the scheme significantly affects costs. Long large diameter primary

feeder pipes should be minimized. The two case studies highlighted that the overall scheme layout affects the efficiency of the design.

11.3 Open Channel Schemes

- Canal scheme design is typically unique to the location and flow requirements, and unit costs are not easily transferred from one scheme to another.
- Local geology, topography and intake locations significantly alter the infrastructure design.
- The acceptance criterion for water losses requires consideration by developers and the appropriate Resource Consenting authority. Where seepage targets are set without regard to the available soil types and construction materials canal lining may become prohibitively expensive or possible unfeasible from a technical viewpoint. Lining costs are a large portion of canal costs.
- Contractors and equipment for canal scheme construction are readily available and competitive prices can be obtained for construction.
- For larger canal schemes it may be appropriate to pipe smaller sub areas of the scheme rather than constructing tertiary canal systems.
- Water management of canal schemes is often more wasteful than pipe schemes. Utilising modern control systems and equipment such as automated gates for a new scheme will provide significantly improved water usages tan a manual system.