Hope Creek - Ida Valley Distribution

Prepared for the Manuherikia Catchment Water Strategy Group

Report DHA12

November 2012

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EXECUTIVE SUMMARY

This report has estimated the cost of the Hope Creek Diversion Race from a proposed lower dam site on Hopes Creek through to the Upper Bonanza Race. It has prepared pre-feasibility estimates based on pumping a 1 m^3/s flow up to a maximum pump lift of 15m and utilising a 9.9km long diversion race inclusive of pipe structures. The race will be substantially constructed through schist rock, similar to the Upper Bonanza Race country.

The estimated capital cost of construction with associated engineering and consenting costs is $4.73m. When the present value of electricity Use of System and power charges are added the Present Value of the proposed diversion sytem is $6.31m.

The diversion would allow for a 60% increase in the average seasonal allocation for existing Ida Valley irrigators. This will allow existing irrigated areas to be more fully irrigated.

There are currently about 10,500 ha in the Ida Valley Irrigation Scheme under contract. Spread over the whole contract area, distribution costs equate to $450 per hectare, or $600 per hectare including present value pumping costs. Hope Creek dam costs would be additional.

The concept of utilising windpower with an associated buffer storage pond is presented and appears to warrant further investigation.

The Hopes Creek water will essentially be used to improve the ability to supply full irrigation demand to existing irrigators rather than go onto part quotas. As such the existing race sizes are adequate. Reliability to irrigators converting to spray irrigation is best handled at the individual farm level with storages for a few days supply being regularly supplied by the existing race network.

Significant sums of money and a variety of methods have been used to limit leakage from the race system. These improvements over the last 40 years have reduced race losses in the Bonanza Race from over 30% to around 10%. This appears to be a practical level in this type of country.

1 Introduction

The Manuherikia Catchment Water Strategy Group (MCWSG) was set up to develop and oversee the implementation of a water strategy for the catchment. The MCWSG envisages that the project will provide information to help the community make informed decisions, leading to a comprehensive Manuherikia Catchment water strategy. Figure 1.1 provides an overview of the study.

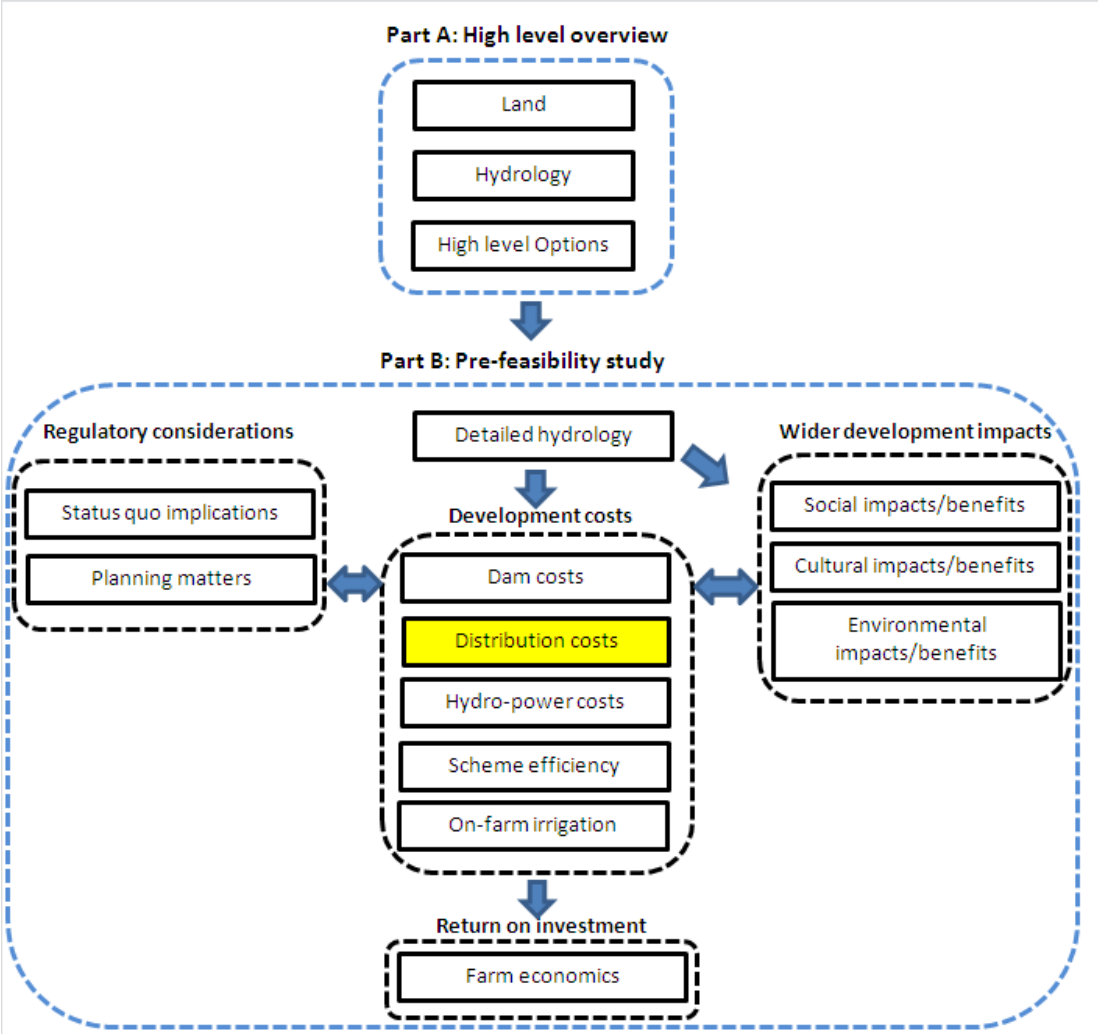

Figure 1.1: Manuherikia Catchment Study overview

This report builds on the High Level Options report, where storage and diversion of Hopes Creek water was seen as the solution to on-going problems with achieving full seasonal water supply quotas.

This report covers the cost of conveyance from Hope Creek to the Ida Valley Irrigation Scheme. A separate report addresses Hope Creek dam engineering.

This report should be read in conjunction with the Manor Burn Catchment Detailed Hydrology (Aqualinc 2012d) report.

Design and costings are at a pre-feasibility level. Total costs are expected to be accurate to ±30%. Cost uncertainty may be higher for individual items.

This study has been made possible by the generosity of the following who have contributed by way of direct funding or by in-kind contributions. MCWSG are grateful for this support and wish to thank the following:

- Ministry of Primary Industries with funding via the Irrigation Acceleration Fund.
- The Otago Regional Council (ORC).
- The Central Otago District Council (CODC).
- The Manuherikia Community.

2. Hope Creek Dam

The hydrology of the Hope Creek dam site is summarised below. Further details are given in Aqualinc (2012d).

"Hope Creek dam

Hope Creek dam has a potential annual average yield of 15 Mm^3. This is 75% of the potential yield of the Upper Manor Burn dam. Fifteen years of near continuous flow data is available for the Hope Creek, near the proposed dam site. This data means we have considerable confidence in the potential catchment yields.

Hope Creek dam could potentially supply an average of 13 Mm^3 per year to Ida Valley. In all but the driest of years, at least 10 Mm^3 per year would be able to be supplied. In wet years, when the Upper Manor Burn dam was spilling, Hope Creek water would not be used. The limited storage in the Hope Creek dam means Hope Creek, Upper Manor Burn and Pool Burn dams would need to be managed together. Hope Creek water would be used first, with the dam being drawn down to the minimum level most years. The Upper Manor Burn and Pool Burn dams store water for several seasons, and in dry years, a greater proportion of water would come from these dams. This additional water would allow an additional 2,500-3,000 ha to be fully irrigated in the Ida Valley.

15 Mm^3 of usable storage would ensure the majority of Hope Creek dam yields are able to be ultilised. A dam water level operating range of about 632 – 644 m amsl would provide 15 Mm^3 of storage. This would require about a 32 m high dam. A 13 to 15 m pumping lift would be necessary to lift water from the minimum lake operating level, to the height of the conveyance race. Raising the dam an additional 2 m, would reduce the pumping lift by about 4 m.

The location of the proposed dam is shown in Figure 2.1.

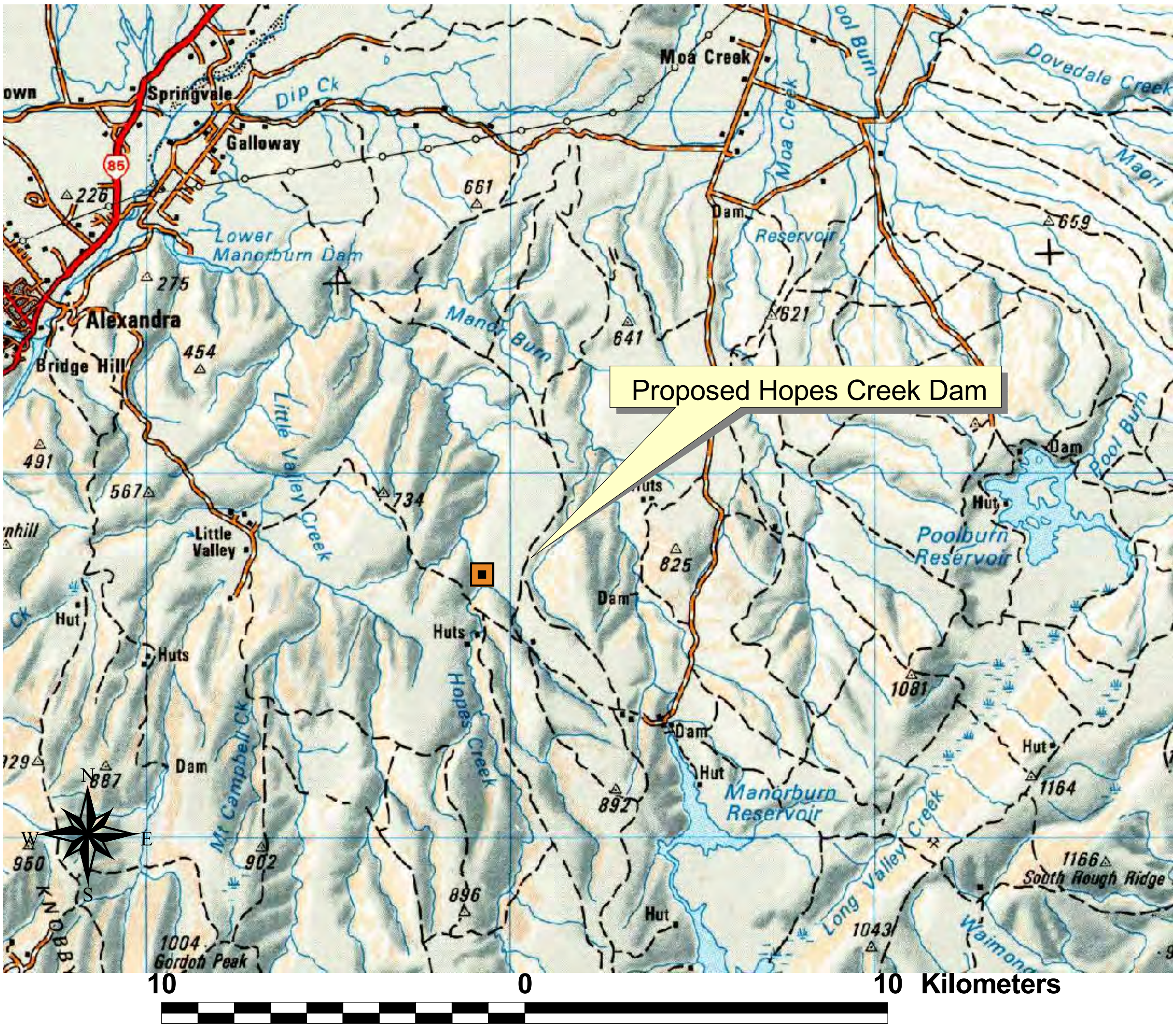

Figure 2.1: General Location Plan of Proposed Hopes creek dam

3. Proposed Raceline

3.1 Elevation

The proposed dam on Hopes Creek operating range of 632 to 644m asl provides a variable start water level with full flow being required at all levels down to the 632m level.

The Bonanza Race water level at the proposed junction is estimated as 639 m asl. This figure has been taken from the old MWD orthophotos Sheet 87, dated approximately 1980. This is shown in Figure 3.12 attached.

To supply this race from the proposed dam will require a pump lift.

Diagrammatically this can be shown:

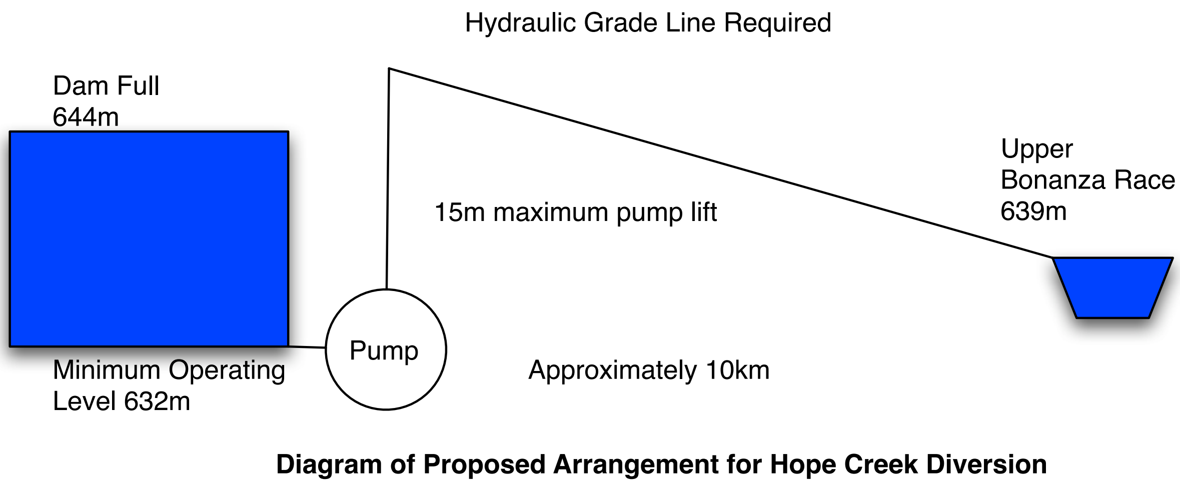

Figure 3.1: Diagram of Proposed Arrangement for Hope Creek Diversion

3.2 Geology and soils

The geology of the area is schist Yc III Caples Terrane. The existing Upper Bonanza Race is constructed in this material. Planar schistocity is developed but bedding is barely recognisable.

Part of the GNS 1:250000 geological map 18. Geology of the Wakatipu Area. 2000 is shown as Figure 3.2

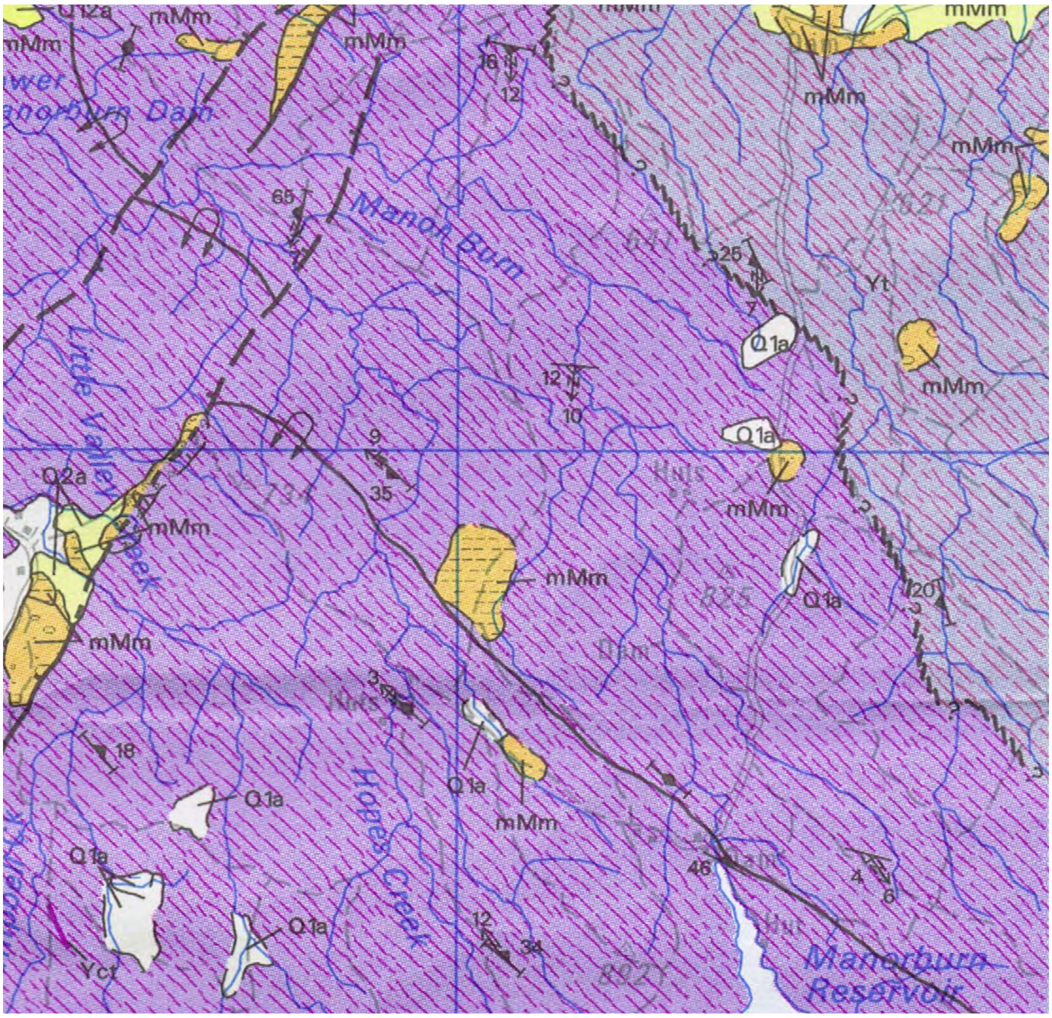

Figure 3.2: Part of Geological Map

Soil types along the route are Blackstone, Matarae and Conroy, primarily sandy loams. They are shallow soils formed from schist loess over schist basement with some schist sands or gravels.

No test pits or excavation has been carried out along the route.

3.3 Race size & Hydraulics

In the Manor Burn Hydrology Report (Aqualinc 2012d) four scenarios were modelled:

- Scenario 1: 1.2 m^3/s peak demand & 15 Mm^3 of usable storage;
- Scenario 2: 1.0 m^3/s peak demand & 15 Mm^3 of usable storage;
- Scenario 3: 0.9 m^3/s peak demand & 15 Mm^3 of usable storage; and
- Scenario 4: 1.0 m^3/s peak demand & 20 Mm^3 of usable storage.

Results indicated that a 1.0 m^3 conveyance capacity from the dam to Bonanza Race should be sufficient.

In order to minimize pumping costs the proposed race grade is relatively flat at 1 in 2000 (Slope S=0.0005 m/m). Race dimensions that are close to minimal wetted perimeter are for a 1.5m bottom width. 1:1 side batters (assumes rock) and a minimum

4m access berm. Velocity based on a Mannings n of 0.04 is 0.39 m/s. Design water depth is 1.02m and freeboard 0.48m, with total race depth of 1.5m.

The experience with the Bonanza Race has led to the Ida Valley Irrigation Company Ltd moving the old race laterally back in to the hillside to provide greater stability and reduce losses. The design for this new race has provided for a 2m top width of the access berm to be undisturbed country with the balance of the access width being provided for by side cast material from the platform and race excavation. See Figure 3.3 attached.

Figure 3.4: Upper Bonanza Race close to site where Hopes Ck Diversion Race would enter. Similar country is expected in parts of the diversion race (Photo 24 Oct 2012)

The initial section of the diversion is the rising main from the pumpstation. From the aerial photography and 20m contour information the rising main from the pumps can run relatively flat on the 630 to 635m contour before rising to the discharge at 646.1m about 210m downstream of the pump station. The side slope is 33 degrees at the steepest. Provisional benching and rising main layout are shown on Figures 3.5 attached and 3.6.

An example of a similar pipeline is shown as Figure 3.11.

The overall length of pipe is 210m rising main and 370m for the Manor Burn syphon, totaling 580m. The friction loss for coated steel pipe or smooth precast concrete pipes is 0.35m/100m for a flow of 1 m^3/s in an 800mm internal diameter pipe. Other pipe sizes were looked at but this was considered to be the best solution between additional pumping and cost. There are entry and exit losses and these have been taken as one times the velocity head for the syphon. The total head loss across this syphon is 1.5m.

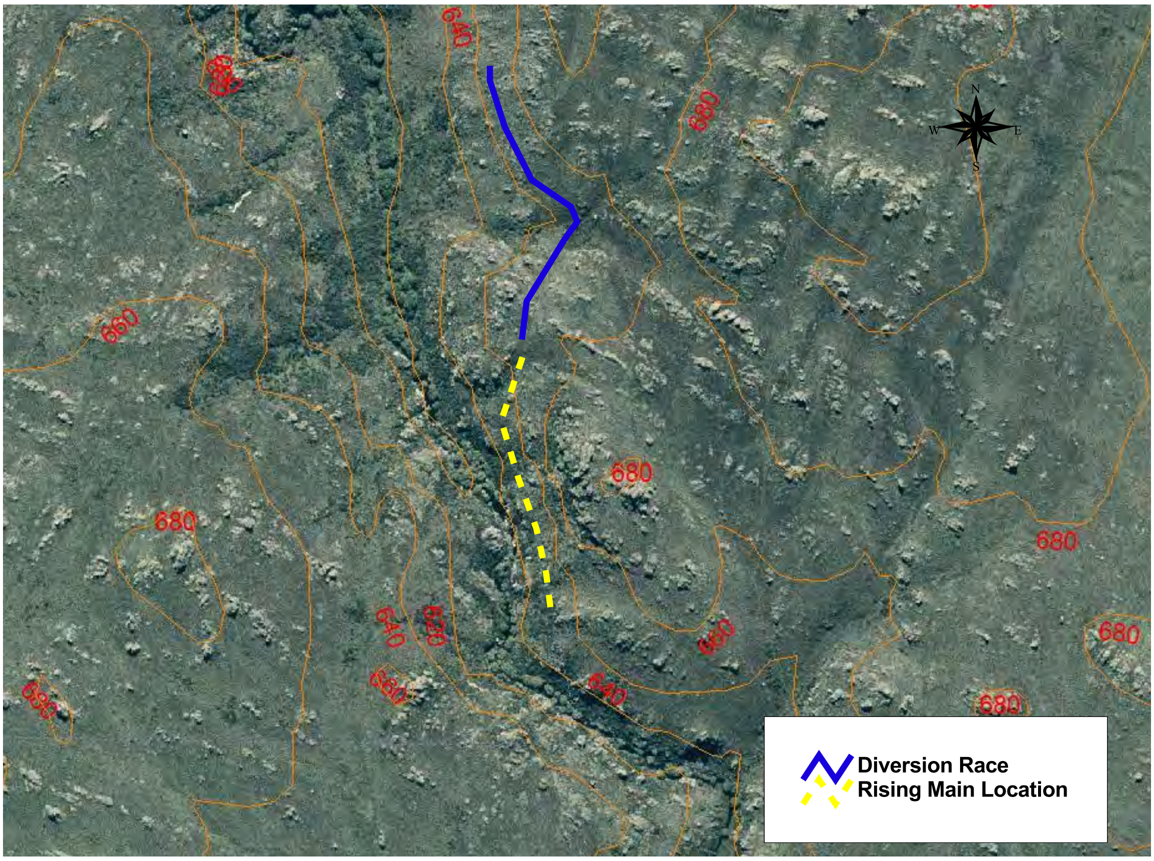

Figure 3.6: Rising main location downstream from proposed Hopes Ck Dam. Rising main is 210m long

Provision has been made for 3 stream crossings. The sites have not been visited but the larger catchments should be a pipe bridge or syphon. There is 0.9m allowed for losses at these locations.

Provision has also been made for two bywashes to be placed at safe locations should high intensity rainfall induced runoff overload the irrigation race.

Location	**HGL masl**
Hopes Creek Reservoir Full Supply level	644
Hopes Creek Reservoir Minimum Operating level	632
Pump to supply race HGL at outlet rising main	646.1
Race level upstream end Manor Burn syphon	640.5
Bonanza Race water level	639

Table 3.1: Critical levels for Hopes Creek Diversion

Figure 3.7: Syphon route through Manor Burn valley from part way down slope below Upper Bonanza Race looking SW to left bank. Syphon would start mid photo nearer ridgeline. Indicative alignment is shown (Photo 24 Oct 2012)

Figure 3.8: Upper Bonanza Race just upstream of where the proposed syphon would join. The race has been relocated through a low saddle. Photo looking south 24 Oct 2012

Based on these levels the approximate location of a raceline has been plotted on aerial photos superimposed with 20m contours. Only at the Bonanza Race end are there more accurate contour levels. It was not possible to enter onto properties over most of the length due to lambing and other factors. For construction purposes the race has been assumed to require heavy machinery suitable for rock excavation and rock breaking over much of the length.

The proposed race is shown on Figure 3.9 with the steeper sections identified. Attached as Figure 3.10 is the same race route plotted on CODC aerial photographs.

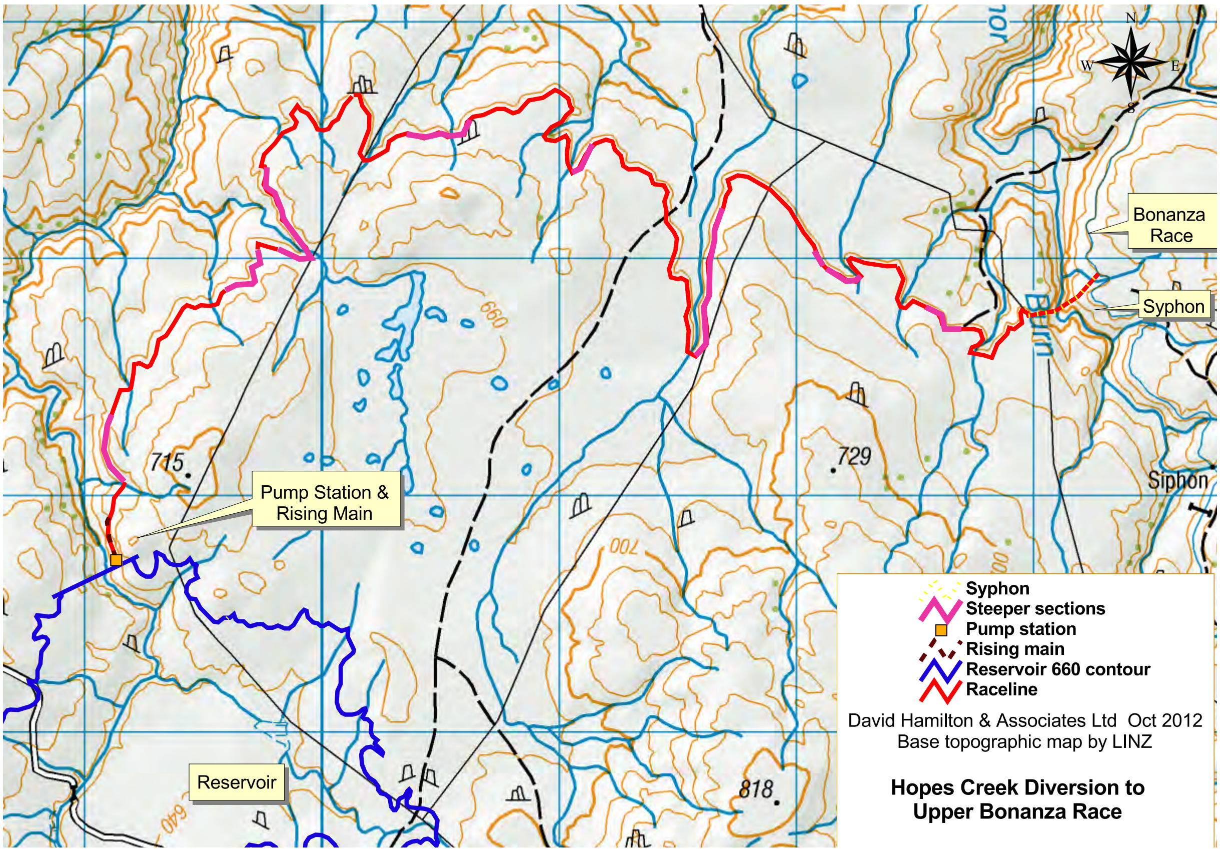

Figure 3.9: Hopes Creek Diversion race layout on topgraphic map

The Manor Burn syphon location selected has chosen the easier valley side slopes to get to the Bonanza Race at elevation 639m. The river level is about 580m so maximum static head in the syphon is just over 60m. Suitable syphon sites are available further back up the Manor Burn valley but the level of the Bonanza Race is some 4 to 5m higher and would involve additional pumping lift, only partially offset by a shorter syphon's lower friction losses. The MWD orthophoto of the Bonanza Race levels as they were about 1980 is shown as Figure 3.12 attached. The current GoogleEarth aerial photo is shown as Figure 3.13 for comparison.

Figure 3.11: Example of pipeline similar to proposed rising main (at Strode Road Earnscleugh Irrigation Co. Ltd, 28 Oct 2012)

3.4 Pump Sizing

This has been based on a flow of 1.0 m^3/s and a pump lift of 15m.

With a variable pump lift and supply rate that can vary during the season a range of pumps would be installed, including backup should one need maintenance during the season.

Installed capacity that may be required to operate at one time is calculated from the following formula:

$$P = Q \times g \times H / \varepsilon$$

Where P = Power in kW
Q = Flow in m^3/s = 1.0 m^3/s
g = Gravitational constant = 9.81 m/s
H = Pumping head = static head + rising main losses =15 m maximum
ε = Pumping efficiency, assumed as 75%

Installed pump capacity required to be used at any one time is 196 kW, say 200 kW .

For the purposes of the feasibility costings it has been assumed that there will be a combination of three pumps, all of nominal capacity 0.5m^3/s: one pump with best operational efficiencies in the 3-8m pumping range; a second pump with best operational efficiencies in the 8-15m range; and a third pump with best operational efficiencies in the 6-12m range. All pumps to be capable of managing the variable duty and be able to pump the full 15m if and when required. They may therefore be equipped with variable speed drive controls. There would be two duty pumps at any one time, selected based on pumping head that depends on the reservoir level, and the third pump as standby.

A provisional layout for a pump building is shown on Figure 3.5 attached

3.5 Electricity Supply

Pumping would be required from October to April. Because of the long lengths of races involved continuous pumping would be used.

If special irrigation or night pumping rates were to be utilised then at least 12 hours buffer storage would be required. Storage size would need to be 45,000-50,000 m^3. Installed pumping capacity and supply lines and transformers would need to be doubled in size to provide for the same average 24 hour flow. This option has not been further investigated at this stage.

To allow for start up current the electricity supply should be a nominal 300 kVa.

Delta were approached to provide preliminary estimates for supply to the dam site for a 300 kVa supply.

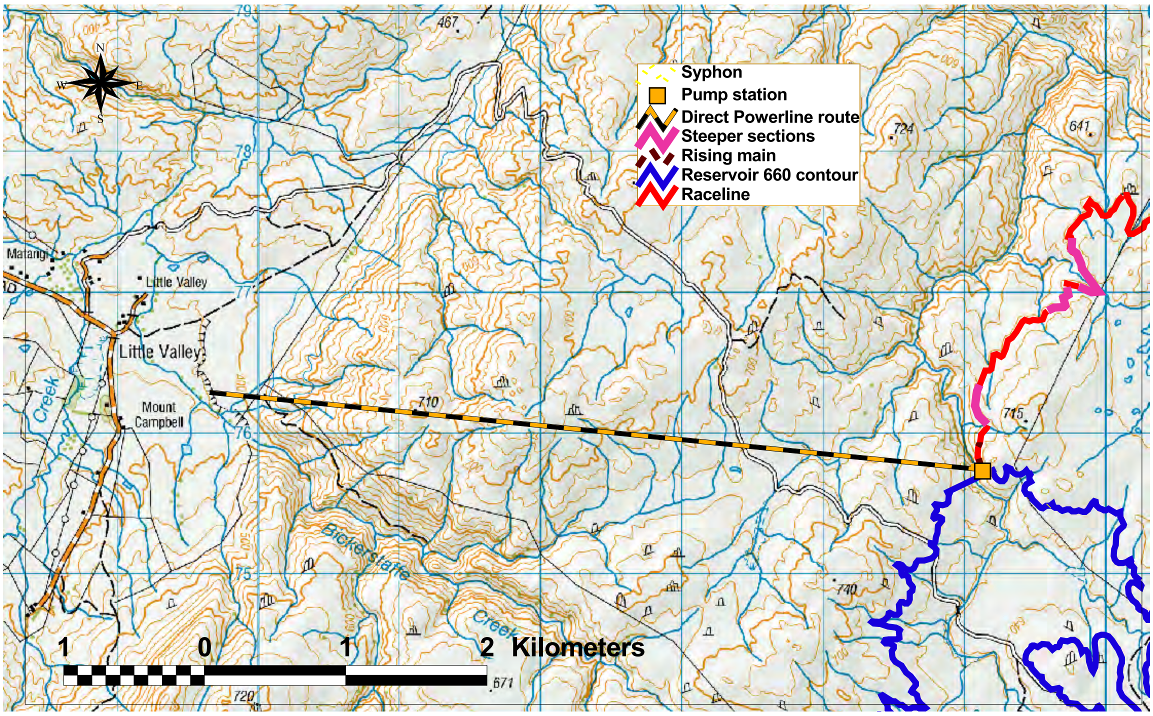

Figure 3.14 : Possible power supply route to pump site at Hopes Creek Dam

Nearest power lines are at Little Valley. Distance to the dam is about 5.4km. Terrain along the route traverses land over 750m in elevation and there is no existing access track over much of the direct route. See Figure 3.14 for the direct route for a power line to the proposed dam site. There may well be merit in following the Bickerstaffe Stream valley track at a lower elevation across to the proposed dam and pumps although it is a slightly longer route.

3.6 Water Measurement

Provision has been made for a water meter installation on the rising main pipeline.

4. Ida Valley Distribution System

4.1 Upper Bonanza Race

The Upper Bonanza Race was originally constructed for mining purposes. The race was enlarged and used as part of the Ida Valley Irrigation system from 1917.

The present capacity of the race is 2.15 m^3/s (76 heads or cusecs). With only 1 m^3/s supply being proposed from Hopes Creek the balance will be supplied from the Manor Burn weir, supplied substantially by the Manor Burn Dam.

Major reconstruction of the Upper Bonanza Race has occurred over the last 40 years to reduce seepage losses and to make the race more secure through benching and lateral moving of the race further into the hill slope. Blowouts could occur at any time of the season and cause disruption to supply to irrigators.. Upstream batters of up to 5m high are common with berms now providing a good access track for inspection and machinery access.

The last major work has only recently been completed.

4.2 Further Race Distribution

The Upper Bonanza Race continues on until Moa Creek. Prior to that the Lower Bonanza Race splits off at Hallidays Flat. The Lower Bonanza Race feeds along to Lows Saddle on Crawford Hills where part of the flow feeds into Dip Creek and the Galloway area. The Syndicate Race supplies the western side of the Ida Valley.

The Moa Creek weir supplies Blacks No.3 Race along the western side at a lower elevation than the Syndicate Race. The Moa Creek weir is also connected to the Poolburn weir that supplies the German Hills Race along the eastern side of the valley.

See Figure 4.1 that shows these races.

4.3 Race Leakage

Leakage from the Upper Bonanza Race is probably now about 10%. In the MWD (1979) the Upper Bonanza Race is shown as losing 32% of the seasonal flow (1972/73 to 1976/77 seasons only). Substantial works were undertaken and the report considered the losses to be about 10% by 1979. Leakage has been an issue from Day 1 and sections of the race were in fact concrete lined. Over the years the concrete lining deteriorated. Sections have had silty clay introduced in attempts to seal the race. Sections have been undercut and compacted. Butynol liners were tested but did not prove satisfactory.

A factor to consider is that the leakage from the race is part of the flow into the Lower Manorburn dam, and although lost to the Ida Valley irrigators it is still utilised.

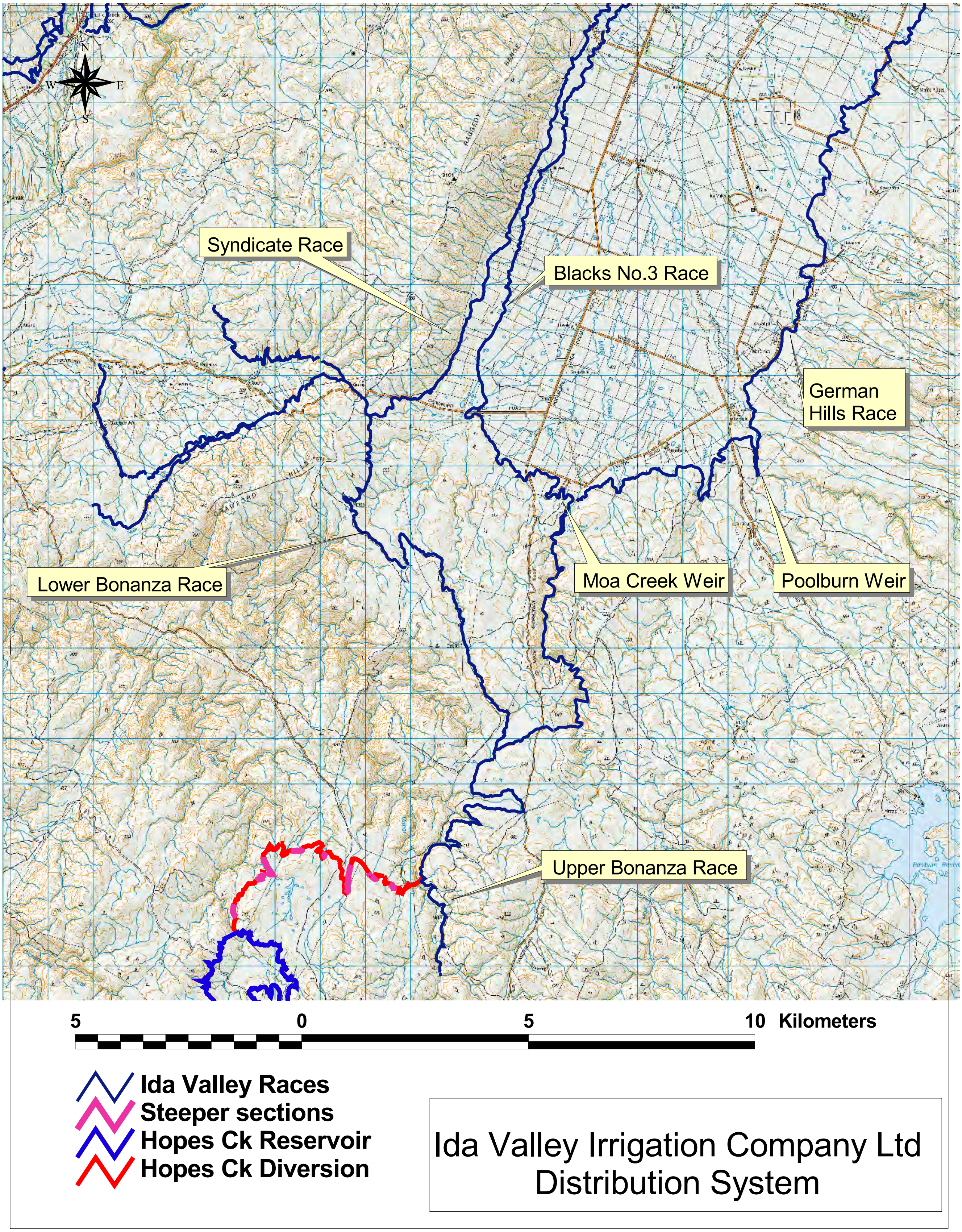

Figure 4.1: Map showing Ida Valley Races

It is considered that losses of the order of 10% are practical given the terrain and the effort already attempted in reducing these losses. Regular inspections are still necessary to identify any new seepage areas or deterioration of any section of the race so that remedial works can be undertaken in a timely fashion.

4.4 Irrigation Efficiency

There has been a steady move towards spray irrigation in the Ida Valley over the last few years. The race system is operated as an on-demand system. The Hope Creek supply will be used to more fully irrigate land within the Ida Valley scheme that is currently only partially irrigated.

In order to make best use of additional water from Hopes Creek a brief look at the race system would suggest that rather than increase the race capacities it is more important that on-farm storages be provided as a buffer for race supply so that all farmers can switch to a more efficient on-farm application system. In a rostered system the size of the buffer pond may be as much as the roster cycle volume, or say 700 m^3 per ha. One hundred hectares would thus need up to 70,000m^3 storage. Because the Ida Valley system provides for some inflow on a continous basis it is considered that a lesser volume would be sufficient and should be equal to a few days supply. The Company could establish the ground rules for this.

The existing shareholding of the Ida Valley Irrigation Company Ltd is 10,676 with one share equating to one hectare of water quota.

5. Estimated Costs

5.1 Pre-feasibility costings

The Hopes Creek diversion has been costed to a pre-feasibility level, using rates from other recent irrigation proposals, and actual quotes for Upper Bonanza Race work. Costings are primarily based on broad desktop assessments with little consideration of site-specific factors. Race costs are highly dependent on ground conditions and may vary from predictions accordingly. It is recommended as part of feasibility investigations that a contractor(s) with earthworks and irrigation scheme experience be engaged to help refine cost estimates.

Costs are estimated to be accurate to ±30%. Cost estimates are a mean estimate, given an average to favourable construction environment and a well-run tender process. Costs also assume the bulk of the work is tendered as part of a single contract, thereby reducing the price by the scale of construction. Costings are shown in Table 5.2.

An allowance for lining particularly leaky race sections has been included. Race velocities will be lower than the Upper Bonanza Race and clay lining may be a viable option.

Costs exclude land purchase costs, legal fees, and GST.

5.2 Electricity Charges

The cost per unit for pumping has been assumed as 15 c/kWh. For the annual power cost the pumps have been assumed as operating for 180 days. It is noted that $15Mm^3$ storage volume would take 173 days pumping at 1 m^3/s. With pumps often having a duty of less than 15m, the full 100 kW per pump will only be drawn when the dam is nearing the minimum operating level. The pumping efficiency may also be less when not at the optimum duty. For the purposes of assessing annual energy cost it has been assumed the average pumping head is 10m.

Annual energy cost is calculated by:

200 kW x 10m/15m x 180 days x 24 hours x \$0.15/kWh = \$86,400

It has been assumed that during the season water will be pumped continuously until the Hopes Creek reservoir is drawn down to minimum operating level. There is not the ability to turn pumps on and off to avoid peak power times.

In addition to the unit cost per kWh for power, an estimate of the Use-of-System charges for the supply to the dam site was sought from Delta.

Their summary table is shown as Table 5.1. The total annual standing charges are \$32,217.

	Component	Quantity	Unit	Rate	Extended
Distribution	Fixed	1	LS	$ 542.00	$ 542.00
	Capacity	300	kVA	$ 28.35	$ 8,505.00
	Distance	5400	kVA-km	$ 0.37	$ 1,998.00
	CPD	75	kW	$ 186.62	$13,996.50
	Transformer	0	kVA	$ 8.40	$ -
	Subtotal distribution component				$25,041.50
Transmissi	Capacity	300	kVA	$ 1.07	$ 321.00
	CPD	75	kW	$ 91.40	$ 6,855.00
	Subtotal distribution component				$ 7,176.00
	Total annual Use-of-System Charges				$32,217.50
	Monthly Use-of-System Charges				$ 2,684.79

Table 5.1: Use of System Charges as provided by Delta

5.3 Estimated Capital Cost

Table 5.2 below is the estimated cost of the various components of the project. Allowance has been made for engineering costs, preliminary and general costs that includes consenting, and contingencies at 20%.

For this project with pumping the annual expected power cost and Use-of-System charges have been converted to Present Value using a discount rate of 7.5%.

Based on existing shareholding of 10,676 hectares the capital cost of $4.73m is $443/ha. The Present Value cost of $6.31m is $591/ha.

Hope Creek Diversion		Pre-Feasibility			
Estimated Rough Order of Costs					
Item	**Description**	**Unit**	**Quantity**	**Rate**	**Amount $**
A	**Engineering** (8%of B-G)	LS	1	$ 292,063	$ 292,063
B	**Preliminary and General** (10% of C-G)	LS	1	$ 331,890	$ 331,890
C	**Pump Station**				
C1	Site preparation	LS	1	$ 20,000	$ 20,000
C2	Building 8 x 4 + Gantry	m2	32	$ 3,000	$ 96,000
C3	Pumps 0.5m3/s, 15m, 75% eff, 100kW	EA	3	$ 80,000	$ 240,000
C4	Control Gear	LS	1	$ 60,000	$ 60,000
C5	Water meter	LS	1	$ 15,000	$ 15,000
C6	Pipework and valves	LS	1	$ 40,000	$ 40,000
D	**Power Supply**				
D1	Power transmission lines incl transformer	LS	1	$ 600,000	$ 600,000
E	**Rising Main**				
E1	Benching	m	210	$ 220	$ 46,200
E2	Steel Pipe 800mm diameter	m	210	$ 800	$ 168,000
F	**Race - primarily in rock**				
F1	Steeper country 20-30 degrees	m	2770	$ 240	$ 664,800
F2	Medium country 10-20 degrees	m	6570	$ 120	$ 788,400
F2	Provision for lining short sections	m	2000	$ 50	$ 100,000
F3	Race access crossings	EA	3	$ 20,000	$ 60,000
F4	Minor stream crossings	EA	3	$ 20,000	$ 60,000
F5	Bywashes	EA	2	$ 8,000	$ 16,000
G	**Syphon**				$ -
G1	Steel pipe 800mm diameter	m	370	$ 850	$ 314,500
G2	Pipe Bridge Manor Burn	LS	1	$ 30,000	$ 30,000
H	**Contingency/unscheduled items** (20% of A-G)	LS	1	$ 788,571	$ 788,571
	TOTAL CAPITAL				**$ 4,731,424**
	Costs exclude GST, land purchase and easement costs and legal fees				
I	**Present Value Power Supply**				
I1	**PV scheme pumping** (67% of 200kW, 180 days, $0.15/kWh, 7.5% y compound interest)	LS	1		1,152,000
I2	**PV Electricity Standing Charges**	LS	1		429,600
	PV COST INCLUDING CAPITAL				**$ 6,313,024**

Table 5.2: Scheme Estimated Cost

6. Alternative Wind Generation Pumping

The report has been based on the concept as adopted by the Manuherikia Catchment Water Strategy Group.

Because of the initial cost of getting power to the site and the on -going operational costs associated with supply it is considered that wind generation may be an option.

In order for irrigation pumping to be supplied solely by wind generation there is a need to either store the energy for pumping when the wind is insufficient, or pump at times when there is adequate wind and store the water where gravity outflow can be provided.

There is a good storage site above the proposed race that with a 20m high dam could store about 2 Mm^3. Figure 6.1 shows the scheme concept. The race from the buffer pond to the Bonanza Race could be at a slightly higher elevation and save on syphon costs. The pump lift is greater than that for the principal option costed.

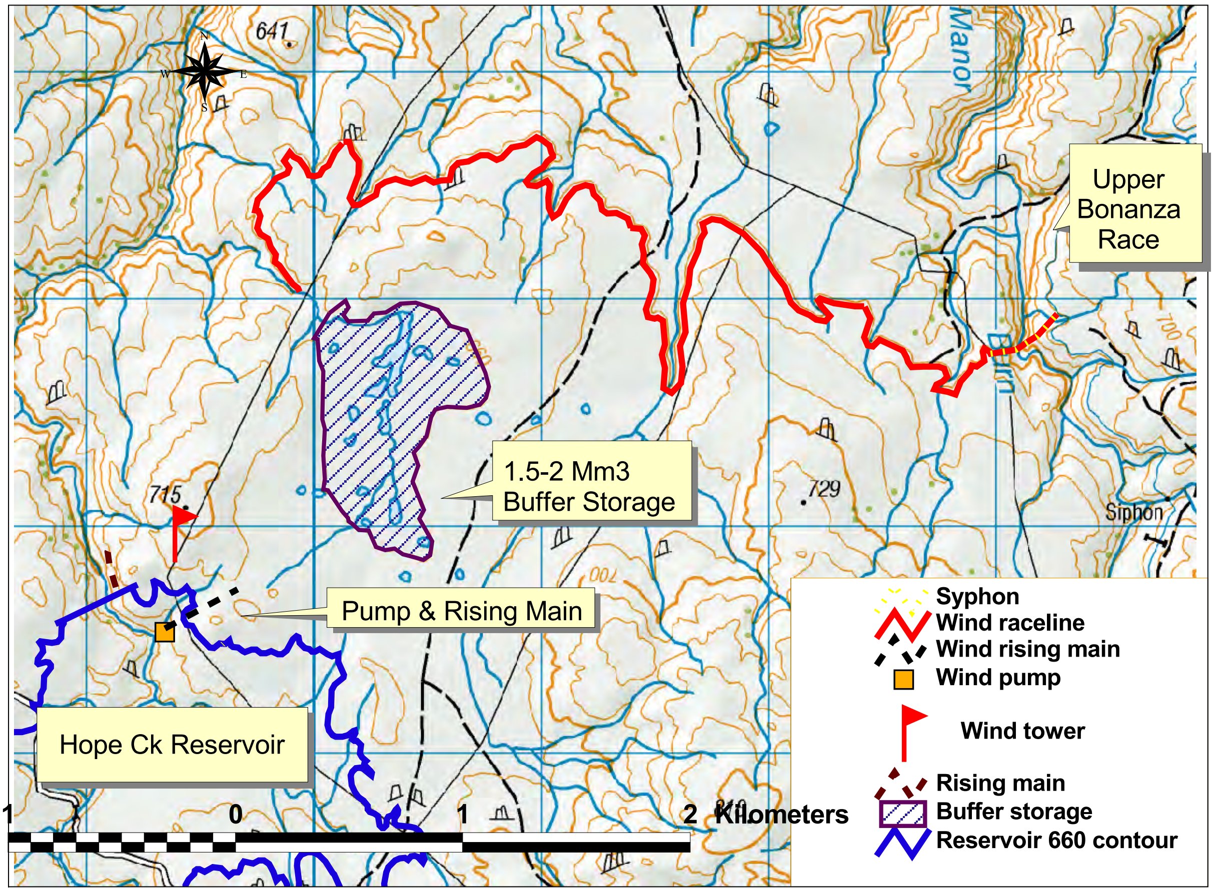

Figure 6.1: Wind powered alternative concept

Average annual wind speed data from GrowOtago shows the site as having a higher average wind speed than the Horseshoe Bend wind power site of Pioneer Generation. The Hopes Creek site averages 2-3 km/hr more than the Horseshoe Bend site that is

12.1-14 km/hr. See Figure 6.2 for Hopes Creek area annual average wind speed. Figure 6.2 shows the annual average wind speed map from GrowOtago with the potential wind tower and pumping location at the centre of the map.

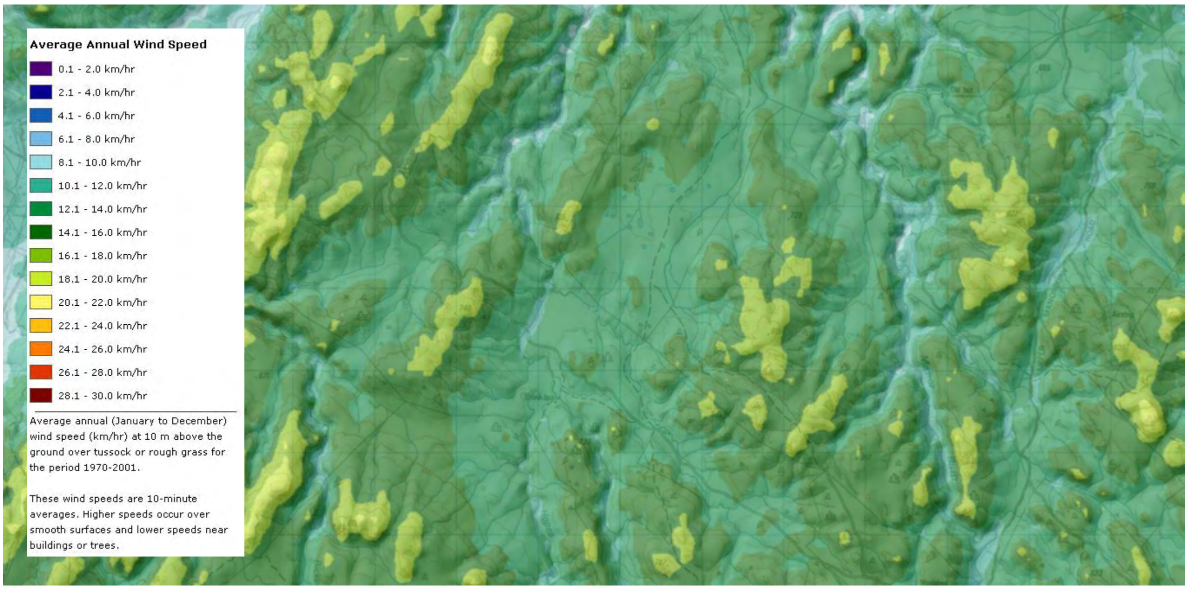

Figure 6.2: Annual average wind speed (GrowOtago) at site

If wind is available for pumping half of the of the time then pump capacity would have to be just over 2 m^3/s, maximum pump lift about 40m and pumps totaling 1050 kW (1.05 MW). For just over 15 Mm^3 pumped per year about 2,270 MWh would be required. The following inset shows details of the Mt Stuart windfarm where the average wind speeds are about 2-4 km/hr greater than at the Hope Ck site.

Technical details of the Mt Stuart windfarm of Pioneer Generation Ltd are:

- *Nine Gamesa 850kW wind turbine generators*
- *45 metre tubular steel towers to support the nacelle.*
- *A three-bladed rotor, 52 metres in diameter will harness the wind energy and drive the 850kW generator*
- *The gearbox, generator and a cabinet containing fail-safe protection equipment are all housed in the nacelle.*
- *The Gamesa turbine will start producing power when wind speed reaches 14.5 km/h; the turbine will reach maximum power at wind speeds above 61 km/h.*
  Each wind turbine will produce 2,845 MWh per annum; providing a total of 25,600MWh.

It is considered that if the Hopes Creek Dam and Diversion are to be more fully investigated that the reliability and costings for the wind power alternative should be investigated.

7 Conclusion

This report has estimated the cost of the Hope Creek Diversion Race from a proposed lower dam site on Hopes Creek through to the Upper Bonanza Race. It has prepared pre-feasibility estimates based on pumping a 1 m^3/s flow up to a maximum pump lift of 15m and utilising a 9.9km long diversion race inclusive of pipe structures.

The concept of utilising windpower with an associated buffer storage pond is presented and appears to warrant further investigation.

The Hopes Creek water will essentially be used to improve the ability to supply full irrigation demand to existing irrigators rather than go onto part quotas. As such the existing race sizes are adequate. Reliability to irrigators converting to spray irrigation is best handled at the individual farm level with storages for a few days supply being regularly supplied by the existing race network.

The diversion would allow for a 60% increase in the average seasonal allocation for existing Ida Valley irrigators. This will allow existing irrigated areas to be more fully irrigated. There are currently about 10,500 ha in the Ida Valley Irrigation Scheme under contract. Spread over the whole contract area, distribution costs equate to $450 per hectare, or $600 per hectare including present value pumping costs. Hope Creek dam costs would be additional.

Significant sums of money and a variety of methods have been used to limit leakage from the race system. These improvements over the last 40 years have reduced race losses in the Bonanza Race from over 30% to around 10%. This appears to be a practical level in this type of country.

8 References

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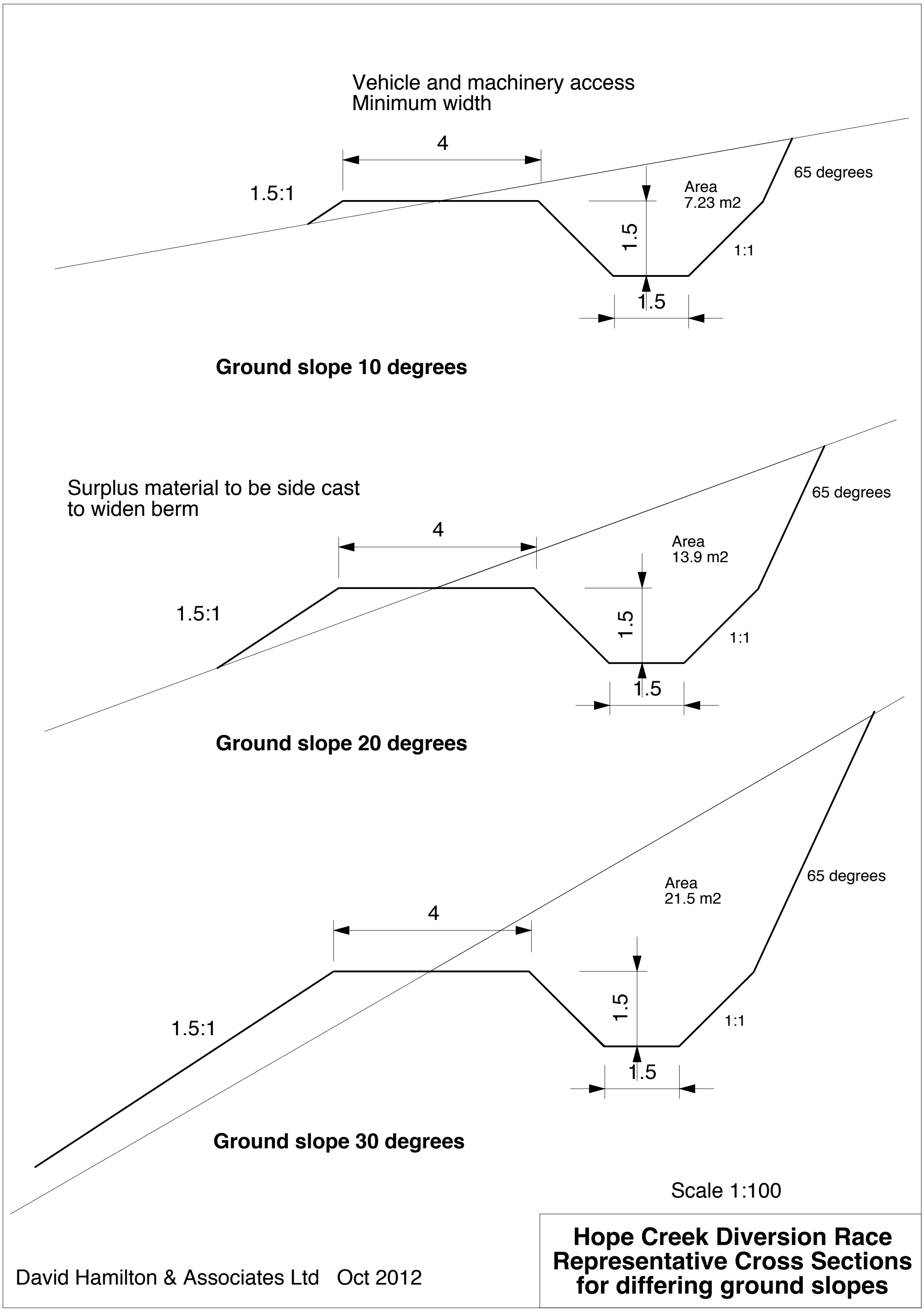

Figure 3.3: Design Cross Sections for Diversion Race

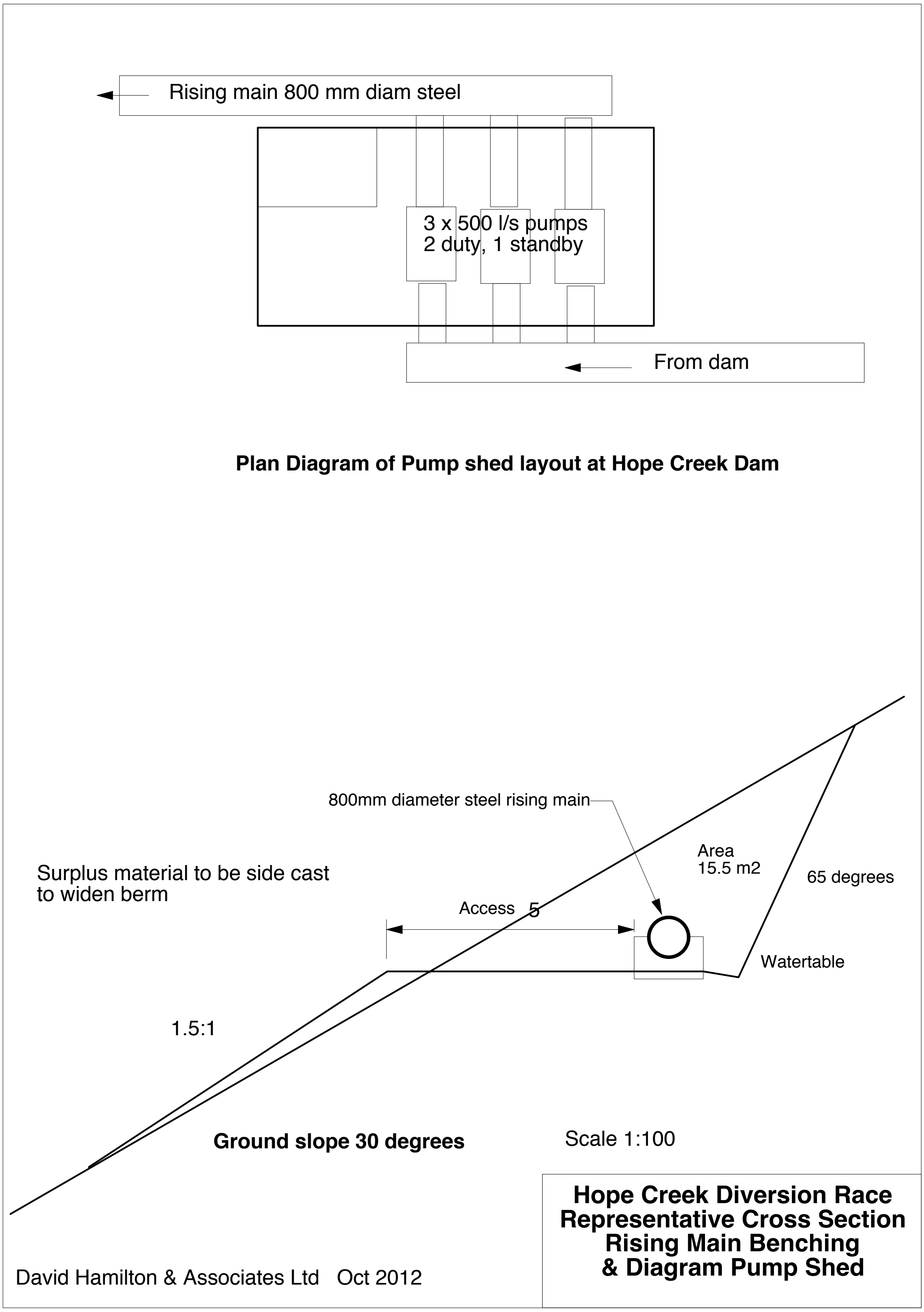

Figure 3.5: Representative cross section of bench for rising main and diagram of pumpshed layout

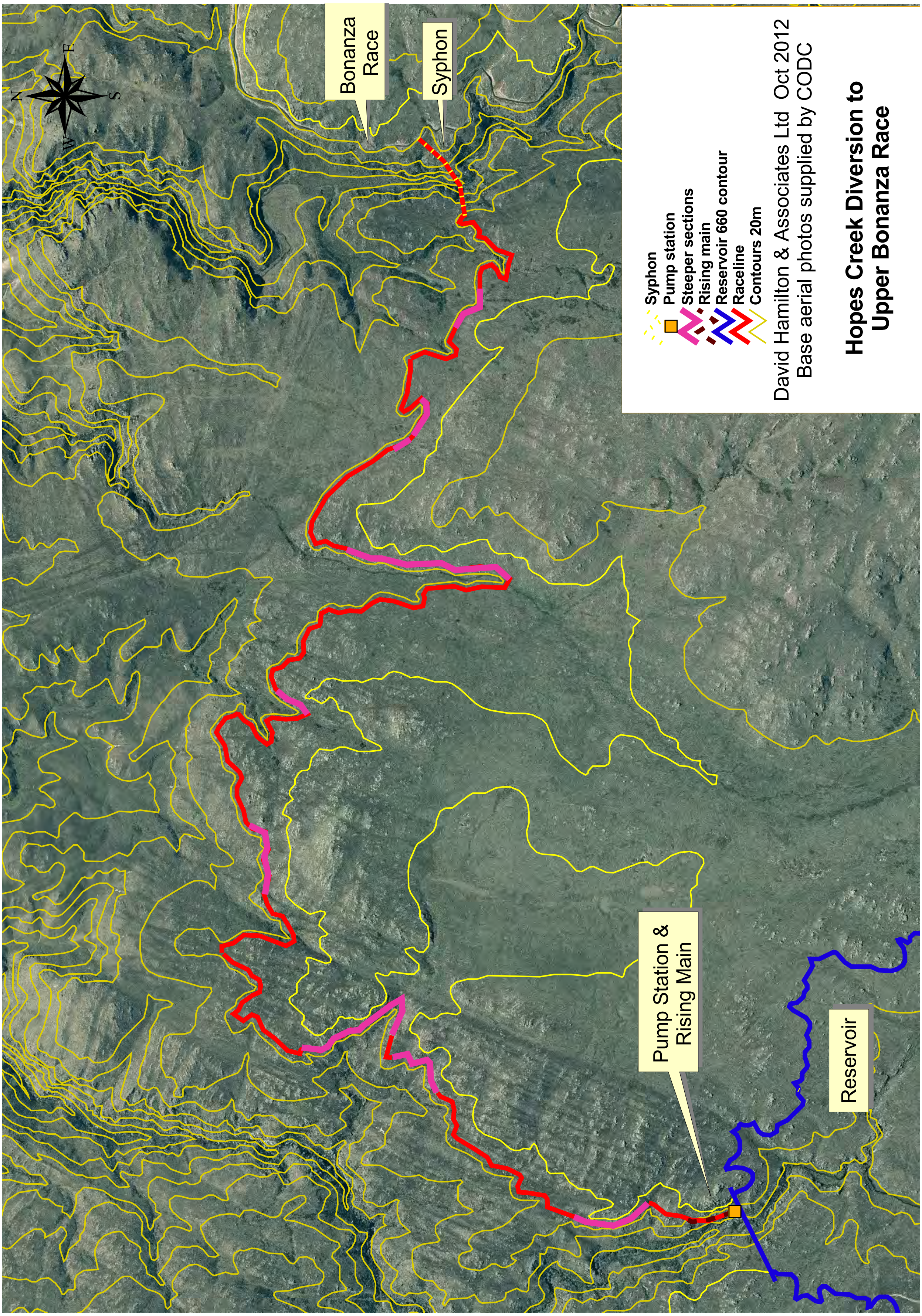

Figure 3.10: Proposed Hopes Ck Diversion Race on CODC aerial photos

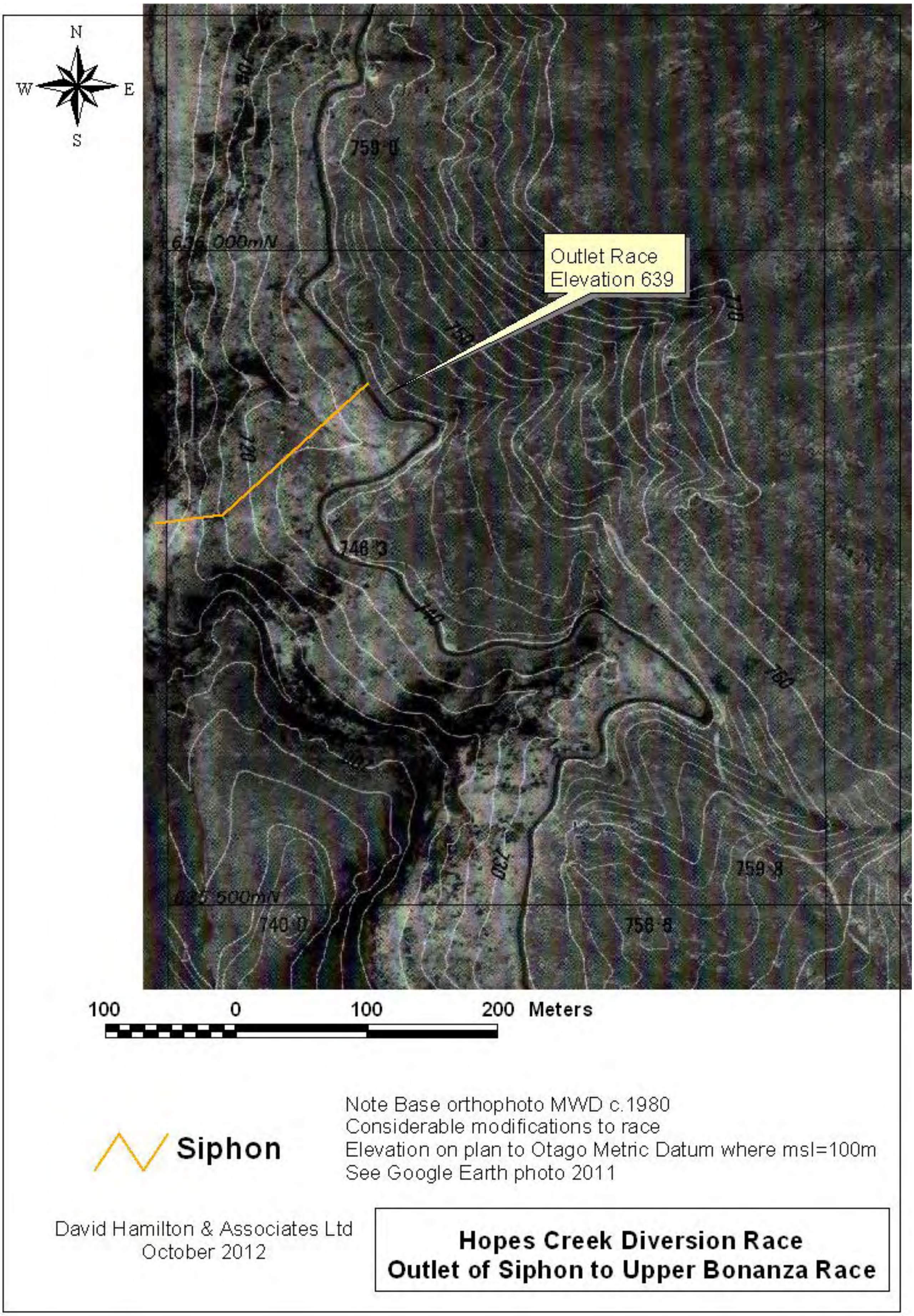

Figure 3.12: MWD orthophoto of Upper Bonanza Race c.1980

Figure 3.13 : Upper Bonanza Race GoogleEarth photo 20 December 2011. This shows significant changes to Bonanza Race compared with the MWD orthophoto c.1980. The scale of the photos is similar.