TECHNCIAL PAPER

THE FIORDLAND LINK EXPERIENCE, CREATING TRANSPORTATION OPPORTUNITIES FOR TOURISM AND RECREATION BY MONORAIL

Author/Presenter
Will Parker NZCE, BE (Hons), MIPENZ, CPEng
Principal Civil & Structural Engineer
Opus International Consultants Ltd
will.parker@opus.co.nz

Co-author/Presenter
Louise Robertson BA, MRRP, MNZPI
Partner and Environmental Consultant
Mitchell Partnerships Ltd
Louise.robertson@mitchellpartnerships.co.nz

Co-author
John Beattie
Director, Riverstone Holdings Ltd
John.beattie@infinity.co.nz

ABSTRACT

Providing transportation infrastructure to meet the needs of tourism, recreation and regional connectivity in the Milford/Fiordland area has been a hot topic since the middle of last century. The challenge has been to reduce the length and duration of travel from Queenstown to Milford Sound.

A 1990's option proposed a high speed boat and monorail to shave significant time off the journey from Queenstown to Milford Sound. The fundamental driver for the monorail technology is the desire to minimise the ecological footprint by raising the 'rail' above the ground.

Riverstone Holdings Limited (Riverstone) has fine tuned the original idea into the Fiordland Link Experience which comprises three modes of transport:

- A 20km catamaran crossing of Lake Wakatipu to Mt Nicholas Station;
- 45km on all terrain vehicles across public roads, and
- 44km on the monorail from Kiwiburn to Te Anau Downs on the shore of Lake Te Anau. (29.5km of this is through the DOC estate).

The total length of the experience at 109km is 100km shorter than the comparative road journey from Queenstown to Te Anau Downs, saving approximately 1hr 20min in travel time.

Passengers continuing to Milford Sound would then travel a further 90km by coach on the most spectacular portion of the road journey which includes the Eglinton Valley and the Homer tunnel.

This paper will focus on the monorail component of the journey which will be a world first in terms of length, terrain and remoteness. This paper discusses the challenges and innovative engineering proposed to construct the monorail and mountain bike track through this World Heritage site.

INTRODUCTION

The distance in a straight line from Queenstown to Milford Sound/Piopiotahi is 75km. A number of people travel by air and use this direct route. For those travelling by surface transport the current trip is around 600km return and approximately nine and a half hours of coach travel, resulting in a very busy period around the middle of the day.

Both Central and Local Government have been aware of the need for enhanced access between Queenstown and Milford Sound/Piopiotahi for many years. There have been a series of investigations and reports over the past 30 years that has seen policies aimed at providing improved transportation links between Queenstown and Milford Sound/Piopiotahi.

Riverstone intends to create a high quality tourism experience from Queenstown on Lake Wakatipu to Lake Te Anau. The Fiordland Link Experience (the Experience) will comprise three modes of transport:

- A 20km catamaran crossing of Lake Wakatipu to Mt Nicholas Station;
- 45km on all terrain vehicles across public roads, and
- 44km on the monorail from Kiwiburn to Te Anau Downs on the shore of Lake Te Anau. (29.5km of this is through the DOC estate).

The total length of the experience at 109km is 100km shorter than the comparative road journey from Queenstown to Te Anau Downs, saving approximately 1hr 20min in travel time. Passengers continuing to Milford Sound would then travel a further 90km by coach on the most spectacular portion of the road journey which includes the Eglinton Valley and the Homer tunnel.

The Experience will improve access to Te Anau, Milford Sound, Manapouri, Doubtful Sound and the Southern Scenic Route generally (Mitchell Partnerships Limited, Concession 2009). The monorail will travel along the edge of the South Westland World Heritage Area, which presents both opportunities in terms of tourism and recreation, and challenges in terms of construction and preservation of ecological values of the Area.

A key objective is to develop a unique and sustainable tourism opportunity that attracts domestic and international visitors and thereby makes a significant contribution to economic growth in the Otago, Southland and Fiordland regions while providing environmental benefits of reduced emissions and safety. An additional benefit of the project will be to establish a mountain bike track linking Lake Wakatipu and Lake Te Anau.

A concession application to enable the Experience to be constructed and operated through the land administered by the Department of Conservation was lodged in 2006, and updated to reflect progress in design, construction methodology and effects assessment in October 2009. The department are now considering the proposal.

This paper is intended to:

- Discuss the project drivers and objectives which have lead to the choice of the monorail mode of transport.
- Provide an appreciation of the remoteness of the monorail route and the type of terrain it needs to traverse.
- Outline the work which has been undertaken to develop the engineering required for construction of the monorail.
- Introduce the environmental and engineering challenges and the approach taken to minimise the impact on this world heritage site.

Figure 1 below details the three proposed modes of the Experience, the proposed mountain bike route, as well as the existing coach trip and southern scenic route.

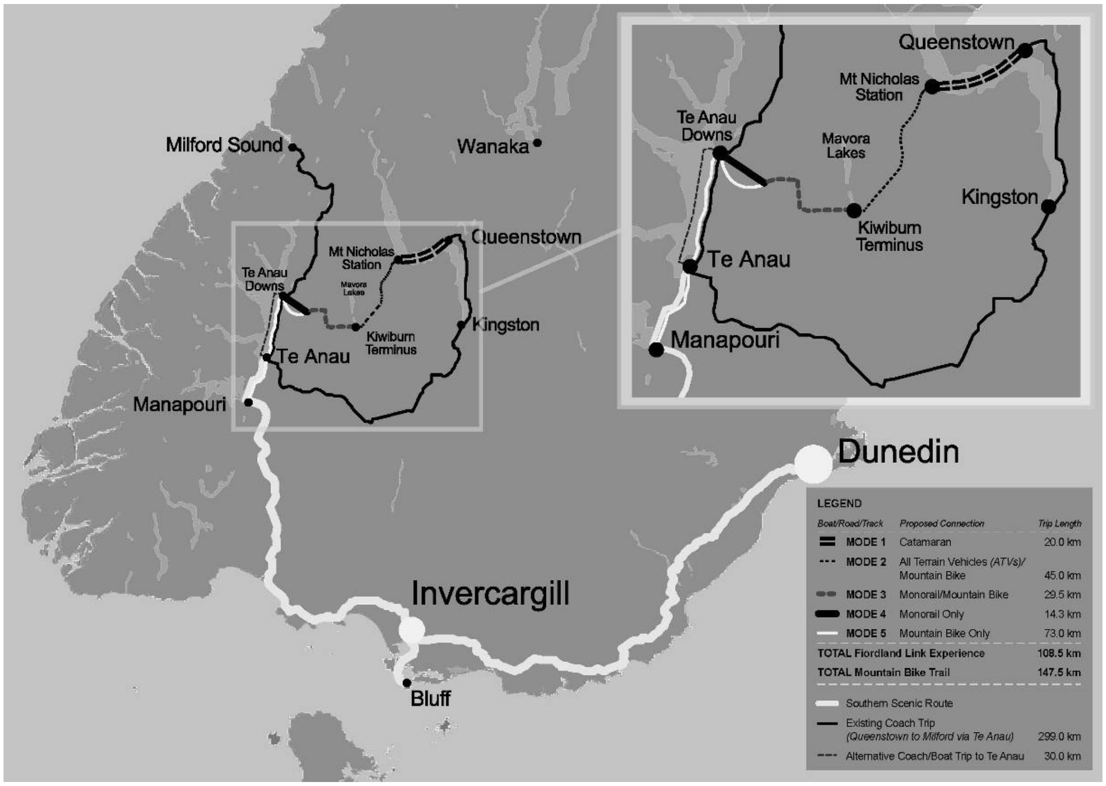

Figure 1: Map depicting the existing and proposed travel modes

PROJECT OBJECTIVES

Regional Benefits for Fiordland

Whilst providing a new and unique tourism experience, the proposal also improves regional transport between Queenstown, Te Anau and other destinations in Fiordland and Southland. Infrastructure investment is important to facilitate the Fiordland economy capturing the growth in nature-based tourism interest from offshore and domestically.

Milford Sound/Piopiotahi

Milford Sound/Piopiotahi is truly an iconic destination and it will continue to attract a very significant proportion of international nature based visitors.

The current return trip from Queenstown by road is a very long day – up to 13 hours, with only marginally more than two hours at destination.

Tourism

New Zealand currently hosts about 2.5M visitors per annum. International tourism is nominally estimated to generate 5% of GDP, with domestic tourism contributing a similar amount. Total visitor expenditure for 2007 was $20.1 billion (Moriarty 2009).

During 2007, 470,000 visitors travelled to Milford Sound, with 95% of these reaching the area by road. The number of visitors to Milford Sound is forecast to grow to 488,000 by 2012. About 18% of all international arrivals to New Zealand visit Milford Sound, and about 30% of people who visit

Queenstown go on to Milford, indicating the widespread appeal of the Milford Sound to visitors in the region.

Recreation

The region is a magnet for New Zealand and overseas based outdoor people who seek opportunities for fishing, walking, tramping and mountain biking. There is an opportunity to improve access for many of these activities.

PROJECT DESCRIPTION

Catamaran – Mode 1

The first sector of the Experience is across Lake Wakatipu from Queenstown to Mt Nicholas Station by catamaran. A medium speed catamaran is particularly suited to this proposal as it can offer speed, comfort and safe handling in a variety of weather conditions.

Figure 2: Catamaran

All Terrain Vehicle – Mode 2

The second sector travels from the lake shore at Mt Nicholas Station up the Von River Valley across the Oreti River Valley and then to the Mararoa River Valley arriving at the Kiwi Burn Terminus.

Figure 3: All Terrain Vehicle

Monorail – Mode 3

The focus of this paper is the third sector from the Kiwi Burn Terminus by monorail in a westerly direction to Te Anau Downs, which is approximately half way up the eastern shoreline of Lake Te Anau.

Figure 4: Monorail

The monorail is an electrically powered vehicle with rubber pneumatic tyres which straddle a concrete riding rail making for a quiet and comfortable journey. This is referred to as ALWEG technology (named after the inventor Dr. Wenner-Gren (**A**xel **L**ennart **WE**nner-**G**ren) which has been used for over 50 years in many countries around the world. The Experience monorail will traverse the most remote and hilly terrain and be longer than any other monorail in the world.

The track used for access during construction of the foundations and piers will become a permanent mountain bike track.

The Three Lakes Ride

Riverstone plans to establish a mountain bike route which will link Lake Wakatipu, Kiwi Burn, Te Anau Downs, and on to Te Anau and Lake Manapouri. Called “The Three Lakes Ride”, this track is in line with the Government’s current thrust for the establishment of mountain biking opportunities around the Country, and meets the Department of Conservation’s Statement of Intent objectives.

FULFILLING OBJECTIVES

The Experience is expected to be an attractive and enhanced alternative to the coach trip for a good portion of the Queenstown based visitors. The shorter distance (100km) and transit time (saving 1 hour 20 mins in each direction) of the Experience will assist by increasing the hours of operation available, smoothing peak visitor flows and reducing the probability of a degraded visitor experience at Milford resulting from congestion.

There will be an environmental benefit in CO_2 emissions, by reducing the overall distance and using electricity (likely to be from renewable generation) rather than fossil fuelled vehicles, and improved road safety outcomes for all those visitors who choose to travel on the Experience rather than by road. (Moriarty 2009).

The size of the investment required by the project is underpinned by the visitor flow to Milford Sound. The project becomes feasible because it can attract a share of the circa 500,000 visitors who travel to Milford Sound each year, providing a sustainable conservation based solution to growing Fiordland tourism numbers.

The Experience provides the connecting access between the Queenstown Lakes and the Fiordland Lakes to deliver a multi-day mountain bike ride opportunity incorporating five lakes and six rivers.

THE MONORAIL ENVELOPE

A 200m wide easement is being sought for the monorail route. This width would accommodate the monorail and the construction/mountain bike track, and has been proposed for the following reasons:

- To provide a visual and experiential separation from the monorail, expected to be 70-80m in flat terrain.
- The mountain bike track could be on either side of the monorail, but is intended to be on the uphill side in sloping terrain.
- To provide flexibility to suit topographic features, such as streams, gullies, steep banks etc.

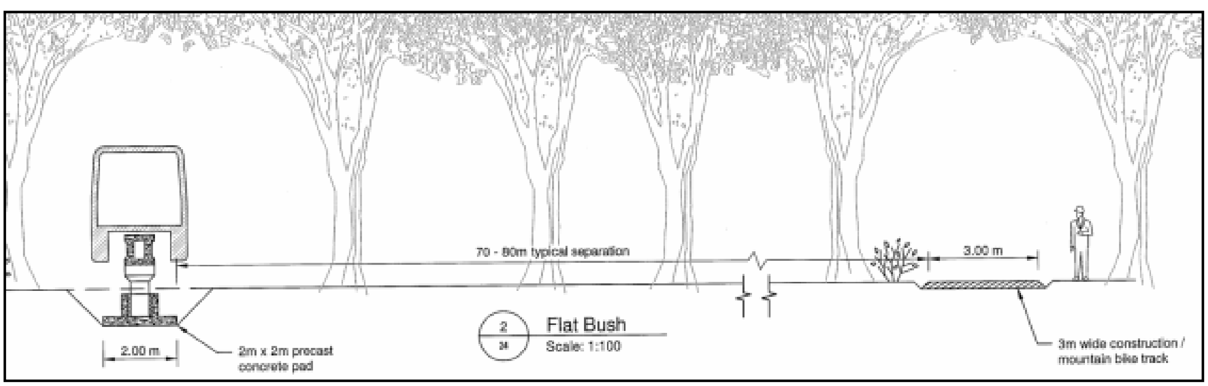

Figure 5: Cross section in 'Flat Bush'

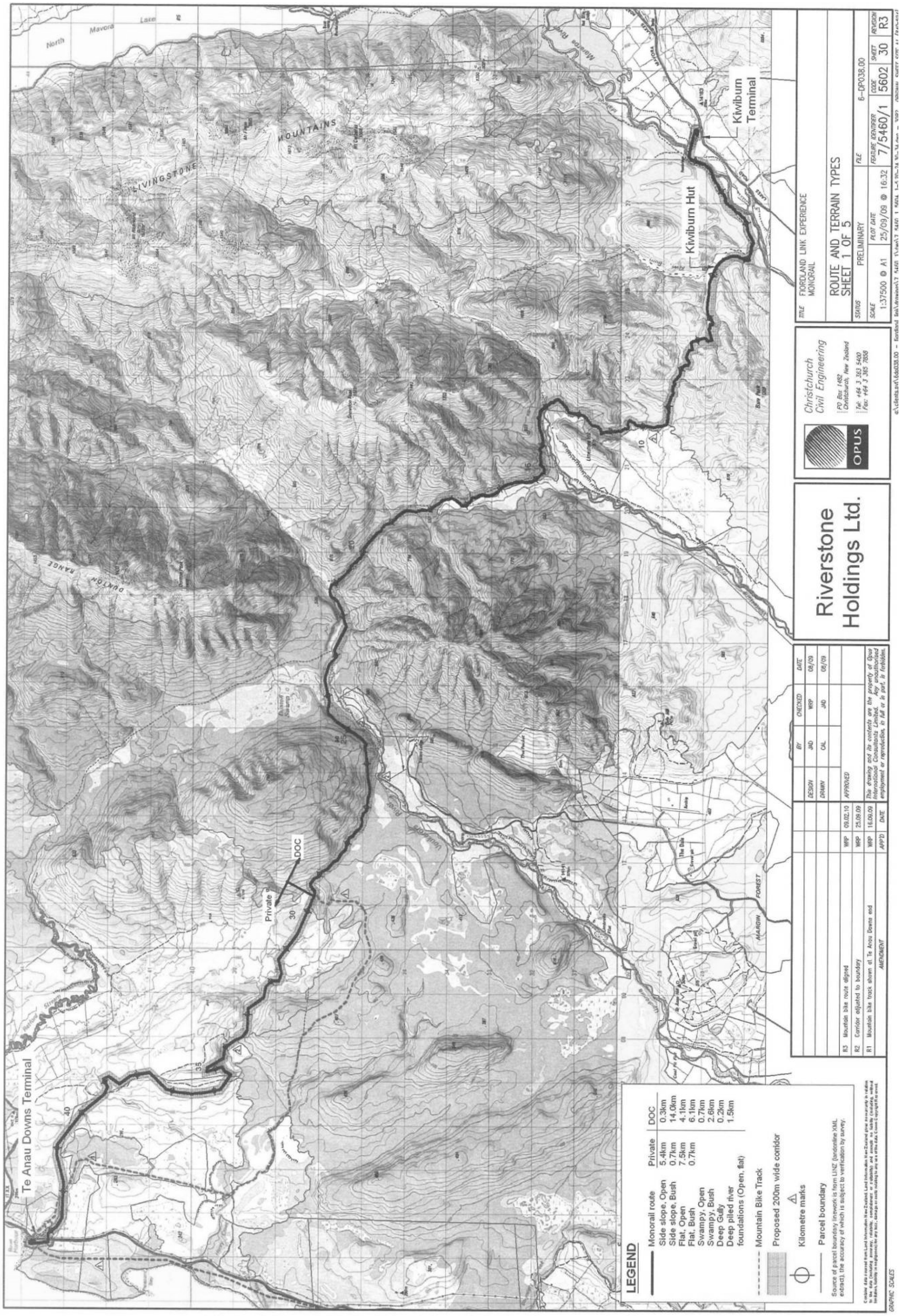

Figure 6: Route map for Monorail – Mode 3

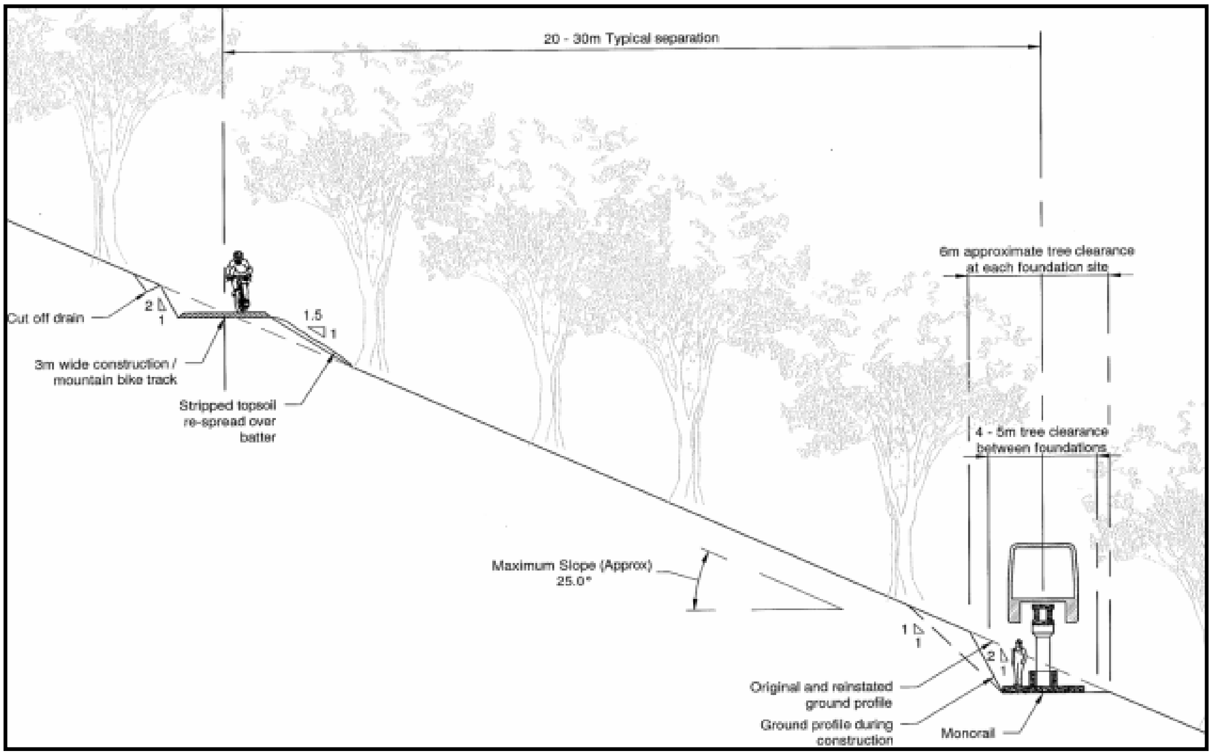

Figure 7: Cross section in side slope terrain

When a more detailed ground model is available, a three dimensional monorail alignment can be fitted to the ground. We note that the monorail will have geometric constraints such as minimum radii for curves and maximum grade.

Construction/Mountain Bike Track

The construction/mountain bike track can be located to avoid trees, minimise impact on vegetation and to take advantage of the topography to minimise earthworks. It is envisaged that the construction track would become a permanent mountain bike track at completion. The 3m wide mountain bike track would also be located to provide a visual separation from the monorail.

A number of 3m wide spur tracks would be required to gain access to the monorail during construction of foundations and piers. It is envisaged that one spur track would provide access to a number of foundations (10-15) that can be constructed linearly (i.e. from the farthest foundation back) without affecting overall project progress.

The route for the construction/MTB track and the spur tracks would be selected to ensure that there is always a significant barrier of bush visible from the monorail train (i.e. there is no view straight down a track or route). The junction points where the spur tracks meet the monorail route would double as passing bays and be located to minimise bush clearance.

The construction track would be located to suit the topography and cross streams at the most advantageous location (e.g. where the stream is at its narrowest or the banks highest) reducing or eliminating the impact on the environment. At stream crossings, the main track or spur track would make use of light bridging units spanning bank to bank, thereby minimising disturbance to the stream stream itself. At the major rivers, permanent lightweight bridges will be required for mountain bikes.

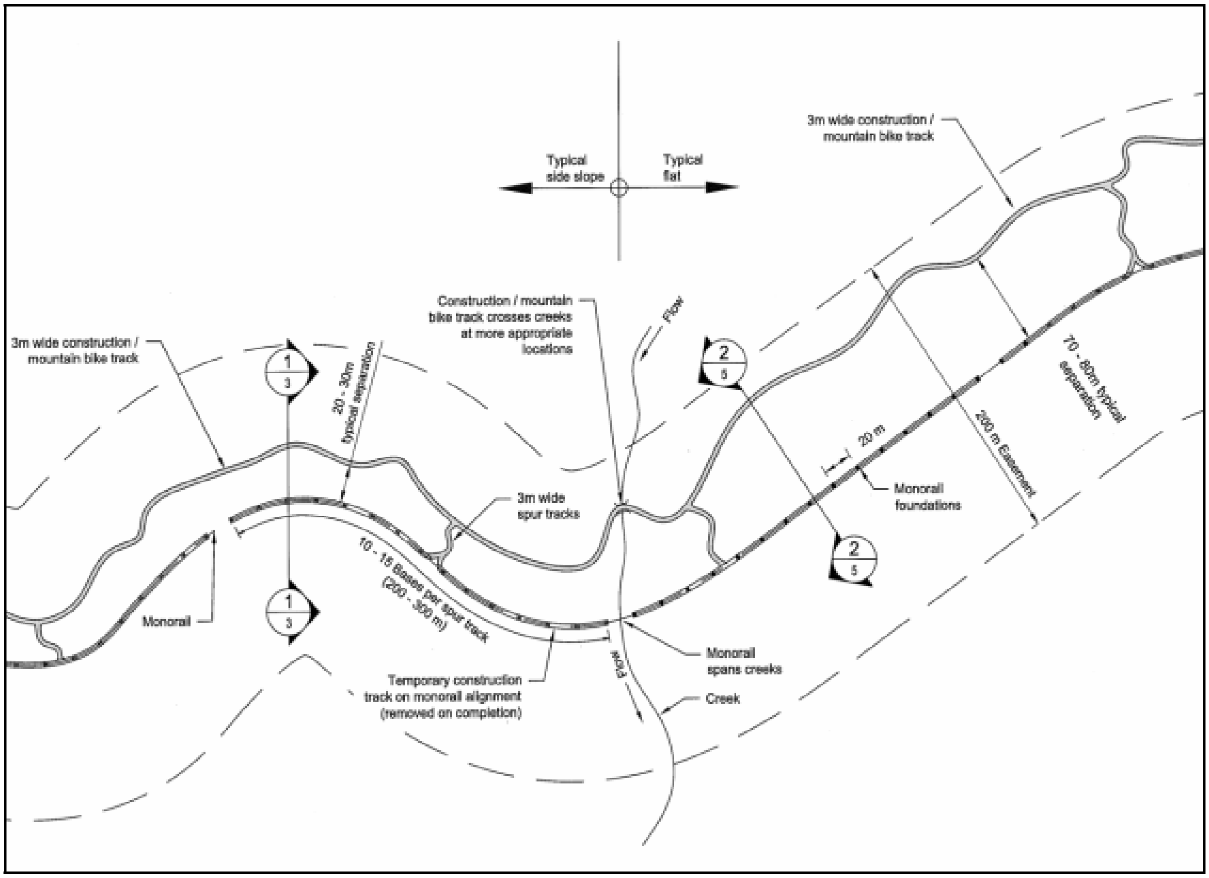

Figure 8: Indicative layout of monorail and mountain bike track

Future Maintenance/Access

Both the monorail corridor and the mountain bike track will require maintenance. It is anticipated that inspection of the corridor will occur daily because of operational safety considerations and any maintenance required will be monitored. It is anticipated that this maintenance would be carried out from rail mounted equipment. The mountain bike track will require periodic maintenance for clearing fallen trees, maintaining culverts and periodic metalling of the track surface. The mountain bike track could provide emergency access if required.

ECOLOGY

The route passes through Snowdon Forest Conservation Area (46,750ha) which is part of the South West New Zealand World Heritage Area (Mitchell Partnerships Limited, Ecology 2009). The Te Anau Downs terminus will be located at the site of the existing Fiordland National Park Lodge, which is the only part of the route which is located in National Park.[1]

[1] The Fiordland National Park

Threatened plants

Only two threatened plants (the yellow mistletoe, *Alepis flavida* and *Kirkianella novae-zelandiae*) have been identified along the proposed monorail route. Coprosma wallii has been identified on the cycle link route. The possibility exists that other rare plants are present but remain undetected (because of their rarity) along the route.

Fauna

Forest birds showed an east-west trend with greatest richness in the west. The most important forests for bird habitat were considered to be the tall red beech dominated forest occurring near Dunton Swamp although the shorter mountain beech forest was good habitat for rifleman (*Acanthisitta chloris*) and perhaps robins (*Petroica australis*). Twenty nine species of bird were heard during May 2009 surveys, and an additional 14 were detected during spring surveys carried out in November 2009. A total of 46 bird species is expected to occur in the vicinity of the route.

Long-tailed bats (*Chalinolobus tuberculatus*) and Green Skink were detected in the Spring 2009 survey. Short-tailed bats (*Mystacina tuberculata*) and other lizards may be present in suitable habitat along the monorail route.

Evidence of introduced pests (particularly deer (*Cervus elaphus*) and pigs (*Sus scrofa*) is common along the route. The goal of the Regional Pest Management Strategy is to suppress these pests so that impacts on the community and the environment are minimised.

Habitats

Parts of the route are of international importance which is recognised in the World Heritage status of the site. Habitats along the route of particular importance are:

- Tall red beech forest;
- Red tussock;
- Low altitude wetlands, and
- Mature Matagouri and bog pine shrubland.

The route has been modified to avoid some important habitats such as Dunton Swamp and further development of the route will aim to avoid significant habitats.

Mitigation

The mitigation of adverse effects arising from the loss of vegetation and habitat will involve:

- Minimising the project footprint;
- Avoidance of large trees where possible because of their importance in providing nesting sites and feeding habitat, including avoidance of bat roost trees in particular;
- Rehabilitating areas as quickly as possible after completion;
- Minimising the potential for weeds to invade the route line;
- Minimising the potential for predators to increase their use of this area, and

Figure 9: Artists cross section of completed monorail

- An intensive predator control programme in the Eglinton Valley to offset the loss of indigenous vegetation and habitat along the route.

Aquatic Ecology

The headwater catchments of the upper Waiau system are relatively pristine and provide a variety of habitats for aquatic life (NIWA 2009b). The greatest potential for the monorail to have effects on aquatic ecosystems will be during the construction phase. These effects include:

- Release of sediments into waterways, having an effect on the population of fish, invertebrates and especially periphyton.
- Removal of canopy from forested streams having effects as above but for a longer duration as the canopy recovers.
- Run off of other pollutants such as liquid fuels or raw cement into waterways.

Operational Effects

Movement of machinery or personnel from the didymo affected main stems of the Mararoa, Whitestone and Upukerora Rivers to the presumably unaffected tributaries carries the risk of transferring live didymo cells. The provision of bridges across all streams will minimise the risk.

Mitigation

During construction, methods will be employed to mitigate any potential adverse effects arising from the construction of the monorail in the bed of rivers or elsewhere around water bodies. Cleaning of equipment will also be necessary to ensure that no pest species, including didymo, are introduced to the water bodies along the route.

WHY MONORAIL?

The monorail mode is preferred over other options such as light rail or road. Factors such as its lower environmental impact due to smaller footprint, lack of substantial earthworks, mode of power and noise levels make it an attractive option for the route selected. Low operating costs, viewing quality and marketing appeal further support its selection.

Figure 10: Osaka Monorail

The rubber tyred monorail allows grades of up to 6.5% or 1:15. The spacing between beams can be varied to suit foundation, topography and alignment conditions.

Natural undulations and variability in pier height (thus track height), will allow easy movement of wildlife, people, bicycles, rivers, creeks and stock. Pre-cast beams and piers minimise on-site fabrication.

Riverstone has investigated a suspended (where the train hangs from an overhead rail) rather than straddle monorail (as shown in figures 10,11,12,13&15) and evaluated cableways and a number of hybrid systems. The conclusions were that to be cost effective the solution could be either:

- a monorail beam supporting a straddle monorail just above the ground, or
- a conventional steel two-rail system on sleepers bearing continuously on the ground.

Conventional and light rail systems have steel wheels on steel rails which limit grades to 2.5% (1:40). This limitation means a rail system cannot climb the high points on the proposed route.

Other limitations are:

- a significantly wider disturbed width of operating corridor;
- more extensive cuttings and embankments;
- rail replacement every 15 years approx, and
- labour intensive maintenance.

Figure 11: Las Vegas Monorail

ALWEG straddle monorail systems are in use around the world on the Osaka, Las Vegas, Seattle and Kuala Lumpur Monorails (refer to figures 10,11,12,13&15) and are manufactured by Bombardier and Hitachi.

Indicative information based on this technology for the Experience Monorail follows:

Capacity	160-224 pax
Length	68m typically for 160 pax
Speed (max)	90km/h @ 4% grade
Speed (average)	75km/h
Distance	43.8kms
Travel time	33 minutes
Maximum grade	6.5% (1:15.4)
Turning	30m radius at 15km/h
Vehicle Height	2.4m above rail
Vehicle Width	2.4m - 2.6m
Power	1000kVA at 11000 volts


Figure 12: Seattle Monorail

ROUTE CHALLENGES/CONSIDERATIONS

Tree Fall

The risk of a Beech Tree falling onto the monorail beam needs to be managed, and a number of measures will be considered such as: establishing a process for identification, assessment and management of falling risk trees; developing contingency plans, such as beam repair or replacement and operational systems, for example remote detection and/or visual checking of the route on a daily basis. Tree clearance will be required on the monorail alignment to provide a safe operating envelope for the trains. A minimum width between trees of 4-6m is proposed.

Survey

Survey undertaken to date has been with a range of GPS techniques, however the efficiency of GPS is limited by the forest cover. It is likely that the aerial technique ‘Light Detection And Ranging’ (LiDAR), a system using laser pulses would be the next step, which is expected to penetrate the Beech Forest canopy to define the ground surface.

Geotechnical Conditions

The majority of the route crosses outwash gravels with the only rock outcropping at the Mararoa River near the Kiwiburn terminus. The flatter areas of the route appear to have more of the finer grained soils near the surface, for instance in the Kiwiburn, Whitestone and Upukerora Rivers. These flatter areas often have poor drainage. The presence of water near the surface will make foundation construction more difficult, although this will be mitigated by using short driven piles.

An initial review of slope stability in the area has shown that the route is generally not subject to instability. There are only isolated slope stability issues along the proposed monorail route. These can readily be avoided by selecting the detailed alignment and pier location to clear these features.

The monorail route also crosses concealed seismic fault traces which are not considered to be active. The effect of these faults has not been investigated in detail but a preliminary seismic assessment indicates that ground shaking associated with these faults will be less severe than that of the alpine fault which is approximately 70km distant.

Figure 13: ALWEG running gear

Monorail Geometric Alignment

A key aspect in defining the alignment is the capability of the monorail train, especially in terms of grade, radius, super elevation and associated speed, warp rate etc. Information has been sought and obtained from a number of monorail manufacturers to guide selection of the preliminary route, more detailed information will be required to progress design of the geometric alignment.

River Crossings

Rivers along the monorail route consist of semi-braided alluvial channels, some with relatively wide flood plains. Piling for the complete width of the active flood channel is proposed to guard against scouring of shallow foundations. It is likely that deeper pad type foundations could be utilised in areas of the flood plain not susceptible to scour following further investigation.

At river crossings it may be preferable to have longer span beams to reduce the number of piers within the active river channel. Construction of these spans could be carried out using two rough terrain cranes where access permits.

Foundation Design and Construction

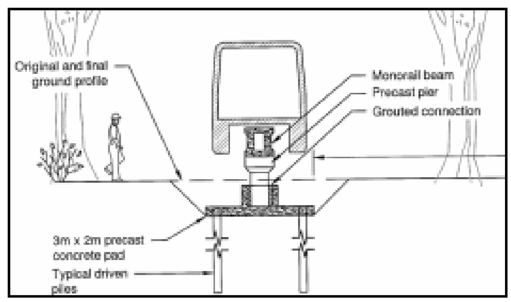

Figure 14: Precast Foundations with driven piles in 'Swampy Bush' terrain

Three foundation types are proposed. These consist of bored piles, precast pads and precast pads supported by driven piles. Precast foundations are preferred as they minimise the amount of work on site, and hence plant and labour requirements are reduced. The foundations would be precast in sizes which allow ease of handling and assembly by small plant on site. There is also no need for concrete mixing on site with the associated water requirements and waste materials. With the exception of the rivers, precast pads would be used in all areas where suitable, with the addition of driven piles in wet and/or soft ground conditions.

The design has focussed on minimising environmental impact by reducing the track width and tree clearance, and the use of efficient precast concrete components in sizes that can be handled by small plant which also reduces root damage.

Piers

The proposed precast concrete piers would be designed for a range of heights to suit the monorail alignment. At this stage it is intended that the piers would be grouted into the precast concrete foundation pads.

The supporting pier cross-section would be approximately 500mm square. The piers will generally be at 20m intervals.

Figure 15: Kuala Lumpur Monorail. Note electrical 'pick up' rail in the foreground on left.

Monorail Beam

The proposed rail beam system is prestressed concrete box beams (0.8mx1.0m deep approx) spanning 20m between piers, with an allowance for steel beams on longer spans or in areas of tight curvature. The final running surface will influence ride comfort so tolerances are important.

The top of the rail would be generally one to two metres above the ground. This height would be varied up to six metres above ground level to provide a consistent grade, span waterways and environmentally sensitive areas, allow vehicular or pedestrian access and avoid earthworks along the rail route.

CONSTRUCTION METHODOLOGY

Construction Environment Management

An overall construction environment management plan will be developed for the project. A key component of this plan will be management of erosion and sediment control. The methods adopted will be developed during the design and construction phases and be specific to each situation. Some of the methods we envisage include diversion channels/bunds, contour drains, sediment retention ponds, grit traps and silt fences.

Depots & Accesses

Three main construction depots along the route are proposed as follows:

- across the Mararoa River from a farm near the Kiwiburn valley;
- in the Whitestone River Valley, and
- near the bush edge at the end of Retford Road

Each depot would be expected to have:

- laydown areas for components i.e. beams, piers & precast foundations;
- fuel storage and maintenance facilities;
- kitchen, toilets, showers, cafeteria, site offices, and
- vehicle wash stations.

It is anticipated that all precast items, including beams, piers and foundation pads would be precast off site. Components would then be transported to the depots by truck and trailer.

Existing roads, farm access roads and access tracks to the depots (and beyond in some locations) would be used where possible and all these roads will need to be upgraded to enable truck and trailer units to access the site depots.

Construction Sequence

A 30 month programme has been developed on the basis that the construction of the foundations and piers is independent of the erection of the monorail beams. The main reason for this is that construction of foundations is by its very nature uncertain, therefore the likelihood of delay during foundation construction is very much greater than during erection of prefabricated superstructure components. By separating these activities, any problems during foundation construction do not have a direct effect on the erection programme.

Foundation and Pier Construction

The methodology has been developed to minimise environmental impact yet provide an efficient construction operation, and the type of equipment proposed is therefore very light, manoeuvrable and compact for an infrastructure project of this scale.

Construction equipment is expected to include 12 tonne excavators (including a pile driving attachment), 4WD trucks, 4WD utilities, a fuel bowser, an air compressor, a 10 tonne Hiab for bringing in precast foundations, a tracked or possibly 4WD Hiab for difficult terrain and 4WD grouting equipped utility vehicles.

Where river foundations are required a 35 tonne piling rig, flat bed truck with reinforcing cage and concrete trucks will also be required. Where the heavier river piling gear is required no tree clearance is required and access and is generally available via existing tracks.

Multiple teams each with 2-5 people would be required to undertake tasks as follows:

- Survey – the survey teams would peg out the route for clearance and undertake detailed survey for the location of foundations and piers and for design and construction of the beams.
- Tree Clearance/transplantation – these teams would clear vegetation along the marked route and remove the vegetation from the route. This may involve salvage of materials or plants to be used in rehabilitation.
- Construction Track/Erosion and Sediment control – these teams would clear topsoil for later re-use, install drainage and sediment control measures and construct a metalled construction/mountain bike track.
- Excavation and placement of pad foundations and pier and backfilling – these teams would excavate each foundation, place the foundations and grout the pier in place. The foundation would then be backfilled with excavated material and rehabilitated. Where required a pile driving attachment to the excavator would be used to drive the short piles.
- Piling of river foundations – these teams would access and construct each piled foundation in rivers where necessary.

Erection of Monorail Beams

Once the piers have been erected, the beams can be installed with a launching gantry without any need for cranes operation from the ground. Beams would be placed using the gantry operating from the section of monorail beam already completed. One gantry would operate from each depot, therefore 3 or 4 gantries would be required. Beams would be brought in on a jinker operating on the completed monorail beam from the construction depot.

Monorail Running Surface

There are several options to complete the final running surface to provide the required ride comfort. Allowance has been made for the site work required.

Rehabilitation

We anticipate removal of the temporary construction track on the monorail alignment and the erosion & sediment control measures. Rehabilitation & restoration will be further developed and implemented in conjunction with DoC. Resources and equipment will be the same as that used for the foundation and pier construction.

CONCLUSIONS

The Experience would provide environmental and safety benefits of reduced road travel and substitution of fossil fuelled vehicles with the electric monorail. It will also reduce congestion in Milford Sound during the middle of the day, and enhance Fiordland's tourist market share.

The monorail will enable those who would not otherwise have the opportunity to experience the beauty of the Snowdon Forest area to do so, in a controlled, comfortable way.

Design and construction of a monorail on the proposed route through the DoC land is feasible. Initial information obtained from monorail suppliers indicates that the grades and curves required for the proposed route can be achieved by a conventional monorail train.

The construction track which runs parallel to the monorail and will become a mountain bike track minimises the environmental impact of construction while providing an efficient means of constructing foundations and piers for the monorail.

The mountain bike track will provide opportunities for tourism and recreation.

Precast concrete pad foundations and piers are proposed wherever practicable to minimise site work and environmental impact. Deep reinforced concrete piles will be required for crossing the active flood channel of the three main rivers.

Initial contractor involvement in the development of the preliminary design and construction methodology has shown that a 30 month programme is challenging but achievable.

The majority of adverse environmental effects will be during the construction of the monorail, such as effects on terrestrial and aquatic ecology. A construction management plan would put in place robust measures to ensure adverse effects do not exceed acceptable levels. The establishment of, and contribution to, a predator control programme will form environmental off set to the loss of habitat.

An innovative approach has been developed to minimise the environmental impact of constructing a monorail through this world heritage site, which will be a world first in terms of its length, terrain and remoteness. Long term the monorail and mountain bike track will provide significant economic, environmental and recreational benefits.

REFERENCES

Mitchell Partnerships Limited, Ecology 2009. Terrestrial Ecology of the Proposed Fiordland Monorail Route. Mitchell Partnerships Limited. Auckland.

Mitchell Partnerships Limited, Concession 2009. Fiordland Link Experience Department of Conservation Concession Application. Mitchell Partnerships Limited. Dunedin.

Mitchell Partnerships Limited, Ecology 2010, Spring Survey Report for Proposed Fiordland Link Experience Monorail Route, Mitchell Partnerships Limited. Auckland.

Mitchell Partnerships Limited, Cycle Linik 2010, Terrestrial Ecology of the Proposed Fiordland Link Experience, Mitchell Partnerships Limited. Auckland.

Moriarty, J.P. 2009. Fiordland Link Experience. A Tourism Assessment. J & H Moriarty Limited. Dunedin.

NIWA 2009b. Assessment of the potential effects of the Fiordland Link Experience monorail on aquatic ecology. NIWA Client report CHC2009:129.

Opus International Consultants Limited. 2009. Fiordland Link Experience Preliminary Engineering Assessment of Monorail Proposal. Opus Christchurch.

ACKNOWLEDGEMENTS

Acknowledgement should be made to the Riverstone project team which includes specialists in ecology and planning (Mitchell Partnerships Ltd), noise (Marshall Day), recreation (Rob Greenaway), freshwater ecology and geomorphology (NIWA), tourism (Moriarty), traffic (Traffic Design Group) and landscape (Stephen Brown Landscapes). Special thanks go to Ian Stewart who has contributed a wealth of knowledge from his involvement in this project for over 20 years. The Opus inputs are the result of team work by Noel Band (HEB Construction), John Davies, John Reynolds, and Jeremy Waldin.