vector

VECTOR Optimised Deprival Valuation
For The Year Ending 31 March 1999

Audit Report

31August, 1999

Summary

This report details the methodologies and assumptions used to calculate the Optimised Deprival Value of the VECTOR Network as at 31 March 1999.

The 1998/99 valuation is based on the valuation performed in 1997/98. Standard lives and standard replacement costs are based on those specified in the April, 1999 release of the Ministry of Commerce ODV Handbook. In addition to this, appropriate changes have been made to update the asset information to 31 March 1998. These changes consisted of;

1. an update of the asset databases to reflect the new equipment added and the old equipment removed from the network,
2. a revision of the subtransmission network optimisation,
3. a further year of depreciation.

The asset databases containing records of all the equipment installed on the VECTOR network were revised by the inclusion of the new assets put in place, and the exclusion of existing assets removed from service during the 1997/98 financial year.

The revision of the subtransmission optimisation took into account the recommended planning horizon of 10 years from the Ministry of Commerce ODV Handbook and the latest VECTOR load forecasts. The optimisation methodology was reviewed and revised this year. Full details on the approach are given in appendix C.

The economic value calculations were not repeated for 1998/99. The reduction for Orere Point from its optimised depreciated replacement cost to its economic value has been included at its 1997/98 value. This reduction is not material in relation to the overall value.

The ODV for the VECTOR network as at 31 March 1999 was calculated to be **$710,138,809**. A breakdown of this figure into the various equipment categories is given on the following page.

Network Valuation for Year Ending 31 March 1999

Equipment	Existing Valuation		Optimised Valuation	
	Replacement Value	Depreciated Value	Replacement Value	Depreciated Value
Transformer	76,816,790	38,257,968	74,421,003	36,820,935
Switchgear	44,778,920	26,379,172	41,860,400	24,466,947
Cable	133,308,308	72,205,155	123,709,037	67,165,833
Line	15,425,966	11,636,475	15,425,966	11,636,475
Submarine Cable	4,263,709	2,447,012	4,263,709	2,447,012
Building	45,430,000	19,935,575	40,271,000	17,751,342
Land	19,743,000	19,743,000	17,708,000	17,708,000
Unused Land	0	0	2,035,000	2,035,000
Miscellaneous	12,519,638	8,958,394	11,585,729	8,238,498
A. Subtransmission Total	**352,286,332**	**199,592,751**	**331,279,844**	**188,300,041**
Ripple Plant	14,053,498	10,481,568	14,053,498	10,481,568
Communications Plant	3,858,000	1,568,200	3,858,000	1,568,200
Communication Cables	20,429,271	10,668,242	11,300,705	7,351,800
B. Communications Total	**38,340,768**	**22,718,010**	**29,212,203**	**19,401,568**
Transformer	94,982,884	63,990,334	94,982,884	63,990,334
Transformer Housing	27,396,200	17,354,220	27,396,200	17,354,220
Switchgear	48,867,088	29,928,790	48,867,088	29,928,790
HV Cables	336,024,614	230,217,496	351,713,075	238,390,627
HV Lines	39,547,500	16,305,293	39,547,500	16,305,293
LV Cables	120,764,911	89,148,250	120,764,911	89,148,250
LV Lines	34,383,426	12,111,939	34,383,426	12,111,939
Pillars	28,638,714	22,150,380	28,638,714	22,150,380
Services	19,721,910	13,003,915	19,721,910	13,003,915
Streetlighting	1,289,947	803,199	1,289,947	803,199
C. Distribution Total	**751,617,193**	**495,013,816**	**767,305,654**	**503,186,946**
Total (A+B+C)	**1,142,244,293**	**717,324,577**	**1,127,797,701**	**710,888,555**
Less Reduction from ORDC to EV for Orere Point				749,746
VECTOR ODV				**710,138,809**

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Existing Subtransmission Network

The subtransmission network consists of all the assets involved in the high voltage transmission of electricity. These assets are the cables from the Transpower points of supply to the VECTOR zone substations, the transformers and switchgear at the zone substations and the buildings that house them.

In the existing subtransmission network, VECTOR owns three 110 kV point of supply substations, two dedicated substations at Pacific Steel and Lichfield, and 45 zone substations. Apart from Lichfield, all of these substations are in the Auckland and Manukau areas and are supplied from eight Transpower points of supply. The three 110 kV points of supply and 45 zone substations are listed in Table 2 and are sorted according to their Transpower points of supply. Pacific Steel is fed from the Transpower Mangere substation at 110 kV and, as it is a dedicated substation, it has not been included in the table. A pictorial representation of the existing subtransmission network is given in Appendix B.

Transpower Point Of Supply	Supply Voltage	VECTOR Substation	Distribution Voltage
Penrose	22 kV	Glen Innes	11 kV
		Newmarket	11 kV
		Onehunga	11 kV
		Remuera	11 kV
		Westfield	11 kV
Penrose	33 kV	Carbine	11 kV
		Drive	11 kV
		McNab	11 kV
		Mt Wellington	11 kV
		Orakei	11 kV
		Rockfield	11 kV
		St Heliers	11 kV
		Te Papapa	11 kV
Penrose	110 kV	Quay *	22 kV
Quay *	22 kV	Hobson	11 kV
		Parnell	11 kV
		Quay	11 kV
Roskill	22 kV	Avondale	11 kV
		Mt Albert	11 kV
		Sandringham	11 kV
		White Swan	11 kV
Roskill	110 kV	Kingsland *	22 kV
		Liverpool *	22 kV
Kingsland *	22 kV	Balmoral	11 kV
		Chevalier	6.6 kV
		Freemans Bay	6.6 kV
		Kingsland	6.6 kV
		Ponsonby	6.6 kV
Liverpool *	22 kV	Liverpool	11 kV
		Newton	11 kV
		Victoria	11 kV
Hepburn Rd	33 kV	Rosebank	11 kV
Pakuranga	33 kV	Greenmount	11 kV
		Howick	11 kV
		Pakuranga	11 kV
		South Howick	11 kV
Otahuhu	22 kV	Bairds	11 kV
		Otara	11 kV

Transpower Point Of Supply	Supply Voltage	VECTOR Substation	Distribution Voltage
Mangere	33 kV	Hans	11 kV
		Mangere Central	11 kV
		Mangere East	11 kV
Wiri	33 kV	Manukau	11 kV
		Wiri	11 kV
Takanini	33 kV	Manurewa	11 kV
		Maraetai	11 kV
		Waiheke	11kV
		Papakura	11 kV
		Takanini	11 kV

* VECTOR owned Point Of Supply

Table 2 - Existing Subtransmission Network

Optimised Subtransmission Network

The aim of optimising the subtransmission network is to ensure that the assets used by the line business are appropriate to the requirements placed on them. Therefore, the optimisation process involves reviewing the rating, configuration, design and materials used in the existing network. The optimisation can effectively be considered to be in two parts, the network optimisation and the equipment optimisation.

This year the optimisation process was reviewed and revised. The process covers the following steps,

1. Determine the requirements placed on existing equipment
2. Determine the standard asset base to be used in the optimised network
3. Optimise the network by combining neighbouring zone substations, subject to economic and technical viability
4. Optimise the equipment and configurations at each zone substation

Details of the specific steps and results of the optimisation are given in Appendix C.

Subtransmission Network Valuation

The valuation of the subtransmission network for 1998/99 used the same methodology as was used in previous valuations. This methodology involved valuing the equipment in each substation according to its asset category and depreciating it using a straight line method with no salvage value. Where substation combinations had taken place in the optimisation, the asset ages for the existing equipment were weighted to give an average age for the optimised equipment.

A schedule of standard replacement costs was used to value all subtransmission equipment. The schedule contained in the ODV Handbook only gave a replacement cost for 33kV 20MVA subtransmission cables. The values for all other sizes of cable were determined from manufacturer and external contractor quotations. No other standard replacement costs were specified for the other categories of subtransmission equipment so these were valued based on quotations supplied by manufacturers and contractors. These quotations included labour, design and project management costs.

As allowed for in clauses B14 and B15 of the ODV Handbook, multiplying factors have been applied to 33kV cable costs. Details of how these multiplying factors were determined and applied is given in Appendix D.

The standard asset lives assigned to subtransmission equipment are those specified in the ODV Handbook. The standard life for switchgear was extended, in accordance with clause B43, to 47.7 years. The justification for this life extension is given in Appendix E.

The specific quantities and locations of equipment installed and removed from the network during the 1998/99nancial year are given in Appendix A.

The following sections detail the different asset categories and note particular methods or parameters associated with the valuation of the category. This also includes the method of calculating the weighted average age of equipment at combined substations.

Transformers

In the optimised network valuation, the transformers at each of the optimised substations were depreciated using the weighted average age of the transformers at each of the combined substations. This weighting was based on the existing transformer MVA capacity.

For example, if two substations were combined with substation A having 20 year old 17 MVA transformers and substation B having 14 year old 12 MVA transformers, then the combined substation transformer age would be:

$$\text{Weighted average age} = \frac{(20\text{ yrs} * 17\text{ MVA} + 14\text{ yrs} * 12\text{ MVA})}{(17\text{ MVA} + 12\text{ MVA})}$$

$$= 17.5\text{ years old}$$

The zone substations were assumed to have either standard 15 MVA or standard 20 MVA transformers so that standard costs could be used. The standard costs included the costs involved in the transformer installation and each transformer was assigned a standard life of 45 years.

Switchgear

In the optimised network valuation, the number of switchgear panels at each substation was based on the number of transformers. It was assumed that there are six panels per transformer and one less bus coupler than there are transformers. Therefore, for a substation with n transformers, the number of panels is n * 6 + (n-1). Thus, for a substation with three transformers there would be 3 * 6 + 2 = 20 panels.

The switchgear panels were assigned a standard life of 47.7 years and for the optimised network valuation, the age of the panels was taken as the weighted average age of the panels in each of the combined substations. This weighting was based on the number of panels.

For example, if two substations were combined with substation A having 21 panels of 15 years old and substation B having 12 panels of 9 years old, then the combined substation cable age would be:

$$\text{Weighted average age} = \frac{(15\text{ yrs} * 21\text{ panels} + 9\text{ yrs} * 12\text{ panels})}{(21\text{ panels} + 12\text{ panels})}$$

$$= 12.8\text{ years old}$$

The standard costs used for the valuation included the costs involved in the installation of the switchgear panels.

Cables

In the optimised network valuation, the length of cable to any optimised substation was assumed to be equal to the length of cable from the Transpower point of supply to the existing substation. This was the case irrespective of any substation combinations as it was assumed that these were the optimal routes for the cables, given the physical and political environment. The optimised substation was sited at the substation that was closest to its Transpower point of supply to minimise the subtransmission cable length. The rating and number of cables was assumed to be equal to the rating and number of transformers at the optimised substation. The age of the cables was the weighted average age of the cables to each of the combined substations. This weighting was based on the existing cable lengths.

> For example, if two substations are combined with substation A being supplied by 1352 metres of 13 year old cables and substation B being supplied by 1019 metres of 21 year old cables, then the combined substation cable ages would be:

$$\text{Weighted average age} = \frac{(13\text{ yrs} * 1352\text{ m} + 21\text{ yrs} * 1019\text{ m})}{(1352\text{ m} + 1019\text{ m})}$$
$$= 16.4\text{ years old}$$

The standard costs used in the valuation separate the cost of the cable and cost of the installation and the cables have a standard life of 70 years. This standard life was chosen because as only 2% of VECTOR's subtransmission cables are XLPE.

Land

The land associated with each zone substation was valued using the Government Valuations. These are based on the last valuations made in September 1997. In the optimised network, land for the substations that were combined is placed under the unused land category so it still appears in the overall network valuation. As the land is not depreciated, the replacement value and depreciated value are equal.

Buildings

Each substation building was valued using standard costs based on the number of transformer bays. Spare transformer bays were not included in the optimisation so the number of transformer bays is the same as the number of transformers.

In the optimised network valuation, the age of the optimised building was taken as the average age of the buildings at each of the combined substations. The average age of the optimised building was not weighted in any way and each building was assigned a standard life of 40 years.

Miscellaneous

Each substation had a series of miscellaneous items attributed to it. These consisted of;

> HV cabling between the transformer and the switchgear panels
> Standby batteries
> Pilot panel and installation
> Protection at the Transpower point of supply

LV switchboard
Oil containment tanks

A standard life was assigned to each group of miscellaneous items of 40 years and the age of the group was the average of the ages of the transformer and the switchgear. The miscellaneous items are valued using a standard cost at each substation. VECTOR is undertaking a program of installing further oil containment assets at its substations. These have been included as a second miscellaneous type.

In the last year VECTOR has installed 141MVAr of capacitors throughout its network. These have been installed at zone substations. They have been included under the miscellaneous items but have not been included in the optimisation process. This is because these assets relate to the nature of the load, which will not change if the zone substation configuration is changed.

Distribution Network

The distribution network consists of all the equipment that operates at 11,000, 6,600 and 400 volts, excluding the 11,000 and 6,600 volt circuit breakers at the zone substations. The 11,000 and 6,600 volt networks are classified as the high voltage network and the 400 volt network is classified as the low voltage network.

In previous valuations, VECTOR's network design criteria and procedures have been examined and it was concluded that these procedures reflect best practice in light of the available technology, network economics and the legal town planning environment. A detailed review of VECTOR's design philosophy is currently underway but results were not available to include in this valuation. Until this review is completed the previous conclusion remains and accordingly, it was considered realistic to take the majority of the existing distribution network as being optimal. There were two exceptions to this, the first regarding the 6.6kV component of the distribution network and the second regarding the specification of lines and cables.

The 6.6 kV component of the distribution network is no longer economic due to improvements in technology. VECTOR's current policy is to progressively uprate all 6.6 kV equipment to 11 kV. A number of cables and lines are rated at 11kV but operated at 6.6kV. These have previously been valued as 11kV assets. This does not take into account the lower capacity provided by these lines at 6.6kV. An adjustment has been made to take this into account. The 6.6kV cables and lines were valued at a cost equivalent to a medium sized 11kV conductor. Standard lives equivalent to the 11kV cable/line were used. It was also assumed that these cables/lines shared the same age profile as the overall high voltage cables/lines.

Many of the lines and cables installed on the existing distribution network do not use present day economic and best practice diameters and materials. Therefore, in order to provide a more optimal distribution system, the sizes and diameters used for the valuation were altered to reflect their present day equivalents.

Distribution Network Valuation

The valuation of the distribution network used the same methodology as that used for previous valuations. The equipment in each asset category was separated into a series of standard sizes and each group was valued individually. The depreciation method used was a straight line method with no salvage value assigned to any equipment.

A schedule of standard replacement costs was used to value all distribution equipment. The majority of distribution assets were valued using the standard replacement costs given in the ODV Handbook. However, in a few cases, no cost was specified in the ODV Handbook so the values used were based on quotations supplied by manufacturers and external contractors. These quotations included labour, design and project management costs.

As allowed for in clauses B14 and B15 of the ODV Handbook, multiplying factors have been applied to cable costs to reflect areas where additional restrictions may be placed on projects due to extra vehicular and pedestrian activity and where environmental conditions impose additional trenching costs. As permitted in clause B8, a multiplying factor was applied to overhead lines to take into account installation in urban areas. The details of how these multiplying factors were determined and applied are given in Appendix D.

The standard asset lives assigned to distribution equipment are those specified in the ODV Handbook. The standard life values for transformers with capacity of 750kVA or greater was extended, in accordance with clause B44, to 55 years. The justification for this life extension is given in Appendix E.

The specific quantities of equipment installed and removed from the network during the 1998/99 financial year are given in Appendix A.

The following sections detail the different asset categories and note particular methods or parameters associated with the valuation of the category.

Transformers

The numbers and ages for the transformers in the 1994/95 ODV were obtained from the Dataflex database. They were grouped according to whether they were pole-mounted or ground-mounted and then according to their size and age. The 1995/96, 1996/97 and 1997/98 updates were obtained from VECTOR's computer based network information program, Merccano

During 1999 Merccano was replaced by another network information system, Smallworld. Smallworld was populated with data migrated from Merccano. The 1998/99 update on the numbers and ages were obtained from Smallworld. This program provided reports of all the transformers installed and removed from the network in the year ending 31 March 1999.

The valuation used standard costs that included the costs associated with the transformer installation and each transformer was assigned a standard life of 45 years, with the exception of transformers with a capacity of 750kVA or greater. The standard life for these transformers was extended in accordance with clause B.45 to 55 years. The justification for this life extension is given in Appendix E.

Switchgear

The switchgear numbers and ages were developed from the distribution transformer information. It was assumed that there was one ring main unit for every two ground mounted transformers and one air break switch for every five pole mounted transformers. All pole mounted transformers were assumed to have fuse isolators.

The valuation used standard costs that included the costs associated with the switchgear installation. Each overhead switchgear unit was assigned a standard life of 35 years and each underground switchgear unit was assigned a standard life of 40 years.

Lines and Cables

The length and ages of the distribution network cables and lines were calculated from Ministry of Energy 705 Returns, AEPB Annual Reports and Merccano. The 1998/99 update figures were obtained from a Smallworld report that gives the total length of each variety of cable installed and decommissioned on the network for the year ending 31 March 1998. It was assumed that all the lines and cables that have been removed from the network were from the oldest age group.

As previously noted the high voltage distribution network operating at 6,600 volts was valued as 11,000 volts but at a smaller conductor size to reflect the reduced capacity by operating these cables and lines at the lower voltage.

As no other information was available on the different sizes of cable, present day economic and best practice guidelines were used to provide optimal diameters and materials for all the distribution lines and cables. All high voltage overhead lines were valued as 100 mm^2 Al and all low voltage overhead lines were valued as 3 core 100 mm^2 Al PVC. The high voltage underground cables were valued as 300 mm^2 Al and the low voltage underground cables were valued as 4 core 185 mm^2 Al.

For the underground network, it was assumed that all 11,000 volt cables would be laid in the same trench as the 400 volt cables. Thus, the length of 400 volt cable laid in a trench by itself is equal to the total length of low voltage cable less the total length of high voltage cable.

For the overhead network, it was assumed that all 11,000 volt lines would be strung from the same poles as the 400 volt lines. Thus, the length of 400 volt lines strung by itself is equal to the total length of low voltage lines less the total length of high voltage lines.

All underground cables on the distribution network were assigned a standard life of 70 years. This assumes all cables are PILC. As the use of XLPE cable has only recently been approved very little has been installed on the network at this stage. As at 31 March 1999 only 0.1% of the total length of all 11,000 volt and 6,600 volt cables installed on the network was XLPE.

All overhead lines on the distribution network were assigned a standard life of 55 years as approximately two thirds of the lines are installed on concrete poles and only one third are installed on wooden poles.

Pillars

The link pillar numbers used in the ODV were from a survey carried out by the VECTOR AM/FM team. These were then depreciated in equal amounts over ten years. The 1998/99 update used information from Smallworld to determine how many more pillars have been installed and removed over the last year.

The number of service pillars was based on the 97/98 valuation and the numbers of additions and removals over the period 1 April 1998 to 31 March 1999. In the 97/98 valuation the number of service pillars was based on the number of customers. This assumed that half of all VECTOR customers will have an underground supply and there will be one pillar for every two underground customers. Large service pillars (400 amp) are the same as 2-way link pillars and have been included in this category.

The same method was used for the depreciation of service pillars and link pillars. A standard life of 40 years was assigned to both varieties of pillars.

Buildings

Each of the transformers installed on the distribution network has some sort of enclosure and/or support structure. Therefore, the valuation of the distribution buildings was based on the distribution transformer numbers and ages.

For all ground mounted transformers, it was assumed that a fibreglass cover or kiosk would be used and for pole mounted transformers, a supporting pole structure would be used.

A standard life of 40 years was assigned to both types of buildings.

Services

Services have been added. The total number of active customer connections as at 31 March 1999, split by single and three phase supplies, was used to determine the overall value of this group. New connections, by supply type, were also provided for the period 1April 1998 to 31 March 1999. The age of those connections made prior to 1 April 1998 was assumed to be the same as the meters.

A standard life of 45 years was used.

Streetlighting Network

The streetlighting network was included as part of the distribution valuation as the streetlight cable and line lengths are based on the distribution cable and line lengths. It was recognised that where the streetlighting network is in close proximity to existing lv reticulation, the modern equivalent asset is a photoelectric cell. An adjustment was made to take this into account. It was assumed that 80% of the streetlights are in close proximity to existing lv mains. This adjustment was made after the value of the streetlighting assets was determined as per previous valuations.

The network has previously been valued as two parts, overhead and underground.

The underground network is assumed to be half as long as the low voltage distribution network with a common size of 1 core 10NS cable. Once the length as determined, it was presumed that there was one streetlight every 60 m, with one relay operating six streetlights.

The overhead network was valued using a dedicated line to supply the streetlights

It was assumed that the length of the overhead streetlighting network was equal to that of the overhead low voltage distribution network, with the same proportion of underbuilt lines. As the average span length is 40m and there is one streetlight for every two poles, the number of relays could be calculated using the assumption that there is one relay for every six streetlights.

For both networks, the ages of the cables and relays were based on the ages of the low voltage distribution network.

The cable lengths and number of relays were scaled back to 20% of this value. This reflects the assumption that 80% of the streetlights were close to existing lv mains. It was assumed that there would be a photoelectric cell for each streetlight. The number of photoelectric cells was derived based on the number of relays. The age of the photoelectric cells was taken to be the weighted average of the two relay types.

The standard life of the streetlight network is 70 years for underground equipment and 55 years for overhead equipment. A life of 20 years was used for the photoelectric cells.

Communications Valuation

The communications network consists of pilot wires and fibre optic cables between the Transpower points of supply, the VECTOR zone substations, the SCADA and the bulk metering equipment. Ripple Plant is also included in the communications valuation.

Communications Cables

The lengths of pilot wires and fibre optic cables were taken from the cable lengths between the Transpower and VECTOR substations and from maps supplied by the Network Information and Mapping Centre. For pilot cables between Transpower and VECTOR substations, the age of the subtransmission cable was used. For pilot cables between VECTOR substations and the fibre optic network, documentation was available to give the asset ages.

The standard life of the pilot and fibre optic cables is 45 years.

Communications Equipment

Information on the SCADA and bulk metering equipment was taken from VECTOR Capital Authorisation documents. These gave the age of the equipment and its replacement cost.

The standard life of communications equipment is 15 years.

Ripple Plant

The ripple plant was valued as inductor-capacitor circuits with ages taken from VECTOR Capital Expenditure Authorisation Forms. The costs were based on recent upgrade projects.

The standard life of 20 years was assigned to all the ripple plant equipment.

Economic Valuation

In the 1997/98 valuation the VECTOR network was reviewed to identify areas where the Economic Value might be less than the ODRC. As a result, one detailed economic valuation was carried out for the supply to Orere Point/Kawakawa Bay. The valuation for this area of the network has not been redone for the 1998/99 valuation. Instead the values calculated as part of the 1997/98 valuation have been used. The details of how this valuation was carried out are given in Appendix F.

Appendix A - Equipment Additions And Removals

Subtransmission Projects

The following subtransmission projects were completed in the year ending 31 March, 1999. These were;

Waiheke – New zone substation established

A new zone substation was established on Waiheke island

Parnell – Rewound subtransmission transformer installed

The ex-Liverpool 22/6.6kV 18MVA transformer was rewound to 22/11kV and installed at Parnell. One of the 22kV cables between Parnell and Quay was reinstated into service

Capacitor Bank Installations

141 MVAr of 11kV capacitors were installed at 23substations throughout the network.

110kV Overhead Line

A 110kV overhead line between Penrose and Liverpool/Quay was completed.

Three 110/22kV ABB transformers installed - two at Quay and one at Liverpool

Two 110/22kV 60MVA transformers were installed at Quay.
One 110/22kV 60MVA transformer was installed at Liverpool

Liverpool – 110kV cable from Transpower Roskill to Liverpool

A double circuit 110kV 150MVA cable from Transpower Roskill to Liverpool (9.1km of cable) was installed. The existing Roskill – Liverpool oil cables were decommissioned

Liverpool – Switchgear changes

110kV GIS (SF6 gas-insulated switchgear) and 22kV GIS switchgear was installed at Liverpool. The 22kV switchgear replaced the existing switchgear. A new building was built to house the switchgear.

Quay – 22kV cables replaced

22kV cabling from the 22/11kV transformers to the 22kV switchgear (71m and 62m of cable) was installed replacing the existing cable.

Otara – New 22kV cable and existing cables paralleled

A 22kV cable was installed from TP Otahuhu to Otara zone sub (3110m of cable). The existing 22kV cables are paralleled to increase the capacity to Otara

Transpower Otahuhu - 22kV cabling rearrangement

22kV cable was installed on Transpower land for their switchgear replacement (2 circuits of 53m and 2 circuits of 122m). The existing lengths of 22kV cable were abandoned

Oil Containment Installations

Oil containment was installed at the following substations.

Substation	Oil Containment Type
Liverpool	Bunding and a plate separator
Quay	Bunding and a plate separator
Mangere Central	Bunding and a plate separator
Te Papapa	Bunding and a plate separator
McNab	Bunding and a plate separator
Mangere East	Bunding and a roof over the transformer bays
Papakura	Bunding and a roof over the transformer bays
Manurewa	Bunding and an oil interceptor tank
Takanini	Bunding and an oil interceptor tank

Mangere Central Relay Replacement

All of the relays were replaced on the 11kV switchgear (22 panels) at Mangere Central

Communications Projects

TP Mangere To Manukau Fibre Optic Cable Extension

Fibre optic cable was laid from TP Mangere to Manukau zone substation, a distance of 1860m

Newton to Hobson Fibre Optic Cable Extension

Fibre optic cable was laid from Newton to Hobson zone substation, a distance of 3,700m

Distribution Projects

Over the course of the year ending 31 March 1999, the following distribution network assets were installed and removed from the network.

Clevedon Voltage Regulator Installations

Three 11kV voltage regulators were installed on the Clevedon distribution network

Cables and Lines

	Installed		Removed	
	Cables	Lines	Cables	Lines
HV	7,780 m	3,070 m	480 m	2,360 m
LV	16,340 m	652 m	20 m	417 m

Distribution Transformers

	Installed		Removed	
kVA	PM	GM	PM	GM
15	0	0	0	0
30	9	0	2	0
50	6	1	0	0
100	2	2	0	0
150	0	2	0	0
200	1	5	0	1
300	9	16	2	2
500	0	15	1	4
750	0	7	0	0
1000	0	6	0	0
	27	54	5	7

Pillars

Pillar Category	Installed	Removed
Service Pillar	1,022	57
2 - Way Pillar	73	73
3 - Way Pillar	22	18
4 - Way Pillar	3	0

Services

As at 31/3/99 there were,

236,937 active single phase connections

17,424 active three phase connections

of these,

5,641 single phase connections were added in the period 1/4/98 to 31/3/99

398 three phase connections were added in the period 1/4/98 to 31/3/99

Appendix B - Existing Subtransmission Network

The following map shows the geographical location of VECTOR's 45 zone substations and their supply areas. Pacific Steel and Lichfield are not shown on the map as Pacific Steel only supplies one customer and Lichfield is not in the Auckland area. The three 110 kV points of supply owned by VECTOR are located on the same site as the zone substations of the same name.

Appendix C – Optimisation of Subtransmission Network

The first step in the network optimisation process is to determine the requirements placed on existing equipment. This enables an effective judgement to be made on what is appropriate to meet those requirements. In VECTOR's case, those requirements are that;

1. n - 1 security be maintained at all substations

2. the fault level at any substation should be maintained within acceptable levels by limiting the number of transformers at any one optimised substation to three

3. the horizon for allowance for future load growth is 10 years

4. no aspect of the optimisation can compromise the operating standards of VECTOR as set out in VECTOR's service standards.

The second step of the network optimisation is to determine the standard asset base to be used in the optimised network. This includes the rating, type and configuration of the equipment. In the VECTOR optimisation, the equipment assumptions were that;

1. there are two standard transformer sizes, 15 MVA and 20 MVA.

2. there are two standard cable sizes that correspond to the transformer sizes with a two hour overload capacity of 150%

3. there is one standard building at each substation and a standard bay for each transformer

The third step in the network optimisation is the optimisation of the system configuration. In accordance with the Handbook, the location of the Transpower points of supply, the location of customers and the boundaries of the VECTOR network were assumed to be fixed. The Mercury 110kV points of supply were considered to be transmission assets and were considered to be fixed, consistent with the approach with the Transpower points of supply. Given these constraints, the VECTOR subtransmission network was represented graphically with the 10 year load forecasts superimposed. From this, the optimisation of the substation locations was carried out as follows;

1. All substations that were either dedicated to a specific customer or geographically isolated were highlighted. In the case of remote zone substations these could not be combined due to either a complete lack of distribution network interlinks or every possible combination would require distribution feeders that are too long to maintain acceptable voltage levels.

2. All substations with a load greater than 50 MVA were highlighted. These could not be combined with another substation as the combined load would compromise network requirement 2 and equipment assumption 1. These state that the maximum transformer capacity that can be installed in any one substation is 3 x 20 MVA. Taking into account a two hour overloading capacity of 150%, this gives a maximum firm capacity of 50 MVA.

3. All substations that had no neighbouring substation to combine with were highlighted. These included those that had neighbouring substations that had been eliminated in the first two steps and those substations where any combination would result in a combined load greater than 50 MVA.

4. All remaining substations were then inspected to determine which could be combined together. The combinations were based on geographical proximity and combined load. All switching stations were combined with a neighbouring substation.

5. Substations that could be combined were analysed to determine whether the combined zone substation was of a lesser value than the existing arrangement. This included valuing the impact on the 11kV from combining the substations. The combined zone substation was valued based on the optimal equipment configuration. If the combined zone substation was more economic than the existing arrangement then the combination was made and an adjustment made to the 11kV cable costs to reflect the impact on the distribution network.

Once the obvious combinations were made, steps 3, 4 and 5 were repeated until all the substations were considered.

The configuration resulting from the optimisation process outlined above is given in Table 3.

Substation	Load	Optimised To	Optimising Step
Avondale	23.7	Avondale	3
Bairds	31.4	Bairds	3
Balmoral	17.9	Balmoral	3
Carbine	29.1	Carbine	3
Chevalier	16.6	Chevalier	5 ⇒ Mt Albert
Drive	29.7	Drive	3
Freemans Bay	22.1	Ponsonby	5 ⇒ Ponsonby
Glen Innes	18.7	Glen Innes	3
Greenmount	32.0	Greenmount	3
Hans	25.4	Mangere East	5 ⇒ Mangere East
Hobson	56.5	Hobson	2
Howick	43.2	Howick	3
Kingsland	17.5	Kingsland	5 ⇒ Newton
Lichfield	20.0	Lichfield	1
Liverpool	65.1	Liverpool	2
Mangere Central	51.2	Mangere Central	2
Mangere East	19.9	Mangere East	5 ⇒ Hans
Manukau	35.9	Manukau	3
Manurewa	54.3	Manurewa	2
Maraetai	8.1	Maraetai	1
McNab	46.6	McNab	3
Mt Albert	8.0	Chevalier	5 ⇒ Chevalier
Mt Wellington	31.8	Mt Wellington	3
Newmarket	42.4	Newmarket	3
Newton	28.8	Kingsland	5 ⇒ Kingsland
Onehunga	20.6	Te Papapa	5 ⇒ Te Papapa
Orakei	25.8	Orakei	3
Otara	34.7	Otara	3
Pacific Steel	58.0	Pacific Steel	1
Pakuranga	23.7	Pakuranga	3
Papakura	23.8	Takanini	5 ⇒ Takanini
Parnell	8.6	Parnell	3
Ponsonby	17.0	Ponsonby	5 ⇒ Freemans Bay
Quay	40.3	Quay	3
Remuera	30.3	Remuera	3
Rockfield	25.1	Rockfield	3
Rosebank	28.5	Rosebank	3
Sandringham	21.5	Sandringham	3

Substation	Load	Optimised To	Optimising Step
South Howick	30.3	South Howick	3
St Heliers	21.0	St Heliers	3
Takanini	21.2	Takanini	5 $\Rightarrow$ Papakura
Te Papapa	27.1	Te Papapa	5 $\Rightarrow$ Onehunga
Victoria	38.4	Victoria	3
Waiheke	10.8	Waiheke	1
Westfield	32.0	Westfield	3
White Swan	31.2	White Swan	3
Wiri	43.2	Wiri	3

Table 3 - VECTOR Optimised Network

Equipment Optimisation

As zone substations were combined the equipment at the new combined substation was optimised. Once the configuration of the optimised subtransmission network had been developed, the equipment configuration could be determined at each remaining substation.

The selection process is the same whether or not the zone substation is a combined substation or an existing substation. The process is as follows.

For any optimised substation with a 10 year load forecast of *x* MVA, the transformers at the substation are chosen such that *x* is less than the firm capacity. The firm capacity of the substation is based on the transformer overload capacity, which is calculated in the following manner.

VECTOR's policy on transformer overloading is that a subtransmission transformer can be overloaded by 150% for two hours. This is based on calculations from the IEC standard 354. The overload is used to prevent a loss of supply while allowing time for load to be transferred away on the 11kV network. As the maximum transfer on the 11kV network between zone substations is 10MVA, the overload on the transformer will be the lesser of 150% of the transformer rating or the transformer rating plus 10MVA. Therefore, for a substation with *n* transformers of *y* MVA, the firm capacity equals the lesser of (*y* x 1.5) x (*n* - 1) or *y* x (*n* - 1) + 10

The possible firm capacity values are given in Table 4.

Installed Transformers	(*y* x (*n* - 1)) x 1.5	(*y* x (*n* - 1)) + 10	Firm Capacity
2 x 15 MVA	22.5 MVA	25.0 MVA	22.5 MVA
2 x 20 MVA	30.0 MVA	30.0 MVA	30.0 MVA
3 x 15 MVA	45.0 MVA	40.0 MVA	40.0 MVA
3 x 20 MVA	60.0 MVA	50.0 MVA	50.0 MVA

Table 4 - Firm Capacity Values

Once the optimised capacity is determined, it is compared to the existing capacity. The final optimised transformer capacity is the lesser of either the optimised capacity or the existing capacity. Therefore, at any given substation, the capacity at that substation can not be optimised to a value larger than the existing capacity.

For any optimised substation with *n* transformers rated at *y* MVA, the cables will be chosen such that there are *n* cables rated at *y* x 150% MVA. However, for easy identification, the cables are referred to as having a capacity of *y* MVA.

For any optimised substation with *n* transformers, the switchgear will be chosen such that there are (*n* x 6) + (*n* - 1) circuit breakers. This gives one incomer breaker and five feeder breakers for each transformer and one bus section breaker between every two transformers at each substation.

For any optimised substation with *n* transformers, if the existing substation has a substation building, there will be one substation building with *n* transformer bays. No spare bays are included.

For any optimised substation, the value of the land assigned to that substation will be equal to the value of the land assigned to the existing substation. The value of land for the substations eliminated in the optimisation is listed in the Unused Land category.

For any optimised substation, there will be one set of miscellaneous equipment for every substation building. This will be based on the equipment already in place at that substation.

Optimisation Example

Consider three substations to be optimised.

Existing Substation	10 Year Load Forecast	Transformer Configuration
A	24 MVA	2 x 15 MVA
B	25 MVA	2 x 20 MVA
C	27 MVA	3 x 15 MVA

Using Table 4, substation A would have an optimised transformer configuration of 2 x 20MVA. However, there are only 2 x 15MVA transformers at the existing substation so the final optimised transformer configuration is 2 x 15MVA. From this, optimised substation A would be supplied by two cables rated at 15*150% = 22.5MVA and have (2 x 6) + (2 - 1) = 13 circuit breakers.

Using Table 3, substation B would also have an optimised transformer configuration of 2 x 20MVA. As substation B already has 2 x 20MVA transformers, this would be the final optimised transformer configuration. From this, optimised substation B would be supplied by two cables rated at 20*150% = 30MVA and have (2 x 6) + (2 - 1) = 13 circuit breakers.

Using Table 3, substation C would also have an optimised transformer configuration of 2 x 20MVA. As substation C has 3 x 15MVA transformers, the final optimised transformer configuration would be optimised back to be 2 x 20MVA. From this, optimised substation C would be supplied by two cables rated at 20*150% = 30MVA and (2 x 6) + (2 - 1) = 13 circuit breakers.

If substation A and substation B were geographically adjacent, they could be combined to form substation A'. This combined substation would be located on the same site as the existing substation A. The 10 year load forecast for substation A' is 49MVA so the optimised transformer configuration would be 3 x 20MVA. From this, substation A' would be supplied by three cables rated at 20*150% = 30MVA and have (3 x 6) + (3 - 1) = 20 circuit breakers. The cables supplying substation A' would be the same length as those supplying substation A.

The ages of equipment for combined substations are determined based on the weighted average age of the equipment at the zone substations being combined. More details on this for each equipment type can be found in the section; Subtransmission Network Valuation.

Appendix D – Derivation and Application of Multiplying Factors

The ODV Handbook allows for the use of multiplying factors to increase the standard costs for overhead lines and underground cables in differing conditions. The following sections detail which factors were used, the actual factor and an explanation of how the factor was determined and applied.

Overhead Lines

Three multiplying factors are allowed for overhead lines. These are;

Overhead line urban	1.5 to 1.8 times the standard cost
Overhead line remote area	1 to 1.25 times the standard cost
Overhead line rugged terrain	1.2 to 1.3 times the standard cost

None of VECTOR's overhead network can be classified as either remote or installed in rugged terrain. However, the majority of the overhead network is in urban areas.

Urban Areas

In calculating the factors to be used for the urban area, the following numbers were determined from maps of the VECTOR distribution area.

The following proportions have been estimated from the HV network diagrams for the previous valuation.

Urban reticulation	80%
Rural reticulation	20%
Urban Underground Cables	100%
Rural Underground Cables	0%
Urban Overhead Lines	51%
Rural Overhead Lines	49%

51% of the overhead lines are in urban areas.

A multiplying factor of 1.8 has been used for urban overhead lines. This has been applied to the overhead lines by deriving an overall multiplying factor for overhead lines for the VECTOR network. Therefore, the final multiplying factor for overhead lines to take installation in urban areas into account is 1.8 x 0.51 + 1 x 0.49 = 1.408. This multiplying factor has been applied to 11kV lines only as VECTOR does not have any 33kV overhead lines in urban areas.

Underground Cables

Two multiplying factors are allowed for underground cables. These are;

Underground cables in the central city	1.15 to 1.25 times the standard cost
Underground cables in rocky areas	1.5 to 2.0 times the standard cost

Both of these factors are applicable to the VECTOR distribution area.

Subtransmission Network Cables

The ODV handbook only specifies standard costs for 33kV cables. Costs for subtransmission cables, including installation, for other voltages have been determined from recent competitive quotes. An installation cost of $700/m has been used for all subtransmission cables other than 33kV. This cost covers trenching, backfilling and refurbishment.

This cost is based on the recently completed Roskill to Liverpool 110kV cable (9.1km in length). This project was competitively tendered. The installation cost for this project worked out to be $751/m. This cost was derived after taking into account special conditions specific to the project, removing factors specific to the 110kV cables, removing VECTOR project management costs and applying a 25% discount to adjust for acceleration effects. The ground conditions in which the cable was laid were better than the average conditions through the VECTOR network.

Standard costs are specified in the handbook for 33kV cables. The same multiplier as derived for the distribution network cables has been applied to the 33kV standard costs to determine the 33kV cable cost. More details are given below on the derivation of the multiplier for distribution cables.

Distribution Network Cables

Two multiplying factors have been derived and applied to 11kV, 6.6kV and 400V cables. The multiplier has only been applied to those low voltage cables that are not overlaid in a trench with another cable of a higher voltage.

The first multiplying factor relates to areas where ground conditions impose greater than normal trenching costs. Whilst this is typically rocky ground there are other conditions which cause VECTOR to incur similar costs.

Apart from areas of volcanic rock, the following regions in VECTOR's network have ground conditions which cause difficulty in trenching,

- Central Business District – this area is all reclaimed land. The fill is made up of indeterminate matter, including large rocks. At regular intervals there are large sea wall erected as part of the reclamation projects. These are extremely difficult to trench through.
- Eastern Bays (Kohimarama/Mission Bay/St Heliers). There are large areas of Waitemata clay, which is extremely hard. In areas where there is not clay the ground is largely sand. This requires extra shoring to prevent collapse. Trenches often fill with water due to tides and then require pumping out.
- Takanini – this area is peat bog and is prone to flooding. There are also a large number of buried swamp Kauri which need to be cut through.

The areas, as a percentage of the total VECTOR urban area, for each of these regions, including those regions which have volcanic rock are given below.

Rocky ground	29.0%
Central Business District	8.9%
Eastern Bays	1.2%
Takanini	8.5%

The CBD has a far higher density of cable than the rest of the network. Based on GIS data there is 1.4 times the amount of cable per square kilometre in the CBD than in the surrounding network. Therefore an equivalent CBD area would be 1.4 x 8.9% = 12.5%. The total area, as a percentage of the total urban area, where ground conditions make installation difficult is thus 51.2%.

A variety of multiplying factors have been applied depending on the designated area and the nature of the problem in that area. These multiplying factors were provided by Worley. Details for each designated area and the overall result are given in the following table.

Designated Area	Multiplier	% of Cable Population	% x Multiplier
Rocky Ground	1.8	29.0%	0.5220
CBD	1.5	1.4x8.9%= 12.5%	0.1875
Eastern Bays	1.5	1.2%	0.0180
Takanini	1.5	8.5%	0.1275
Rest of Network	1.0	48.8%	0.4880
Total		100.0%	1.3430

The final multiplying factor to be applied to all cables to take difficult ground conditions into account is 1.343.

A similar approach has been used for the second allowable multiplying factor. This factor applies in circumstances where there is increased pedestrian and/or vehicular activity. This causes costs to be incurred for traffic control, can impose time restrictions and can lead to higher reinstatement costs.

A multiplier of 1.25 has been used. This has been applied to the central business district and surrounding areas (Newmarket, Parnell) and major arterial routes.

As previously noted 12.5% of the distribution cables are in the CBD. A further 14% are on major arterials. Therefore the multiplier to apply to all cables is 1.25 x 0.265 + 1 x 0.735 = 1.06625.

Both multipliers were summed to give an overall multiplier to apply to distribution cables. This multiplier was 1.343 + 1.06625 = 1.40925.

Appendix E – Life Extensions

The ODV Handbook allows for the extension of the standard lives for subtransmission switchgear and distribution transformers under clauses B44 and B45 respectively. The following sections detail the extensions that were applied for under each asset type..

Subtransmission Switchgear

The ODV standard life for subtransmission switchgear has been extended from 45 to **47.7** years based on the proportion of the different types of switchgear in use on the subtransmission network.

Specifications

The specifications used in the purchase of vacuum and SF_6 circuit breakers were BS 5311 and BS 5227 in conjunction with the specification generated by VECTOR. Both the vacuum and the SF_6 breakers are considered to be of a sealed type design and are specified to operate without maintenance for an extended number of operations.

Maintenance

The trigger for maintenance on subtransmission switchgear is 3 fault operations OR

- every 8 years for oil circuit breakers
- every 12 years for vacuum and SF_6 circuit breakers

Normal operation counts are not considered.

Switchgear Types

There are currently 801 panels of subtransmission switchgear installed on the VECTOR network. Of these, 218 are either vacuum breakers or SF_6.

The following table shows how the life extension is calculated.

Switchgear Type	No Of Panels In Use	% Of Total Population	Applicable Standard Life	Average Life
Oil Breakers	583	73%	45 years	32.85 years
Vacuum Breakers/ SF6 Breakers	218	27%	55 years	14.85 years
Total	801		Total	47.7 years

Distribution Transformers

The ODV standard life for distribution transformers has been extended from 45 years to 55 years for transformers with a capacity of750kVA and above. This is as a result of a review and subsequent recommendation by Worley based on the information provided below..

Age Profile

A graph of the age profile for distribution transformers in service on the VECTOR network is given in on the following page. Of the original transformer population, the transformers that were constructed before 1961 were constructed with a steel that had very high losses. For this reason, when such transformers are taken off the network, they were not refurbished. As a result, there are very few transformers in use on the network that are older than 37 years. However, it should be noted that the pre-1961 transformers have not been actively sought out and are only replaced when the transformers are returned for other reasons such as faults, uprating from 6.6kV to 11kV and upgrades in capacity.

Maintenance

The maintenance philosophy for distribution transformers is given in the Asset Maintenance Management Plan and is as follows;

"Present practice is that distribution transformer component maintenance is failure-driven and self-checking as long as the component is livened. There is a visual check of external condition every three years."

All aspects of the transformer maintenance are expensed, including the refurbishment programme. This programme involves testing transformers that have been removed from service due to changes in requirements or failures and refurbishing those with cores in acceptable condition. Since the decline in the number of transformers manufactured prior to 1961, the number of transformers not suitable for refurbishment has dropped to below 15% of the total number removed from the network each year. Of the 15% that are scrapped, the majority have been replaced due to damage by external elements such as vehicular collisions and switchgear failures.

Loading

The distribution transformers on the VECTOR network are generally lightly loaded. The most recent load readings taken from 2287 distribution transformers showed that 83% of the transformers never reached full load and only 2% exceeded the rating at which IEC 354 states significant loss of life may occur.

The loading information implies that the majority of the distribution transformers installed on the VECTOR network are lightly loaded and will therefore, according to IEC 354, the insulation deterioration due to heating effects is slowed down and correspondingly the useful life of the transformer is extended.

Throughput

Information was also provided to Worley on distribution transformer throughput for refurbishment through its in house workshop and external suppliers for the last 5 years.

Appendix F – Orere Point Economic Valuation

In the 1997/98 valuation the VECTOR network was reviewed to identify areas where the Economic Value might be less than the ODRC. As a result, one detailed economic valuation was carried out for the supply to Orere Point/Kawakawa Bay. As previously noted the valuation has not been redone for the 1998/99 valuation. Instead the values calculated as part of the 1997/98 valuation have been used. The details for this valuation are as follows.

The valuation used a 20 year time horizon with yearly operating and maintenance costs of $170 per customer and a line charge of $696 per customer. The depreciation rate was taken as 1.43%, which corresponds to a 55 year lifetime for distribution assets. This was chosen, as it is the standard lifetime for overhead lines and distribution transformers, which form the majority of the assets in supplying this area of the distribution network. A WACC of 10% was used and a variable inflation rate was used as follows;

Year	1	2	3 - 20
Inflation Rate	2.2%	1.7%	2.0%

It was assumed that 6% of the Papakura ODRC should be included in the Orere Point ODRC. This gave an ODRC of $1,746,150 and an economic valuation of $996,404. Therefore, as the ODRC is greater than the economic valuation, it was necessary to reduce the total ODV by $749,746.