PowerWater

Program Business Need Identification

Power and Water Corporation

NFO (PRD33405)

Overloaded Feeders / Distribution Augmentation Program

Proposed:	Approved:	
Jim McKay A/Chief Engineer Power Networks Date: 6/2/2018	Michael Thomson Chief Executive Power and Water Corporation Date: 23/02/2018	
Djuna Pollard Executive General Manager Power Networks Date: 15/2/2018	Refer to email D2018/72353 Finance Review Date: 6/02/2018	Refer to email D2018/64141 PMO QA Date: 12/02/2018

1 Program Summary

Program Name:	Overloaded Feeder/Distribution Augmentation program		
Program No:	PRD33405	**SAP Ref:**	
Financial Year Commencement:	2019/20		
Business Unit:	Power Networks		
Program Owner (GM):	Djuna Pollard	**Phone No:**	8985 8431
Contact Officer:	Christina Camilleri	**Phone No:**	8924 5192
Date of Submission:	23/02/18	**File Ref No:**	D2017/382257
Submission Number:		**Priority Score:**	
Primary Driver:	Growth/Demand	**Secondary Driver:**	Compliance
Program Classification:	Capital Works Program		

2 Recommendation

2.1 MAJOR PROJECT >$1M OR PROGRAM

It is recommended that IRC note the proposed Overloaded Feeder/Distribution Augmentation Program for an estimated budget of $6.0M, and approve the inclusion of this Program into the SCI for this amount, with a corresponding completion date of June 2024.

This program is a continuing program from the current regulatory control period. The forecast for this program of work aligns with the 2019-24 regulatory period and will be included in the 2019-24 Regulatory Proposal to the Australian Energy Regulator (AER).

Note that individual projects within the program will be documented in Business Cases as per the PWC governance framework for capital projects and programs.

3 Description of Issues

3.1 Background

The urban areas of Darwin and Alice Springs are supplied predominately by 11kV distribution feeders while the rural areas, as well as the townships of all of Katherine and Tennant Creek are supplied by 22kV distribution feeders. While the rural network is significantly radial in nature, the urban feeders are generally inter-connected or 'meshed', in order to:

- Restore supply to customers following a fault, in a timely cost effective manner and to achieve required reliability standards[1].
- Provide opportunity to conduct network maintenance activities with limited customer disruption and cost.
- Comply with the supply contingency criteria under the Network Technical Code and Planning Criteria

Providing alternative supply paths for customers within the network meets these needs. The interconnectedness of the distribution networks provide a cost effective way of achieving these outcomes and through good planning practices can maximise asset utilisation, minimise cost and provide reliable supply options for most urban customers. While designs vary a 1-to-3 approach, where one feeders' load can be switched to be supplied by two adjacent feeders in a timely manner, is common and in line with broader industry practice[2]. This allows for average feeder utilisation of up to 65%, ie sufficient 'headspace' is maintained to manage restoration following contingency events (N-1) or for other maintenance activity. In order to ensure that these supply alternatives remain available as load develops, as well as ensuring that feeders remain within thermal and power transfer (voltage) limits, feeder utilisation must be monitored and balanced.

The loading levels of feeders are monitored and analysed annually. Should corrective action be required, it is normal practice to explore opportunities to distribute the load amongst other feeders in the load area before considering augmentation options.

3.2 Current and Emerging Issues

The proposed program is a continuation of the existing augmentation program for the 2019-24 period that responds to two main issues:

- Overloaded feeders: distribution feeders identified as being loaded above 100% of rated overload capacity; and

- Non-compliant feeders (below N-1 Redundancy): distribution feeders identified as being loaded at a level which does not provide a sufficient level of redundancy to comply with the technical planning criteria

PWC undertakes an annual planning review to identify the feeders that require augmentation works to address these issues.

[1] Supply contingency criteria (Clause 14.6, Table 13 & 14) in the Network Technical Code and Planning Criteria
[2] Power and Water Network Management Plan, January 2015, Page 56

In previous years, the feeder augmentation program concentrated only on overloaded feeders and this has resulted in the significant improvement in the utilisation profile of feeders. Going forward more effort will be placed in meeting the planning criteria requirements for contingencies.

3.2.1 Overloaded Feeders >100%

While regional demand growth is steady, areas of localised growth continue, notably the areas of Palmerston/Archer and Berrimah /Wishart[3]. There are four feeders expected to be overloaded within the next 5 years. Two feeders are at Archer Zone Substation and two at Berrimah Zone Substation. These feeders are all forecast to overload, past thermal capacity, due to step load increases due to development.

Archer

The feeders from Archer Zone Substation are increasing utilisation due to step load changes from new residential land releases in the East Palmerston area. No further load transfers are possible in this area due to alternate feeders also having relatively high utilisation[4]. As indicated in Table 1, the average utilisation of the 6 feeders in 2022 is 86% with two exceeding 100% within 5 years if not addressed. This level of utilisation is too high to continue to meet forecast demand and when considering available switching points, insufficient to effectively manage contingency (N-1) events.

Table 1 - Archer feeder forecast loading and utilisation[5]

FEEDER NAME	AR01 (ZUCCOLI SOUT	11AR07 (JOHNSTON)	11AR14 (ZUCCOLI NORTH)	11AR15 (ROSEBURY HUB)	11AR17 (ROYSTONEA)	11AR18 (ZUCCOLI EAST)
FULL RATING	412	412	458	412	412	412
FEEDER RATING	329.6	330	366.4	329.6	329.6	329.6
alternate feeders	1	1	2	1	1	1
N-1 Utilisation %	50%	50%	67%	50%	50%	50%
BASE GROWTH	0.00	0	0	3	14	0
2017	0	273	0	185	245	76
2018	38	302	74	188	259	152
2019	77	331	147	191	273	227
2020	115	346	221	195	288	303
2021	153	346	221	198	302	378
2022	192	346	295	201	316	378
2017	0%	83%	0%	56%	74%	23%
2018	12%	92%	20%	57%	79%	46%
2019	23%	100%	40%	58%	83%	69%
2020	35%	105%	60%	59%	87%	92%
2021	47%	105%	60%	60%	92%	115%
2022	58%	105%	80%	61%	96%	115%

Berrimah

The McMillans and Hidden Valley feeders at Berrimah are also expected to be overloaded due to step loads in future residential and industrial land releases. These areas are currently serviced by existing feeders from Berrimah Zone Substation as

[3] AERReportForPWC_V3
[4] Utilisation is defined as the loading level against rated capacity at peak.
[5] 2016 2017 FEEDER UTILISATION AND ZONE SUBSTATION RECONCILIATION (PWC Ref: D2017/348293)

listed on Table 2 below. The average utilisation in 2022 for these 6 feeders is 83%, again with two feeders reaching 100% capacity. As with the Archer area, this utilisation is too high to meet demand or to effectively manage contingency (N-1) events.

Table 2 - Berrimah southern feeder loading and utilisation[6]

FEEDER NAME	11BE03 (TDZ)	11BE04 (MCMILLANS)	11BE09 (JAIL)	11BE13 (KORMILDA)	11BE18 (PORT)	11BE19 (HIDDEN VALLEY)
FULL RATING	412 / 340	412	412	412	340	412
FEEDER RATING	272	330	330	330	272	330
alternate feeders	1	2	2	2	1	2
N-1 Utilisation %	50%	67%	67%	67%	50%	67%
BASE GROWTH	-5	8	3	6	0	0
2017	152	161	181	196	141	173
2018	188	199	230	202	141	251
2019	183	237	233	208	142	278
2020	220	276	236	213	142	304
2021	265	314	240	219	142	330
2022	259	352	243	225	143	330
2017	56%	49%	55%	59%	52%	52%
2018	69%	60%	70%	61%	52%	76%
2019	67%	72%	71%	63%	52%	84%
2020	81%	84%	72%	65%	52%	92%
2021	97%	95%	73%	66%	52%	100%
2022	95%	107%	74%	68%	52%	100%

3.2.2 Non-Compliant Feeders (below N-1 Redundancy)

The recent planning study[7] has identified that 35 feeders (27% of total) in the Darwin 11kV network and 7 (47% of total) in the Alice Springs 11kV network exceed the N-1 contingency specified in the planning criteria, and are therefore non-compliant.

Table 3 – Number of feeders overloaded and below N-1 redundancy[8]

	Overloaded	N-1 exceeded		Total feeders
Darwin 11kV	4	35	27%	131
Alice Springs 11kV	0	7	47%	15

Further study needs is required to determine the augmentation requirements for each feeder. It is estimated that 50%, or a total of (21) of the identified feeders are likely to need some sort of augmentation.

[6] 2016 2017 FEEDER UTILISATION AND ZONE SUBSTATION RECONCILIATION (PWC Ref: D2017/348293)
[7] NPR1702 Feeder Augmentation 2019-24 (PWC Ref: D2017/558202)
[8] 2016 2017 FEEDER UTILISATION AND ZONE SUBSTATION RECONCILIATION (PWC Ref: D2017/348293)

3.2.3 Compliance

This program is required to maintain the quality of supply to customers and ensure that PWC comply with the supply contingency criteria (Clause 14.6, Table 13 & 14) in the Network Technical Code and Planning Criteria.

3.3 Risk Analysis

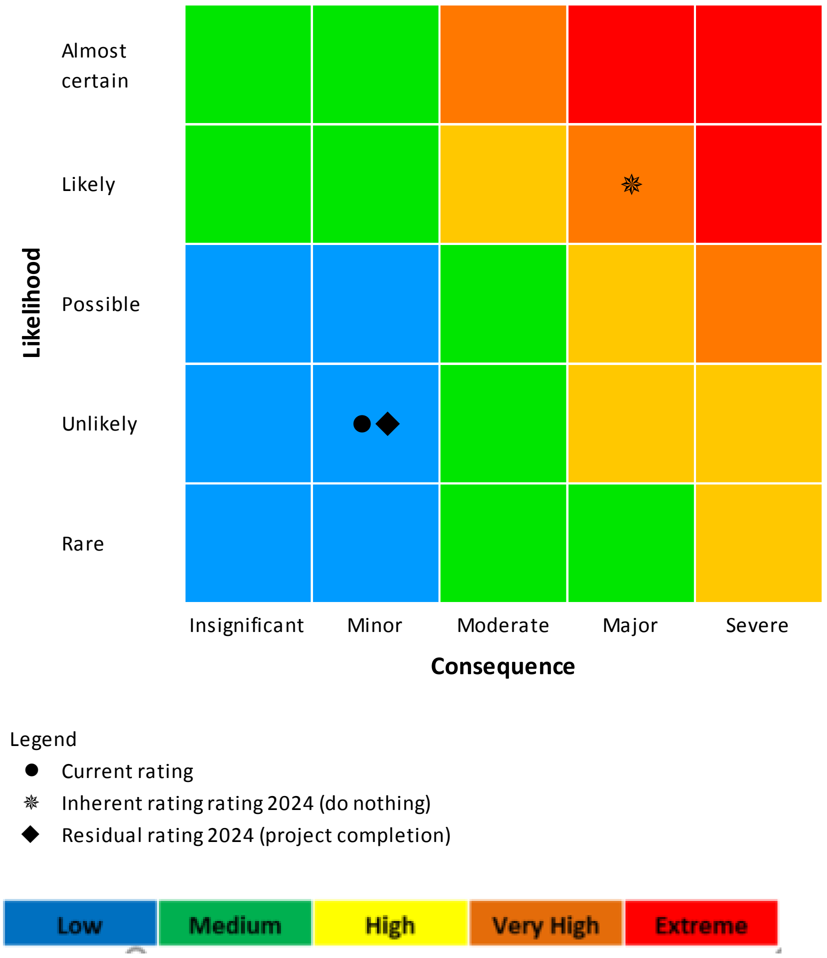
Figure 1 shows the current rating, inherent rating (in 2024, ie. Is no action is taken in the interim), and the residual (post-treatment) risk ratings associated with the overloading of feeders and reduction in N-1 redundancy for distribution feeders in Darwin, Katherine, Tennant Creek and Alice Springs:

(i) Current rating: The current rating (2017) is assessed to be "Low" because for the current levels of feeder loadings in the system and the existing program to identify and augment feeders when issues are identified, it is "Unlikely" that there would cable failures in the distribution system. If they do occur, the failure would result in a short interruption of less than 2 hours and once-off negative media attention. This consequence is classed as "Minor"

(ii) Inherent rating: If the program does not continue in the next regulatory period, the probability of feeder cable failures by 2024 is "Likely", and the failure will result in long term interruption of greater than 12 hours due to the inability to transfer load as the general overloading in the area. There is also likely to be prolonged adverse media attention due to repeated customer outages in the distribution system. This consequence is classed a "Major". The overall risk rating is therefore "Very High".

(iii) Residual rating: The continuation of the proposed program will address the probability and consequence of cable failure. The program will analyse and address overloaded feeders as they become evident and ensure that there is available capacity for N-1 redundancy. Therefore, the likelihood of a failure event is "Unlikely" and the impact of the event will be significantly lessened, to a level classified as "Minor", with the ability to restore supply by transferring load to adjacent feeders. The overall risk rating is therefore "Low".

Figure 1: Feeder Augmentation Risk Assessment[9]



It is Power and Water's current practice to take action on risks that have an inherent rating of 'HIGH' or above. The PBC summarises the proposed response to this impending risk.

4 Potential Solution

A number of potential solutions exists and are briefly discussed below:

4.1 Transfer load to adjacent feeders

Under Class of supply H in the Network Planning Criteria, the area load must be restored within 30 minutes of the first supply contingency. The preference is to explore the possibility of load transfers to keep conductors and cables within their normal ratings rather than cyclic ratings.

It is often not possible to transfer loads in the rural areas due to the radial nature of the network. However, load transfers has been successfully carried out in the urban

[9] Based on PWC's Risk Assessment Guide

areas and has played a significant role in reducing our overloaded feeders from 21 in 2012 to only 4 forecasted in 2018 to 2022 period.

One disadvantage of this solution is that the loading on adjacent feeders can increase significantly due to the transfers and will increase the number of heavily loaded feeders under normal conditions.

Load transfers are generally used as a first step to augmentation works, used to confirm that the high utilisation is due to increase in load and is because of system switching. It can also provide time for investigations and project development should further augmentation works be required.

4.2 Upgrade feeders

The first level of augmentation is to upgrade the feeder to a higher rating. This usually involves replacing the first section of a feeder cable from the medium voltage switchboard in the zone substation to the first RMU or pole. This can be very effective in increasing the capacity of the overall feeder as the first section is usually affected by significant derating due to mutual heating from multiple cables in a common duct or trench in the zone substation.

This solution was implemented at Strangways Zone Substation where the first section of the 22kV feeders were upgraded with 240sqmm Copper XLPE cable. This increased the overall rating of feeders from 180Amps to 291Amps (6.8MVA to 11MVA).

In addition the identification and rectification of any obvious ‘bottleneck’ ratings that may exist within the feeder main truck line.

4.2.1 Berrimah

It is recommended that all six feeders south of Berrimah Zone Substation (11BE03 (TDZ), 11BE04 (MCMILLANS), 11BE09 (JAIL), 11BE13 (KORMILDA), 11BE18 (PORT), 11BE19 (HIDDEN VALLEY), are replaced from the zone substation switchboard to the cable pit on Berrimah Rd, or to the nearest pole where the feeder goes to an overhead powerline. There is a separate project to replace part of the Port feeder (11BE18) due to condition and reliability issues and it is not included in this program[10].

For efficiency, these works should be scheduled with the Berrimah Zone Substation replacement. The estimated cost of the upgrade works is $1.25M. Replacing the first 500m of these cables will improve the available capacity for N-1 redundancy with the average feeder utilisation reducing to approximately 70%.

[10] PBC33006 – Preliminary Business Case – Replace Port Feeder (PWC Ref: D2017/394399)

Table 3 - Berrimah southern feeder loading after increased cable rating in first leg

FEEDER NAME	11BE03 (TDZ)	11BE04 (MCMILLANS)	11BE09 (JAIL)	11BE13 (KORMILDA)	11BE18 (PORT)	11BE19 (HIDDEN VALLEY)
FULL RATING	412 / 340	412	412	412	340	412
FEEDER RATING	340	366	366	366	340	366
alternate feeders	1	2	2	2	1	2
N-1 Utilisation %	50%	67%	67%	67%	50%	67%
BASE GROWTH	-5	8	3	6	0	4
2017	152	161	181	196	141	203
2018	188	199	230	202	141	233
2019	183	237	233	208	142	263
2020	220	276	236	213	142	267
2021	265	314	240	219	142	270
2022	259	352	243	225	143	274
2017	45%	44%	49%	54%	41%	55%
2018	55%	54%	63%	55%	42%	64%
2019	54%	65%	64%	57%	42%	72%
2020	65%	75%	65%	58%	42%	73%
2021	78%	86%	66%	60%	42%	74%
2022	76%	96%	66%	61%	42%	75%

4.3 Demand Management

The cost of demand management on a distribution feeder will vary significantly with the changes in solar and battery prices. Demand Management options will be considered in the short term (2 years) before the feeder is expected to fall outside the Network Technical Code and Planning Criteria requirements.

It should be noted that demand management through use of solar generation is only suitable if supply requirements can still be met under all conditions (e.g. cloudy), or if customers is willing to accept a reduced supply capability under these conditions through load curtailment contracts.

4.4 Augmentation Tie/New feeder

If none of the previous options are viable then augmentation work to install a new feeder or network ties connecting multiple feeders must be carried out. This option is the least likely to be used.

4.4.1 Archer

In the case of Archer, It is recommended that due to the number of highly loaded feeders in the same area, that a new feeder be installed to provide N-1 capacity as well as to cater for the expected load growth. The estimated cost of the new feeder is approximately $2M and will be about 4km in length.

4.5 Non Network alternatives

Non-network options will be considered on a case by case basis.

4.6 Capex/Opex substitution

Capex/opex substitution will be considered on a case by case basis.

5 Strategic Alignment

This project aligns with the Corporation's key result areas of operational performance and customer centricity, where the goals are to be an efficient provider of services and delivering on customers' expectations.

This project will allow PWC to safely and reliably meet current and future demands for the distribution networks in Darwin, Katherine, Tennant Creek and Alice Springs.

6 Timing Constraints

It is important to complete the required augmentation works to relieve constraints in the network and ensure compliance with the technical planning criteria as they are identified, so that PWC can met all its regulatory obligations.

7 Expected Benefits

Driver	Benefit	Measure
Growth / Demand	Meet customer requirements	Feeders not overloaded beyond rating.
Compliance	Customers remain on supply under contingency.	Meets Network Planning Criteria N-1 requirements.

8 Milestones (mm/yyyy)

Investment Planning	Project Development	Project Commitment	Project Delivery	Review
08/2017	03/2019	06/2019	06/2024	09/2024

9 Key Stakeholders

Stakeholder	Responsibility
General Manager Power Networks	Internal governance stakeholders
Group Manager Service Delivery	
Chief Engineer	

Stakeholder	Responsibility
Senior Manager Network Development and Planning	Internal design stakeholders
Senior Manager Contracts and Projects	
Senior Manager Asset Management	
Manager Test & Protection Services	
General Manager System Control	
Manager SCADA and Communication Services	
Local Residents	External – Unions and public
ETU	
Ministers	
Utilities Commission	External regulators
Australian Energy Regulator	

10 Resource Requirements

Resource Type/Role	How Many	Internal/ External	Anticipated Start Date	Duration Required	Review Allocation (% time or # hrs/days/ wks/mths)
Planning Engineer	1	Internal	Jan 2020	3 months	30%
Procurement Officer	1	Internal	Jan 2020	3 months	30%
Project Manager	1	Internal	Jan 2020	3 months	30%

11 Delivery Risk

A Preliminary Project Implementation Assessment was conducted for this project and the key risks to delivery of the investment are detailed below:

Risk/Impact Description	Proposed Action

Risk/Impact Description	Proposed Action
System Outages will be required for connection of new equipment or modifications to existing equipment	Cutover/outage plan to be developed with System Control
There may be work on or near existing high voltage equipment.	Personnel accessing the switchyard shall follow existing Access to Apparatus Rules.
Possible budget overruns	Ensure detailed budget and RACE analysis are completed during the project development phase.

The project will be delivered by the Power Networks Contracts and Projects group or the Network Engineering group, with the Investment Planning phase completed by the Power Networks Network Development and Planning group.

12 Financial Impacts

12.1Expenditure Forecasting Method

The expenditure forecast is based on extrapolation from historical cost and a forecast of overloaded and low redundancy feeders.

12.2Historical and Forecast Expenditure

The table below shows the previous actual historical expenditure (2014-2017) and forecast expenditure (2017/18-2018/19) for the feeder augmentation program. The current regulatory control period is estimated to total $6.96M. It can be seen that the program expenditure shows a decline in recent years.

Program	2013/14 ($'000)	2014/15 ($'000)	2015/16 ($'000)	2016/17 ($'000)	2017/18 ($'000)	2018/19 ($'000)
Feeder Augmentation Program	2581	1627	1352	1380	1300*	1300*

*Budgeted for 2017/18 and 2018/19

The previous augmentation expenditure on medium voltage feeders and declining load growth has resulted in a significant decrease in overloaded feeders. In 2012/13, there were 21 feeders identified as being overloaded or forecasted to be overloaded within a five year period. The 2016/17 study on medium voltage feeders has only 6 feeders indicated to be overloaded, of which 2 have solutions underway.

It should be noted that the focus in previous years has been on reducing overloaded feeders in the distribution network. In the next regulatory period, PWC will focus on meeting its obligations in the Technical code and Network Planning Criteria by reviewing contingency situations.

12.3 Validation

The expenditure forecast has been validated through trend analysis and based on previous expenditure in the regulatory period.

12.4 Capex Profile

The capex below is in $2017-18 and is excluding capitalised overheads and cost escalation.

Phase	2019/20 ($'000)	2020/21 ($'000)	2021/22 ($'000)	2022/23 ($'000)	2023/24 ($'000)	Total ($'000)
Investment Planning						
Project Development	100	100	100	100	100	500
Project Commitment	50	50	50	50	50	250
Project Delivery	1,000	1,000	1,000	1,000	1,000	5,000
Review	50	50	50	50	50	250
Total	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**6,000**

12.5 Opex Implications

Opex for feeders after augmentation works associated to capacity increases will remain similar and is not expected to change. There will be opex increases associated with new feeders or extensions to tie to an existing feeder. The cost of maintenance of a distribution feeder is estimated to be approximately $198 per km.

12.6 Variance

N/A

Appendix A – Planning Report

Refer:

NPR1702 Feeder Augmentation 2019-24

PWC Ref: D2017/374982

PowerWater

Report No:	NPR1702	**File No:**	D2017/374982
Revision	Final	**Container No:**	F2005/13996
Date:	13th February 2018		
Author:	Christina Camilleri		
Approved by:	Tat Au-Yeung – Senior Manager Network Development and Planning		
Title:	Feeder Augmentation 2019-24		

Report Circulation:

The following staff members are on the circulation list for this report:

Goutham Maddirala	Peter Kwong	

13 Executive Summary

This study reviews the forecast loading of 11 and 22kV feeders across all regions. The report demonstrates that the current configuration of the distribution network often does not meet the contingency requirements Network Technical Code and Network Planning Criteria.

Individual feeder works will need to be carried out as limits are reached to ensure that under normal conditions and contingencies the planning criteria is met.

It is recommended that development work is carried out to determine appropriate methods of meeting demand requirements on feeders and estimated that cost of works between 2019-2024 will be $6.0M.

14 Background

The urban area of Darwin and Alice Springs is fed with 11kV distribution feeders. These are generally meshed to meet return of supply timeframe requirements under the Network Technical Code and Planning Criteria.

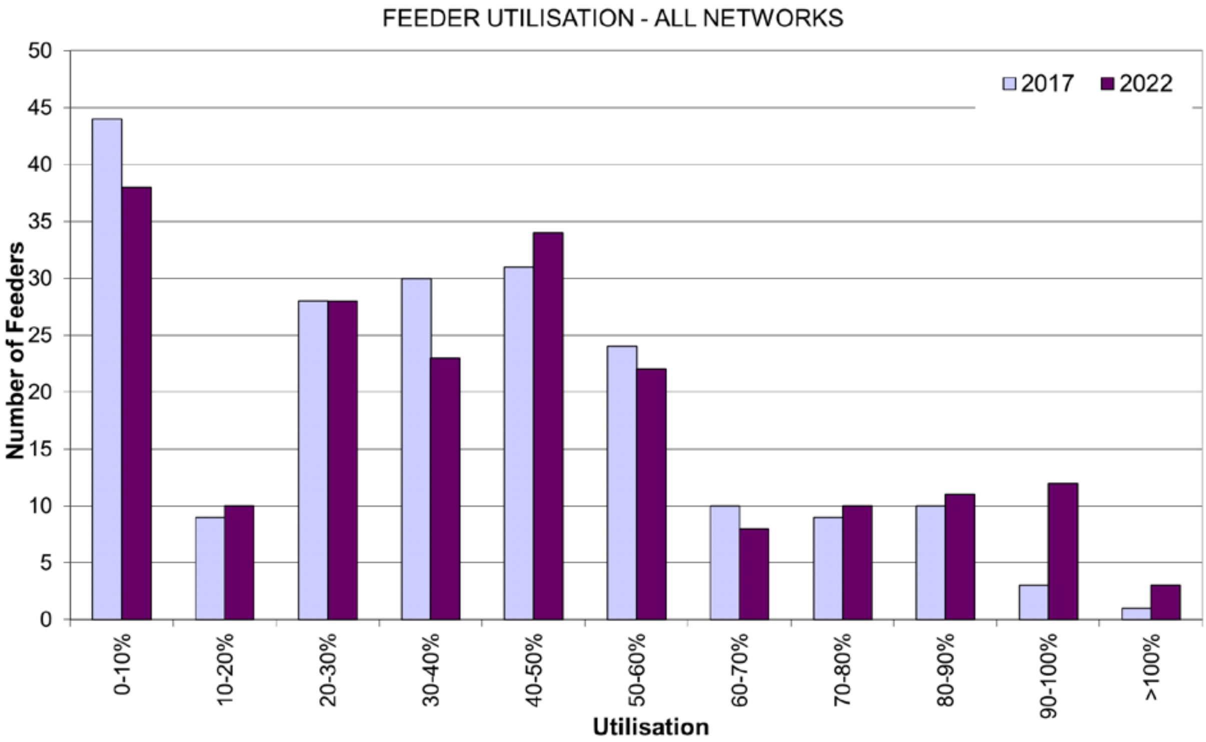
The remaining rural areas of Darwin and Alice Springs, as well as all of Katherine and Tennant Creek run a 22kV distribution network. Within the inner town area these are generally meshed.

Base growth on feeders has reduced significantly as has step changes due to developments occurring. However when there is change in growth, it is rapid and the first areas of constriction will be on the feeder network due to lower diversification. Notification from developers is usually only 1 year in advance and no notification for industrial subdivisions where empty lots are developed within their initial design allocation.

15 Review of overloaded feeders

There are 4 feeders expected to be overloaded within the 5-year timeframe. Two feeders are at Archer Zone Substation and two at Berrimah Zone Substation.

These feeders are all overloaded because of step load changes due to subdivision development.



15.1 Archer

The feeders at Archer Zone Substation are increasing due to step load changes from new residential land releases in the east Palmerston area. It is expected that no further transfers would be possible in this area due to alternate feeders also having high utilisation. The forecast 2022 average utilisation of the 6 feeders (inc 2 overloaded) is 86% (Table 1), this is very high when considering available switching points and N-1. Due to the number of highly loaded feeders in the same region, a possible solution would be a new feeder be installed to provide N-1 capacity as well as any minor load growth. Estimated cost is $2M for 4km at a cost of $500,000 per kilometre. The need for any work to proceed would be dependent on the annual forecast and potential solutions considered when load growth is confirmed.

Table 3 - Archer feeder forecast loading and utilisation

FEEDER NAME	AR01 (ZUCCOLI SOUT	11AR07 (JOHNSTON)	11AR14 (ZUCCOLI NORTH)	11AR15 (ROSEBURY HUB)	11AR17 (ROYSTONEA)	11AR18 (ZUCCOLI EAST)
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FEEDER RATING	329.6	330	366.4	329.6	329.6	329.6
alternate feeders	1	1	2	1	1	1
N-1 Utilisation %	50%	50%	67%	50%	50%	50%
BASE GROWTH	0.00	0	0	3	14	0
2017	0	273	0	185	245	76
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2017	0%	83%	0%	56%	74%	23%
2018	12%	92%	20%	57%	79%	46%
2019	23%	100%	40%	58%	83%	69%
2020	35%	105%	60%	59%	87%	92%
2021	47%	105%	60%	60%	92%	115%
2022	58%	105%	80%	61%	96%	115%

15.2 Berrimah

The McMillans and Hidden Valley feeders at Berrimah are also expected to be overloaded due to step loads in future residential and industrial land releases. 6 feeders south of Berrimah Zone Substation (11BE03 (TDZ), 11BE04 (MCMILLANS), 11BE09 (JAIL), 11BE13 (KORMILDA), 11BE18 (PORT), 11BE19 (HIDDEN VALLEY), are forecast to have an average utilisation in 2022 of 83% (refer to Table 2).

Replacing the first 500m of these cables will improve available capacity for N-1 with average utilisation reduced to 70% (Table 2). This would involve replacing from the Zone Substation circuit breaker to a pit on Berrimah Rd, or to the nearest pole where within 200m the feeder goes to an overhead. Two of these feeders are paper lead insulated and have been experiencing reliability issues. These works could be timed with the Berrimah Zone Substation switchboard replacement. Estimated cost $1.5M (6 feeders in a bank, 500m). Estimated increase in capacity of 1MVA.

The Berrimah area has high amount of industrial load and growth is spurious so it is likely that overload and contingency issues will occur in the 2019-2024 period.

Table 2 - Berrimah southern feeder loading and utilisation

FEEDER NAME	11BE03 (TDZ)	11BE04 (MCMILLANS)	11BE09 (JAIL)	11BE13 (KORMILDA)	11BE18 (PORT)	11BE19 (HIDDEN VALLEY)
FULL RATING	412 / 340	412	412	412	340	412
FEEDER RATING	272	330	330	330	272	330
alternate feeders	1	2	2	2	1	2
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2018	69%	60%	70%	61%	52%	76%
2019	67%	72%	71%	63%	52%	84%
2020	81%	84%	72%	65%	52%	92%
2021	97%	95%	73%	66%	52%	100%
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Table 3 - Berrimah southern feeder loading after increased cable rating in first leg

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FEEDER RATING	340	366	366	366	340	366
alternate feeders	1	2	2	2	1	2
N-1 Utilisation %	50%	67%	67%	67%	50%	67%
BASE GROWTH	-5	8	3	6	0	4
2017	152	161	181	196	141	203
2018	188	199	230	202	141	233
2019	183	237	233	208	142	263
2020	220	276	236	213	142	267
2021	265	314	240	219	142	270
2022	259	352	243	225	143	274
2017	45%	44%	49%	54%	41%	55%
2018	55%	54%	63%	55%	42%	64%
2019	54%	65%	64%	57%	42%	72%
2020	65%	75%	65%	58%	42%	73%
2021	78%	86%	66%	60%	42%	74%
2022	76%	96%	66%	61%	42%	75%

16 Review of feeders under N-1

In previous years feeder augmentation concentrated only on overloaded feeders. It can be seen in Appendix A that the utilisation profile of feeders has greatly improved. Going forward more effort will be placed in meeting the planning criteria requirements for contingencies.

A high level of feeders under N-1 contingency in the planning criteria, shows that in the urban areas of Darwin and Alice Springs (11kV systems) there are quite a number that are unlikely to meet the current network planning criteria in 2022.

	Overloaded	N-1 exceeded		Total feeders
	No.	No.	%	No.
Darwin 11kV	4	35	27%	131
Alice Springs 11kV	0	7	47%	15

Further study needs to be carried out on each feeder to check augmentation requirements but it is estimated that 50% (21) of the identified feeders are likely to need some sort of augmentation. Estimated cost per feeder for augmentation is $300,000. Total N-1 augmentation is expected to be $6.3M. Some work will be completed prior to the next regulatory period (2019-2024).

17 Review of feeder voltage limits

Modelling of the distribution 11kV and 22kV network is carried out to determine if there are voltage limit issues. Due to resourcing constraints this is currently only carried out when considering new subdivisions.

In future, modelling of both the existing system combining both load and penetration of embedded generation will be carried out and resourcing allocated in the 2019-2024 period.

18 Options Considered

When a feeder is identified as being overloaded within a 2 year period, this triggers the assessment of options to meet future loading requirements.

18.1 Do Nothing

This option is not considered reasonable since the forecast maximum demand on feeders can vary significantly with step changes or sudden economic changes. The system needs to be analysed annually to ensure that there has not been a shift in growth areas, new development etc as these impact immediately on feeders. Annual analysis also assists in deferring work until it is required.

18.2 Transfer load to adjacent feeders

Most 11kV feeders fall under Class of supply B (1-5MVA) in the Network Planning Criteria area load must be restored within 3 hours of the first supply contingency. 22kV feeders are usually Class F requiring restoration in 6 hours. This makes transfer of load rather than installation of temporary generators preferable to meet the timeframe.

Wherever possible, transfers are carried out to meet normal supply or contingency requirements. In the urban areas load transfers have been carried out as a significant part of reducing our forecast overloaded feeders from 21 feeders in 2012 to only 4 in 2017 (refer to Appendix D and Appendix E).

When a feeder is identified as being overloaded within a 2 year period, transfers are used in the first year to allow confirmation that the load is correct, and secondly to give time to organise design and funding of other augmentation work as required.

18.3 Upgrade feeders

The first level of augmentation is to upgrade the feeder to a higher rating. There are some instances where this is very effective and it has been seen when replacing the first section of a feeder cable into a Zone Substation as this will have a derating due to mutual heating. The length of the cable where mutual heating occurs as well as the remaining backbone feeder conductor is what determines the effectiveness of this augmentation work. During the replacement of McMinns Zone Substation with Strangways Zone Substation the first section of the feeders were replaced with our current 240sqmm Copper XLPE 22kV standard cable. This increased the rating of feeders from 180Amps to 291Amps (6.8MVA to 11MVA).

18.4 Demand Management

The cost of demand management on a distribution feeder will vary significantly with the changes in solar and battery prices. Demand Management options will be considered in the short term (2 years) before the feeder is expected to fall outside the Network Technical Code and Planning Criteria requirements.

It has to be considered that demand management through use of solar is only suitable if under cloudy conditions supply requirements can still be met, or customers accept reduced supply capability.

18.5 Augmentation Tie/New feeder

If none of the previous options are viable then augmentation work to install a new feeder or provide a tie to another feeder must be carried out. This option can provide additional security as well as capacity to customers.

19 Comparison with previous expenditure

Previous expenditure in Appendix A Table 2.3.4 Augex expenditure shows a decline in recent years.

The augmentation on HV feeders and declining load growth has resulted in a significant decrease in overloaded feeders. In 2012/13 there were 21 feeders identified as being overloaded/forecast to be overloaded within a five year period (refer to Appendix D). The 2016/17 studies on HV feeders (refer to Appendix E) has only 6 feeders indicated to be overloaded, of which 2 have solutions underway.

It should be noted that the focus in previous years has been on reducing overloaded feeders. In future, PWC will also be ensuring it meets the Technical Code and Network Planning Criteria by reviewing contingency situations.

The expenditure proposed is $9.8M across the regulatory price period, it is expected that efficiencies can be made and reduce this to $6.0M. Per year this is still less than 2015/16 expenditure.

D2013/276061 2013 FEEDER UTILISATION AND ZSS RECONCILIATION 3/01/2014 at 2:50 PM 28/05/2013 at 4:40 PM DOCUMENT - BEN HAMMOND

20 Conclusion

$6.0M of augmentation works to prevent overloaded feeders under normal situations and contingency situations.

2.3.4 - AUGEX - TOTAL EXPENDITURE									
	EXPENDITURE ($0's)								
AUGMENTATION CAPEX (as incurred)	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Subtransmission Substations, Switching Stations, Zone Substations	15,317,973	17,702,705	13,119,127	18,660,445	38,333,853	16,534,123	11,296,870	6,267,058	
Subtransmission Lines	3,642,960	1,867,952	1,905,988	-	-	-	-	-	
HV Feeders	17,338,627	11,427,732	6,726,658	7,940,151	14,691,178	5,781,353	7,242,419	3,301,464	
HV Feeders - Land Purchases and Easements	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	
Distribution Substations	5,044,144	5,228,017	3,771,122	1,532,998	1,615,335	573,758	269,576	204,216	
Distribution Substations - Land Purchases And Easements	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	
LV Feeders	996,864	290,335	237,940	712,554	891,058	353,046	76,485	59,529	
LV Feeders - Land Purchases And Easements	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	
Other Assets	-	412	-	1,928,098	4,958,799	4,274,827	2,542,444	1,110,335	

D2017/207563 Revision 33

				2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
NFO	Overloaded Feeders / Distribution Augmentation Program	NFO	Distribution Lines	1,300,000	1,300,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000

Overloaded Feeders/Distribution Augmentation estimated asset quantities

PROJECT TYPE	Units	VOLUMES (0's)						
		2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
DESCRIPTOR METRICS - UNITS ADDED								
HV Feeder Augmentations - Overhead Lines	Circuit Line Length in KM		3	4				2
HV Feeder Augmentations - Underground Cables	Circuit Line Length in KM				.45	1.2	1.2	.5
DESCRIPTOR METRICS - UNITS UPGRADED								
HV Feeder Augmentations - Overhead Lines	Circuit Line Length in KM							
HV Feeder Augmentations - Underground Cables	Circuit Line Length in KM	0.3	.6	1.5	1.5			1

Appendix C. Forecast overloaded feeders

ZONE	ARCHER		BERRIMAH			CASUARINA	PALMERSTON				WEDDELL
FEEDER NAME	**11AR07 (JOHNSTON)**	**11AR18 (ZUCCOLI EAST)**	**11BE03 (TDZ)**	**11BE04 (MCMILLANS)**	**11BE19 (HIDDEN VALLEY)**	**11CA15 (HOSPITAL)**	**11PA04 (BAKEWELL)**	**11PA08 (YARRAWONGA)**	**11PA15 (MOULDEN)**	**11PA18 (WOODROFFE)**	**22WD103 (BLAYDIN)**
FULL RATING	412	412	412 / 340	412	412	412 / 340	300	340	300	300	415
FEEDER RATING	329.6	329.6	272	330	330	272	240	272	240	240	332
alternate feeders	1	1	1	2	2	2	3	2	3	2	1
N-1 Utilisation %	50%	50%	50%	67%	67%	67%	75%	67%	75%	67%	50%
BASE GROWTH	0.00	0.00	-5	8	0	-7	1	4	1	-1	0
2017	273	76	152	161	173	288	193	249	212	225	191
2018	302	152	188	199	251	281	194	253	213	224	341
2019	331	227	183	237	278	273	196	257	215	223	341
2020	346	303	220	276	304	266	197	261	216	222	0
2021	346	378	265	314	330	258	199	265	218	221	0
2022	346	378	259	352	330	251	200	269	219	221	0

> N-1 Utilisation%

> 100% utilisation

2017	83%	23%	56%	49%	52%	106%	80%	92%	88%	94%	58%
2018	92%	46%	69%	60%	76%	103%	81%	93%	89%	93%	103%
2019	100%	69%	67%	72%	84%	100%	82%	95%	90%	93%	103%
2020	105%	92%	81%	84%	92%	98%	82%	96%	90%	93%	0%
2021	105%	115%	97%	95%	100%	95%	83%	97%	91%	92%	0%
2022	105%	115%	95%	107%	100%	92%	83%	99%	91%	92%	0%

11AR07 (JOHNSTON): new subdivision loading. monitor. overload is within cyclic rating of cable

11AR18 (ZUCCOLI EAST): new subdivision loading. monitor. Transfer load to Bellamack1 or Rosebury Hub

11BE03 (TDZ): new subdivision loading. near limits of cable. Monitor. New feeder from Wishart to transfer all load south of Tiger Brennan (2km, conduit already laid). $500,000

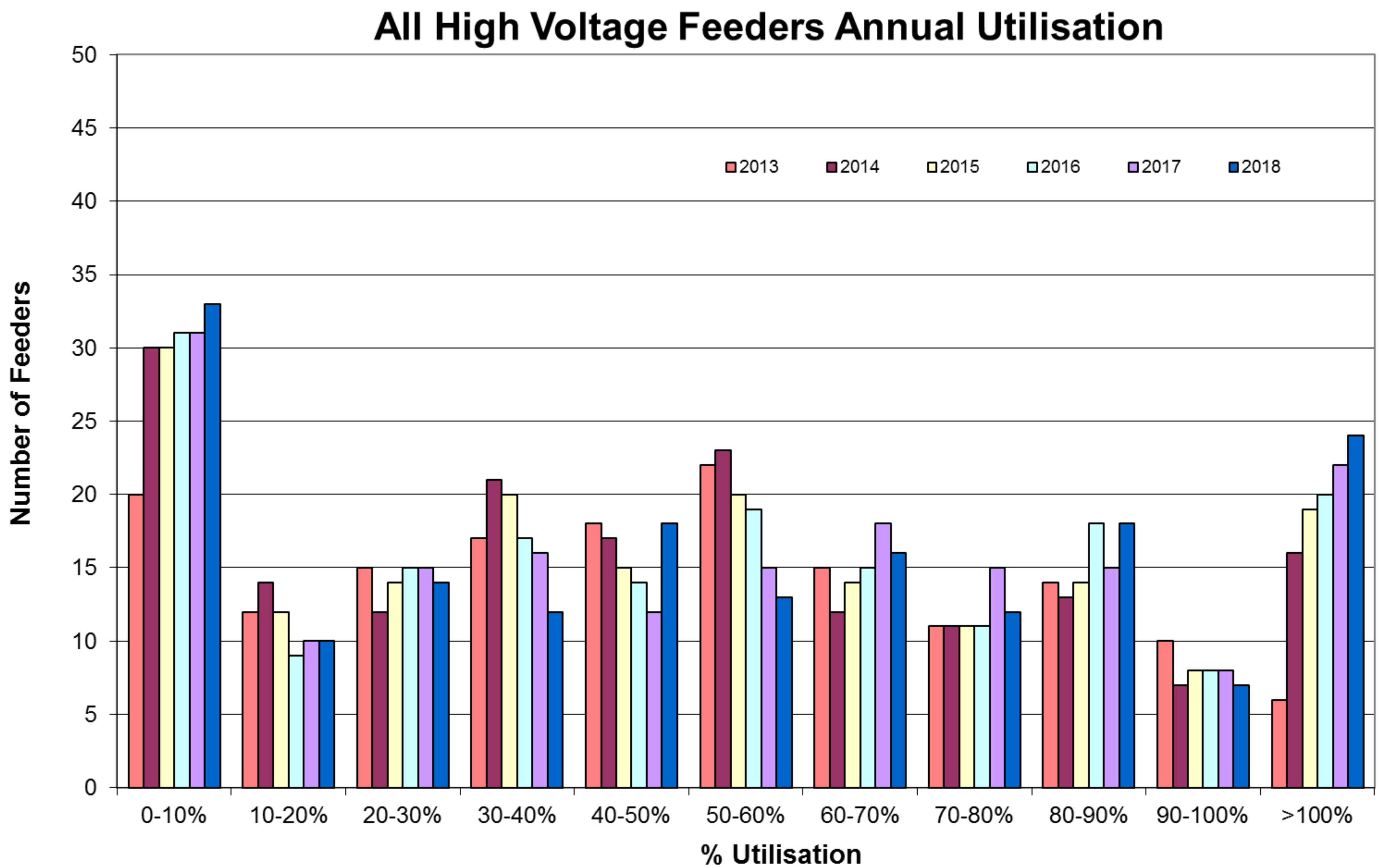
11BE04 (MCMILLANS) / 11BE19 (HIDDEN VALLEY): new subdivision loading. monitor. overload is within cyclic rating of cable. New wishart feeder to deload TDZ will assist

11CA15 (HOSPITAL): current loading. monitor overload is within cyclic rating of cable. New wishart feeder to deload TDZ will assist. Load to be transferred to leanyer ZSS. Load within cyclic rating of cable, load is declining. Loading within cyclic rating

PALMERSTON: Several feeders highly loaded, low growth. It is worth uprating these feeders particularly those with 240A rating to their full 300A rating by upgrading the first section of cableout of the zone substation. $200,000

22WD103 (BLAYDIN): customer load - inpex. Load within cyclic rating of cable. Load expected to be removed 2018-19

Appendix D. Feeder Utilisation 2013-14 Forecast



Appendix E. Feeder Utilisation 2016-17 Forecast