Alma-Rock Elm Area Transmission Study

Prepared By:

Terry Torgerson

Power Delivery Planning & Operations

Dairyland Power Cooperative

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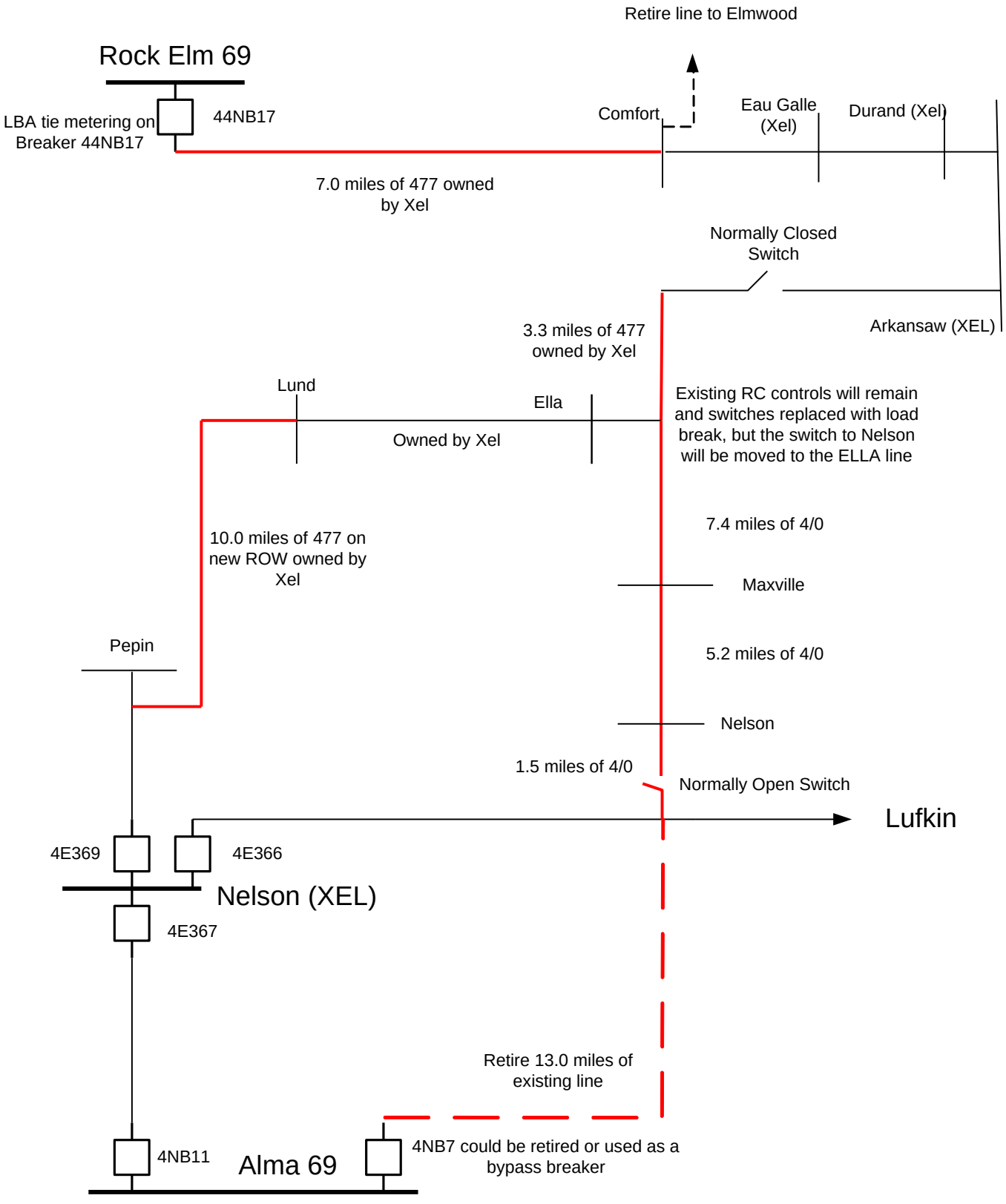
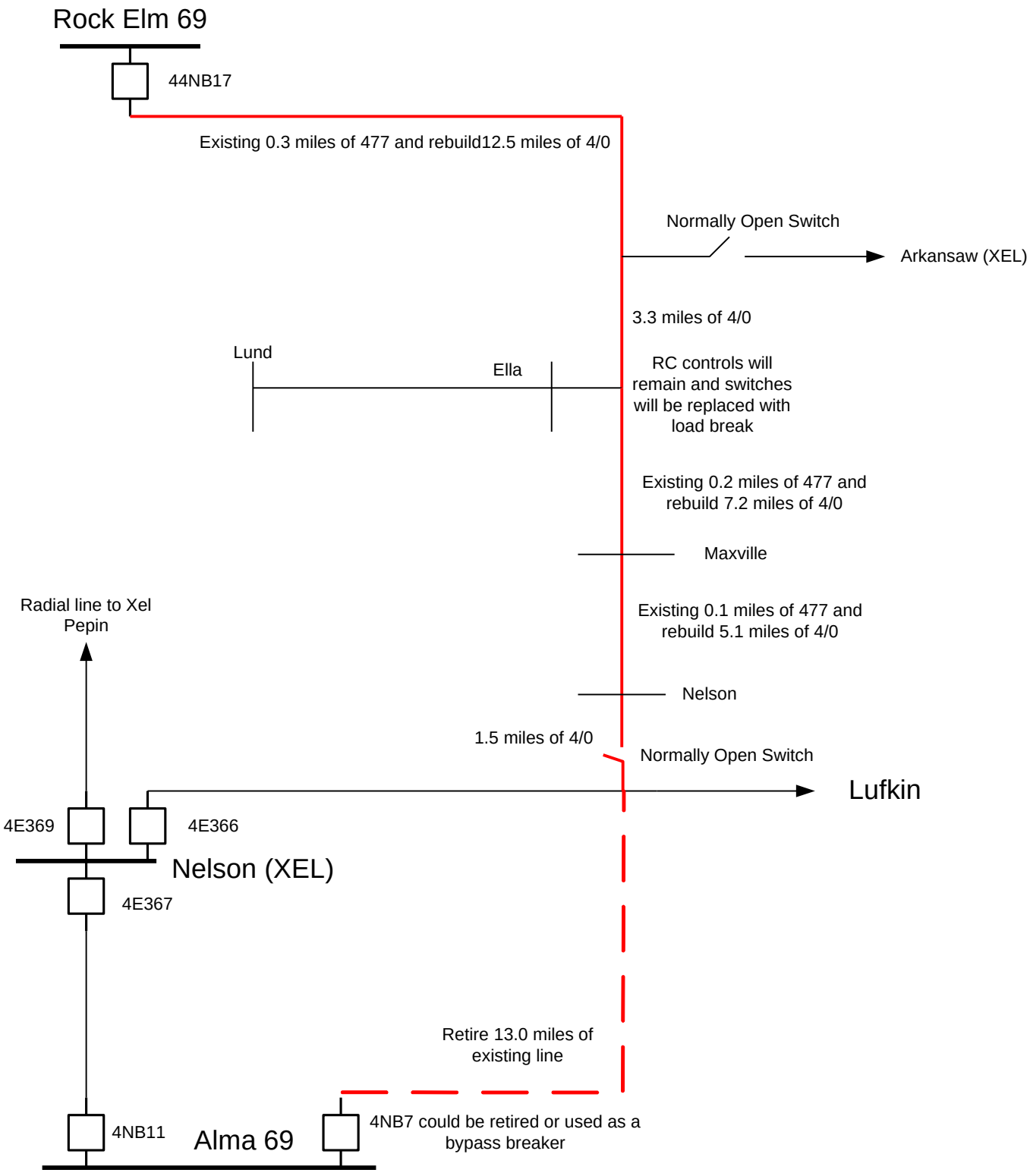


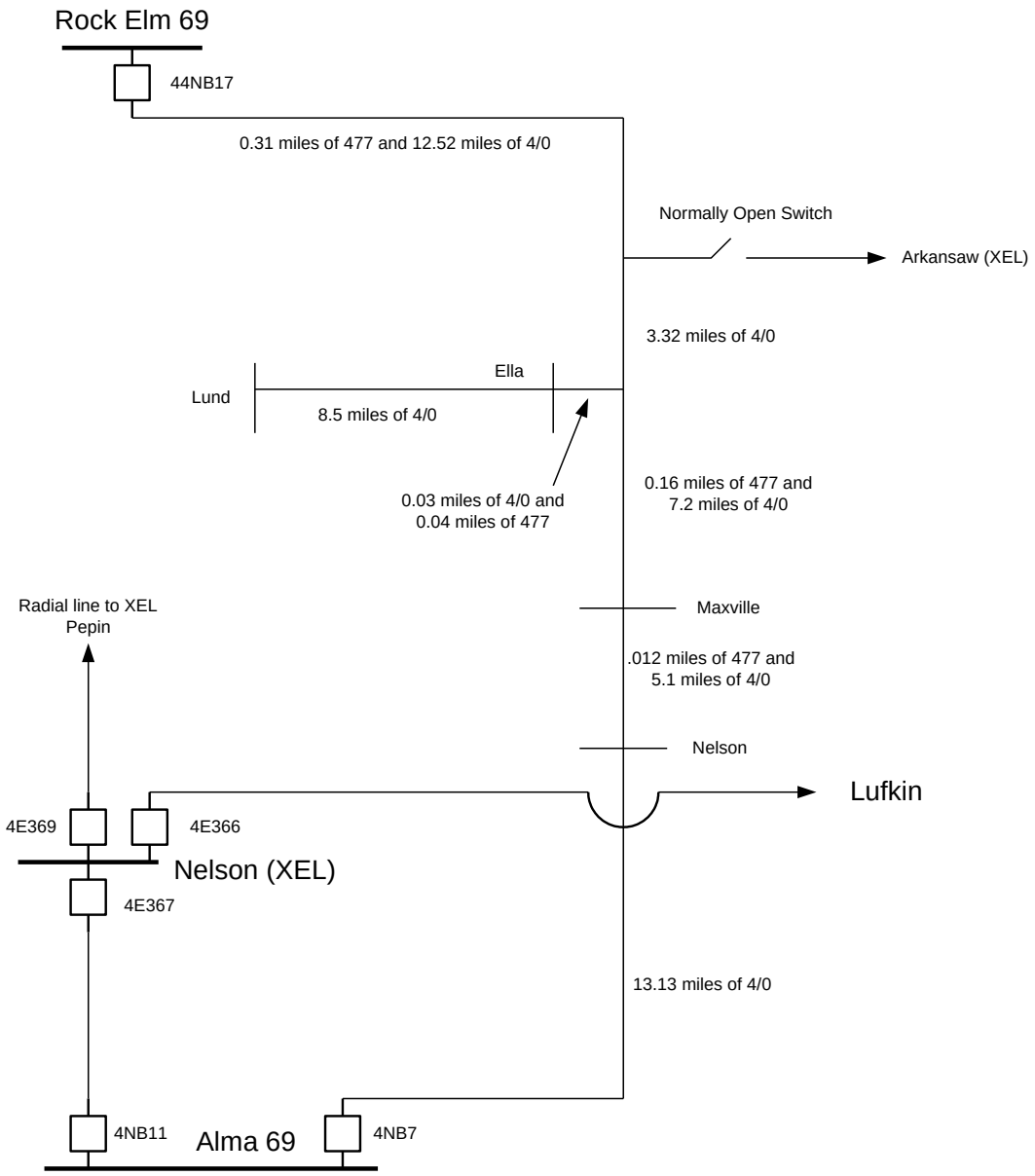
Alternative 8



1. Executive Summary

This report analyzes the 69 kV transmission needs for the Alma-Rock Elm area. The main sources for the Alma-Rock Elm 69 kV line (N-5) are Dairyland Power Cooperative's (DPC's) Alma and Rock Elm 161/69 kV substations. The Alma-Rock Elm 69 kV line serves customers of Riverland Energy Cooperative and Pierce Pepin Cooperative Service.

Existing System



Built in 1948, the N-5 transmission line is approaching the end of its useful life, due to potential future reliability issues and maintenance costs. The primary purpose of this study is to examine

the long-term requirements in the Rock Elm-Alma area, in particular for distribution loads served from the N-5 line.

Eight alternatives were examined based on economics, line exposure, reliability history, age, condition, and contingency performance. Alternative 8 is DPC's recommended plan (see Figure 1), which mainly includes the rebuild of existing facilities. The project cost is approximately $7.5 Million. See the list below of the upgraded facilities for Alternative 8:

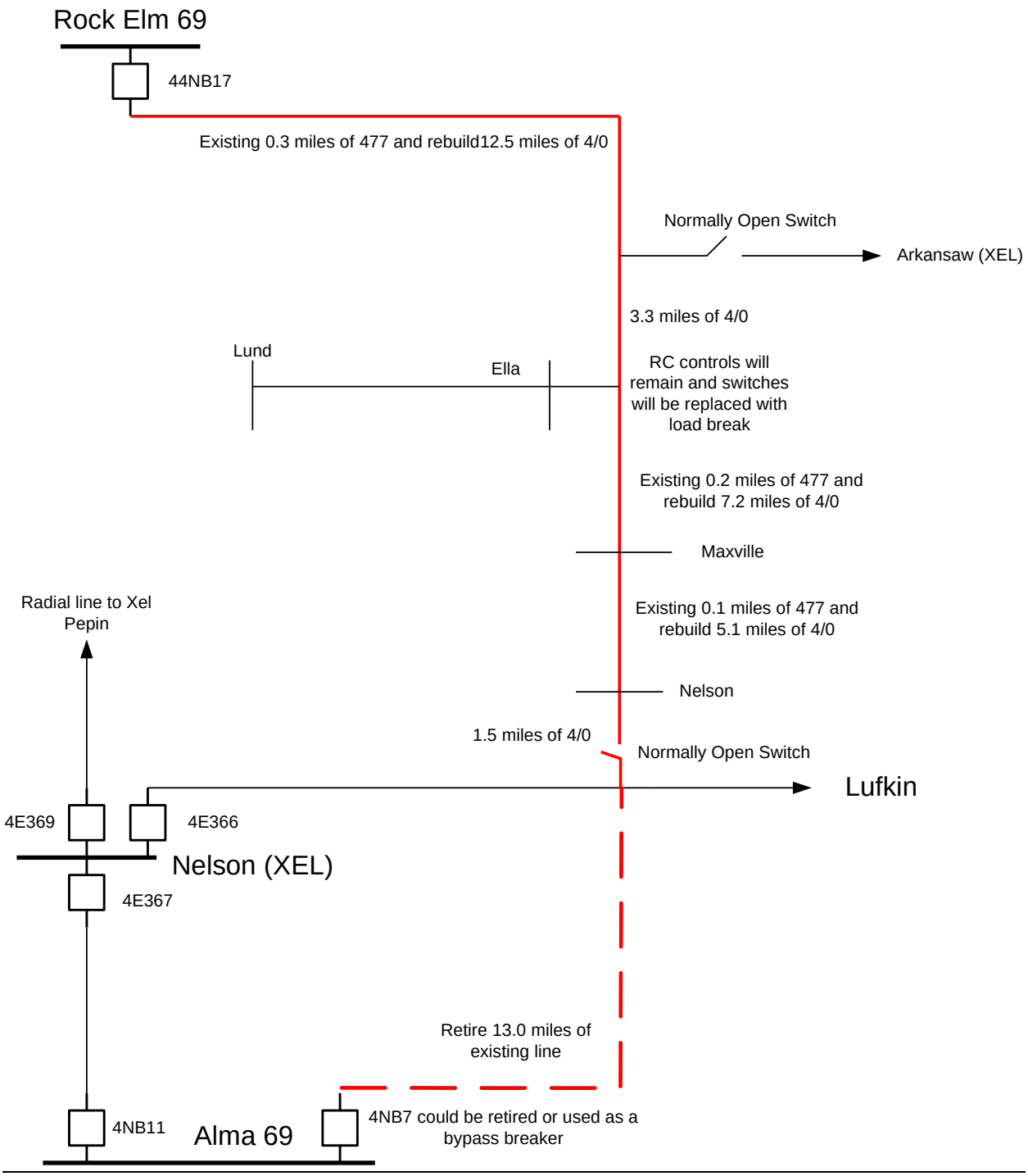
1. Rebuild 29.8 miles of the N-5 from Rock Elm to XEL's Nelson to Lufkin 69 kV line with 4/0 ACSR.
2. Retire approximately 13.0 miles of the N-5 line between Nelson and Alma
3. Xel installs a 3-Way GOAB at the new interconnection on the Nelson-Pepin 69 kV line.

An optional plan to Alternative 8 is Alternative 3, if XEL is willing to build the line from Pepin to DPC's Lund substation. Alternative 3 provides a second source to XEL's Pepin load, which is served on an 8-mile radial line. This alternative also provides a second source to DPC's Lund substation, which provides a higher reliability to this load even though the cooperative can back-up the Lund substation from other sources. See Alternative 3 in the back of this report.

Figure 1. (Alternative 8)

Rebuild/ new facilities in red

Alternative 8



Introduction

1.1 Purpose and Background

The purpose of this study is to identify age, condition, and load-serving issues on DPC's transmission system in the Rock Elm-Alma area. The study will also determine the optimum plan for serving the Alma-Rock Elm (N-5) load into the future.

1.2 Scope

The N-5 line from DPC's Alma to Rock Elm substation is approximately 41 miles long with four 69 kV distribution taps at Nelson (0.03 miles), Maxville (0.04 miles), Ella (0.07 miles) and Lund (8.3 miles). The construction of the N-5 line occurred in 1948 therefore this line is approximately 67 years old. The typical estimated life span of a wood pole structure is between 55 to 65 years old. This line is beyond that age and will be reviewed for a possible rebuild.

The study scope includes:

- Review the N-5 outage data.
- A visual assessment by the North-Area Transmission Maintenance Supervisor.
- Identify any long-term transmission deficiencies in the area due to transmission contingencies
- Test proposed alternatives using PSS/E.
- Determine the Transmission Exposure indices for each alternative and the existing system.
- Perform an economic analysis of each alternative.

2. Model Development and Changes

The base cases for the Rock Elm-Alma (N-5) Transmission Study are the 2016 summer, 2016 winter, and 2020 summer peak models (MRO 2014 series). DPC utilizes the Siemens Power Technologies International program: Power System Simulator (PSS/E) to determine the existing transmission system problems for the Rock Elm-Alma area. No changes were required in the area for these existing cases.

3. Existing System Analysis

The study area for the N-5 study includes the loads (see table below for loads) from the Durand area to the Alma-Rock Elm area. This area has approximately 55 MW of load in the area. DPC owns the N-5 line from the Rock Elm substation to the Alma substation. This line was constructed in 1948 with 4/0 ACSR conductor, at a design sag limit of 120° F. This line has a summer rating limit of 25 MVA.

Alma-Rock Elm Area Loads

	2016 loads	2020 loads	2025 Loads
Station Name	MW	MW	MW
Lund	1.7	1.7	1.8
Ella	1.8	1.9	2
Maxville	1.8	1.9	1.9
Nelson	2.5	2.6	2.7
NSP Nelson	0.9	1	1
Pepin	3.2	3.3	3.2
Gilmanton	1.4	1.5	1.5
Naples	5.5	5.7	5.7
Rock Falls	3.7	3.9	4
Arkansaw	4.7	4.9	4.9
Durand	6.6	6.8	6.9
Eau Galle	3.6	3.7	3.7
Comfort	1.9	2	2
Elmwood	3.5	3.6	3.6
Mondovi	2	2.1	2.2
El Paso	2.3	2.4	2.5
Trimbell	3.7	3.8	4
Beldenville	2.3	2.4	2.5
Total	**53.1**	**55.2**	**56.1**

3.1 Age and Condition of the N-5 line

Table 1 shows the age, condition and design of the N-5 line. The opinion of the Transmission Maintenance Supervisor of the DPC-North Area describes the condition of the N-5 from Alma to Rock Elm as deteriorating and in need of a rebuild. The basis for this opinion is the amount of future line maintenance and the perceived reliability of the 1948 vintage line.

Table 1 **Existing Line Data**				
Line Name **(Number)**	Installed/ built Date	Condition	Structure Type	Shield Wire
N-5 (Rock Elm-Alma)	1948	Poor	Wishbone	Yes

3.2 Condition of Xel's Radial Pepin 69 kV line

XEL's Pepin 69 kV line has 4/0 ACSR conductor and has a shield wire for lightning protection. In 2011, Xel recognized the Pepin 7.8 mile tap line was performing less than desirable. Xel initiated a project that focused on enhancing reliability and minimizing outages for this line. The project repaired or replaced numerous pieces of hardware, such as the removal of the existing insulators and replacing them with 115kV or 88 kV horizontal post insulators, replacing some wooden guy wire strain insulators, tightening guy wires, repairing damaged guy wire anchors, and performing other refurbishment type work. This project was completed in September 2012. Since completion of that work, Xel has experienced two outages on this line, which both occurred in 2013. The first outage was a momentary outage due to a lightning strike, while the other outage was a sustained outage. The sustained outage was unavoidable due to numerous downed trees during a severe storm. The opinion of Xel's asset management personnel is the condition of radial 69 kV line to Pepin is good and should perform well for another 10 to 15 years.

3.3 Momentary/ Sustained Operations

The basis for the momentary outage history, shown in Table 2, is the automatic opening and closing of the circuit breaker(s) protecting each line. The number of breaker operations (open and close), time and date of each breaker operation provides the raw breaker operations data. The automatic reclosing relaying will attempt to reclose the line one or more times before a breaker locks out. This locking out of a breaker/ line is an unscheduled sustained outage. The temporary operation of a circuit breaker within a five-minute window without the breaker locking out is considered a single momentary event or outage. All scheduled outages and unscheduled sustained outages are removed from the number of operations. Only momentary unscheduled event outages are included in Table 2. The Alma to Rock Elm 69 line momentary operations are 41% more than the DPC system average. The total miles of exposure on this line is 51 miles. The total line mileage is 57% over the system average of 32.4 miles.

Table 2 Momentary Outages	2010 Ops	2011 Ops	2012 Ops	2013 Ops	2014 Ops	5 year Average Ops (10-14)
Alma-Rock Elm 69kV	4	4	2	2	4	3.20
System average	2.86	2.54	2.04	1.94	2.17	2.27

Table 3 documents the sustained outages for the Rock Elm-Alma 69 kV line. The Rock Elm-Alma 69 kV line section has experienced five sustained outages in the last five years. The sustained outages were due to weather or tree contact with an energized line. Table 3 shows the number and issues surrounding the sustained operations.

Table 3 Sustained Outages	2010	2011	2012	2013	2014	5 year Average (09-13)
Alma-Rock Elm 69kV	1	1	0	1	2	1.0
Sustained Outage Issues						
09/24/2010	Pole washed out (One hour outage)					
05/30/2011	Tree fell into line (One hour and 49 minutes outage)					
05/02/2013	Snow storm in the area (Five minutes outage)					
02/21/2014	Snow, ice and wind storm (Five minutes outage)					
06/02/2014	Tree in the line (Two hour outage)					

3.4 Terminal Limits

Table 4 shows the terminal limits of the Alma-Rock Elm 69 kV line. While not an issue for the existing 4/0 conductor, both of the terminal limits are below the 477 ACSR conductor summer limit of 86 MVA, which is DPC's standard for new and rebuilt 69 kV looped lines.

Table 4

(Existing Terminal Limits)

Line Section	Line conductor size	Conductor Limit (MVA)	Limiting Substation Equipment rating	Next Limit (MVA)
Alma-Nelson	Conductor 4/0 ACSR	47 (25 sag limit)	CT Alma Jumpers 477 ACSR 600 amp Switches RLL	144 97 72 57
Rock Elm-NSP Tap	Conductor 4/0 ACSR	47 (25 sag limit)	RLM Jumpers 636 ACSR CT 600 amp Switches RLL	118 96 72 69

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3.5 Contingency Analysis

No single contingency outages in the area bounded by Alma, Red Wing, Hastings, and Cedar Falls results in equipment overloads or low voltages with the existing Rock Elm to Alma 69 kV line looped. DPC's contingency criterion includes the following:

- System normal; no line overloads greater than 100% of the normal rating and system voltages between 95% and 105% of nominal voltage.
- Single contingency outages; no line overloads greater than 100% of the normal rating and system voltages between 90% and 110% of nominal voltage (exceptions for voltage criteria at generation stations such as Alma have a voltage criteria of 95% to 105% of nominal voltage).

4. Analysis of Alternatives

This study compares eight alternatives based on cost, contingency performance, and transmission exposure. Appendix A provides a one-line drawing depicting each alternative. Appendix B also provides a cost summary of each alternative.

Alternative 1

- Rebuild 33.88 miles of the N-5 from Rock Elm to Alma with 477 ACSR
- Rebuild 2.78 miles of the Alma-Elk Mound 161 line (Q-5) with 795 ACSS/477 ACSR double circuit 161/ 69 kV.
- Build on new ROW 4.6 miles of 477 ACSR conductor.

Alternative 2

- Build on new ROW 22.6 miles of 477 ACSR conductor.
- Rebuild 18.07 miles on the existing N-5 ROW to the Alma 161/69 KV substation with 477 ACSR conductor.
- Rebuild 2.78 miles of the Alma-Elk Mound 161 line (Q-5) with 795 ACSS/477 ACSR double circuit 161/ 69 kV.
- Rebuild 3.29 miles from the Ella tap to the Xel Arkansaw tap with 4/0 ACSR
- Retire 16.0 miles of the N-5 line between Rock Elm and Xel's Arkansaw tap

Alternative 3

- Rebuild 13.77 miles from Ella tap to Nelson distribution substation with 4/0 ACSR
- Rebuild 15.87 miles from the Rock Elm 161/69 kV substation to the Ella distribution substation
- Build 10.0 miles on new ROW with 477 ACSR connecting the Lund substation to Xel's Pepin 69 kV line.
- Retire 13.0 miles of the N-5 line between Alma and Nelson distribution tap.
- Add LBA tie metering at the Xel 69 kV switching station

Alternative 4

- Rebuild 28.13 miles of the N-5 from Rock Elm to Nelson with 477 ACSR
- Build 2.0 miles of new 477 ACSR 69 kV line
- Build 2.2 miles of new 69 kV 477 ACSR double circuit line
- Add new breaker with LBA tie metering at the Xel 69 kV Nelson switching station
- Retire 13.0 miles of the N-5 line between Alma and Nelson distribution tap

Alternative 5

- Rebuild 12.3 miles of the N-5 from Ella to Nelson with 477 ACSR
- Build 20.0 miles of new 477 ACSR 69 kV line
- Build 2.2 miles of new 69 kV 477 ACSR double circuit line
- Rebuild 3.32 miles to the Xel Arkansaw tap with 4/0 ACSR
- Add new breaker with LBA tie metering at the Xel 69 kV Nelson switching station
- Retire 30.0 miles of the N-5 line between Alma and Rock Elm substations

Alternative 6

- Rebuild 28.13 miles of the N-5 from Rock Elm to Nelson with 477 ACSR
- Build 4.2 miles of new 477 ACSR 69 kV line from DPC's Nelson distribution substation to Xcel's Pepin tap line along County Road D.
- Add LBA tie metering at the Xel 69 kV Nelson switching station
- Retire 13.0 miles of the N-5 line between Alma and Nelson distribution tap

Alternative 7

- Rebuild 14.0 miles from Ella tap to Nelson distribution substation with 4/0 ACSR
- Rebuild 7.0 miles from the Rock Elm 161/69 kV substation to DPC's Comfort distribution substation.

- Rebuild 3.0 miles from Ella tap to Arkansaw Tap with 477 ACSR.
- Build 10.0 miles on new ROW with 477 ACSR connecting the Lund substation to Xel's Pepin 69 kV line.
- Retire 19.0 miles of the N-5 line between Alma and Nelson distribution tap.
- Add LBA tie metering at the Xel 69 kV switching station.

Alternative 8

- Rebuild 29.8 miles of the N-5 from Rock Elm to XEL's Nelson to Lufkin 69 kV line with 4/0 ACSR
- Xel installs a 3-Way GOAB at the new interconnection on the Nelson-Pepin 69 kV line.
- Retire 13.0 miles of the N-5 line between Alma and Nelson distribution tap.

4.1 Load Flow Analysis

This analysis examined the eight alternatives for load serving capability for single (N-1) contingencies in the 2016 & 2020 summer cases and the 2016 winter peak case. All eight alternatives meet the DPC contingency criteria for single contingency outages.

As a sensitivity for serving load into the future, the 2016 summer base case load was increased by 10 percent and the eight different alternatives were evaluated using this sensitivity case. All eight alternatives meet the DPC contingency criteria even with the load increased by 10 percent for DPC and Xel in the area.

4.2 Prior Outage Analysis

The prior outage analysis examines a future maintenance outage of either AT1 or AT2 161/69 transformer at Alma. The analysis simulated a maintenance/ prior outage such as AT1 transformer out for maintenance then loss of the other 161/69 (AT2) transformer at Alma. This type of analysis simulates a maintenance outage and assures the next contingency does not cause low voltage or overloads, which is defined as an N-1-1 analysis. This maintenance/ prior outage analysis will utilize the 2016 summer peak case as a proxy for a future off peak case and one 161/69 kV transformer at Alma out of service. This system configuration must maintain the Alma 69 kV bus voltage greater than 95%. All eight alternatives do not have any voltage or overload issues due to a prior outage of either AT1 or AT2 at Alma in the area.

4.3 Exposure/ Reliability Analysis

Two indices called the Permanent Fault Exposure Measurement (PFEM[1]) and the Temporary Fault Exposure Measurement (TFEM[2]) are used to measure the relative exposure of DPC's customers to permanent or temporary faults on the transmission system. These indices measure the potential quality of service to DPC's customers. The basis for quality of service is the likelihood of a transmission line interruption, which is due to a number of factors, such as the mileage of the transmission elements serving the DPC customer, switching time to isolate line faults, and size of the load.

The customer delivery points or substations in the Rock Elm-Alma area are a subset of the total DPC customer delivery points or substations on the DPC transmission system. The substations in this area have a previous pre-determined value for the PFEM and TFEM based on the existing transmission system. The existing exposure values are used in evaluating the different alternatives in the Rock Elm-Alma area. The previous pre-determined existing PFEM or TFEM value establishes a base line in comparing the decrease or increase in PFEM or TFEM for each alternative.

In Table 5, the transmission exposure for each alternative was analyzed in an attempt to minimize the transmission exposure of the distribution substations on long 69 kV transmission lines. This table compares DPC loads only in the table. Alternative 1 has the worst ranking out of the eight alternatives, based on the PFEM or permanent fault exposure. This is partly due to the Lund distribution load served form a radial tap line. The distribution cooperative that serves the Lund distribution substation has the ability to serve this substation from other distribution substations to minimize the impacts of this long radial tap line. Alternative 5 is the best solution due to having system redundancy for each load. The other alternatives have a higher sum of the TFEM and PFEM than Alternative 5, which points to the loss of redundancy in the system by not having a backup transmission source to the individual distribution substations and high line exposure mileage.

In Table 6, the transmission exposure for each alternative was analyzed in an attempt to minimize the transmission exposure of the distribution substations on long 69 kV transmission lines. This table included the XEL's Pepin load in the analysis along with the DPC loads. The XEL Pepin load was approximately 3.2 MW on an existing 7.8-mile radial line. Alternative 7 has the worst ranking out of the eight alternatives, primarily due to the TFEM or temporary fault exposure. This is partly due to the increase in line exposure miles to the XEL Pepin distribution load. Alternative 5 is the best solution due to having system redundancy for each load. The other alternatives in this table have a higher sum of the TFEM and PFEM than Alternative 5.

[1]Note: the higher the number for PFEM the lower the quality of the transmission supplies.
[2]Note: the higher the number for TFEM the lower the quality of the transmission supplies.

Table 5 Transmission **Exposure DPC only**					
ALTERNATIVE	**PFEM (1)**	**TFEM(2)**	**PFEM Decrease**	**TFEM Decrease**	**Total**
	Average	**Average**	**%**	**%**	**Ranking**
DPC average	117.5	74.0			
Existing study area	71.2	80.3			
1	71.2	80.3	0.0%	0.0%	8
2	54.6	87.2	23.4%	-8.6%	5
3	41.6	81.5	41.6%	-1.5%	2
4	64.2	68.2	9.9%	15.0%	4
5	47.5	53.6	33.3%	33.3%	1
6	70.3	78.8	1.3%	1.9%	7
7	40.1	109.7	43.7%	-36.6%	6
8	60.9	62.8	14.4%	21.8%	3

1 – PFEM = Permanent Fault Exposure Measurement
2 – TFEM = Temporary Fault Exposure Measurement

Table 6 Transmission Exposure **with Xel Pepin load added**					
ALTERNATIVE	**PFEM (1)**	**TFEM(2)**	**PFEM Decrease**	**TFEM Decrease**	**Total**
	Average	**Average**	**%**	**%**	**Ranking**
DPC average	117.5	74.0			
Existing study area	109.3	71.1			
1	109.3	71.1	0.0%	0.0%	6
2	95.4	76.8	12.7%	-8.1%	5
3	49.7	95.6	54.5%	-34.5%	3
4	103.4	61.0	5.4%	14.1%	4
5	89.5	48.8	18.1%	31.4%	1
6	102.8	92.2	6.0%	-29.8%	7
7	49.2	128.3	54.9%	-80.5%	8
8	100.7	56.5	7.8%	20.6%	2

1 – PFEM = Permanent Fault Exposure Measurement
2 – TFEM = Temporary Fault Exposure Measurement

4.4 Economic Comparison

Table 7 summarizes the present worth (PW) of the revenue requirements for all eight alternatives in 2015 dollars. The assumed in-service date for each alternative is 2018 or later. The PW calculations use the following assumptions:

Discount Rate:	6.50%
Inflation Rate:	2.50%
LARR Rate:	12.54%

The revenue requirement is based on a 35-year life cycle of each facility. The lowest cost plan is Alternative 8. This plan has a PW cost of approximately 23.1 million dollars. The most expensive plan is Alternative 7 estimated at 33.8 million dollars. In Alternative 7 the XEL tariff cost for the DPC loads is included in the analysis. This tariff cost due to XEL owning the transmission system is approximately $500,000 per year with a PW of 35 years of year tariff cost estimated at $8.8 Million. This tariff cost is significant and would be yearly cost that could increase every year going forward.

Table 7
N-5 Present worth analysis

Alternatives	Cumulative Present Worth 2015 Dollars	2015 PW Energy Loss Savings	2015 PW Demand Loss Savings	2015 PW Net Facility Cost
1	$28,595,424	$162,913	$108,620	$28,323,890
2	$33,272,484	$151,277	$100,863	$33,020,344
3	$28,857,530	($267,643)	($178,455)	$29,303,628
4	$27,124,182	($186,187)	($124,136)	$27,434,505
5	$30,302,608	($174,549)	($116,378)	$30,593,536
6	$24,972,527	($209,460)	($139,659)	$25,321,646
7	$25,177,370	$81,456	$58,009	$33,848,118
8	$22,624,849	($314,189)	($223,746)	$23,162,783

4.5 Tariff Costs

DPC load served by Xel's transmission will pay Xel's transmission tariff rate. Xel's yearly transmission tariff cost is potentially a significant cost to DPC's load. This tariff cost is perpetual and likely to increase in the future. DPC's Comfort substation is within

one mile of the existing N-5 line, but due to minor re-routes in the area, the Comfort distribution substation will be three miles from the rebuilt N-5 line. Due to proximity of the Comfort substation to the rebuilt DPC transmission system, the Xel tariff costs will be compared to the cost to build from the Comfort substation to the DPC transmission system.

The estimated yearly Xel transmission tariff cost for the DPC Comfort substation is $80K for 2018. This tariff 2018 cost is projected to increase yearly due to annual load growth and future increases in tariff rates. The cost of building approximately three miles of 69 kV line to the comfort load from the N-5 line is approximately $888,000. The pay back to build the three-mile tap line would be more than 11 years.

The Comfort tariff PW Analysis is shown below in Table 8. This analysis is based on a 35-year cost evaluation, and escalating the Xel transmission tariff cost by 2.5 percent per year. The PW analysis does not justify the extra-added construction cost to remove the Comfort load from the Xel transmission tariff costs.

Table 8
2015 Present Worth Facility and Tariff cost

Alternatives	PW Net Facility Cost	PW Comfort Tariff Cost	PW Cost Savings
Comfort Tap Line	$1,262,354	$1,188,231	($74,123)

4.6 Regulatory and Environmental Process Review

The USDA Rural Utilities Service (RUS) and State of Wisconsin will require an environmental and regulatory review due to the need for new ROW. These processes include an environmental review and assessment of the project. This section provides a brief overview of the required steps in the review processes for this project.

Federal Review

DPC intends to seek financial assistance from the RUS for this project. RUS may fund the Project, thereby making it an undertaking subject to review under Section 106 of the National Historic Preservation Act (NHPA), 16 U.S.C. § 470(f), and its implementing regulations (36 CFR part 800). All the alternatives will require completion of an

Environmental Assessment (EA) because it involves construction of more than 25 miles of transmission line. Preparation of an EA typically takes 3 years.

The US Fish & Wildlife Service will require an endangered species review. The Corps of Engineers will require permits for river crossings and wet lands in the area also.

State Review

A phase I archeological survey will be required with correspondence to the state of Wisconsin SHPO office. Consultation with the Department of Natural Resource will be required for endangered species, wetland and erosion control permits.

4.6.1 Alternative Review

Alternative one – This alternative would rebuild approximately 41 miles of 69 kV line if the existing ROW is followed. The line crosses two large wetland complex's associated with the Buffalo and Chippewa Rivers. There are numerous wetlands associated with the crossing of Trout Creek, Missouri Creek, Arkansaw Creek, Rock Elm Creek and their tributaries. The line also crosses the Tiffany Wildlife Area, which has numerous state and federal endangered species.
Due to the difficult terrain, a large number of access roads will be needed which may require significant tree clearing and land disturbance.

Several alternative routes have been identified which would reduce wetland impacts and the number of access roads that would be required. An alternative route has also been reviewed which would utilize an existing 161 kV (Q-17) river crossing that would remove the line from the Tiffany Wildlife Area. However, the line is located on DNR property, crosses thru Silver Birch Park, and has the same state and federal endangered species. This alternative will be evaluated in detail in the Environmental Assessment.

Alternative two – This alternative would build approximately 47 miles of 69 kV line and retire 21 miles of existing 69 kV line. Approximately 18 miles of this alternative would be on new ROW adjacent to road ROW. The retirement of 16 miles would also reduce the number of access roads that would be required. The environmental impacts associated with alternative one would also apply to this alternative.

Alternative three – Alternative three would build 49.5 miles of 69 kV line and retire 21.5 miles of 69 kV line. The retirement of the first 13 miles out of Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. The new route between the Lund substation and Xcel's Pepin line would be built by Xcel Energy and will not be part of the ER for RUS.

Alternative four – This alternative would build 36.5 miles of 69 kV line and retire 11 miles of existing 69 kV line. The retirement of the first 11 miles out of

Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. The retirement section would also reduce the number of access roads that would be required. This option would still cross the Chippewa River and the Tiffany Wildlife Area.

Alternative five – Alternative five would build 37.62 miles of 69 kV line and retire 30 miles of existing 69 kV line. The retirement of the first 11 miles out of Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. The retirement section would also reduce the number of access roads. This option would still cross the Chippewa River and the Tiffany Wildlife Area. Approximately 18 miles of this option would be on new ROW, parallel County Highway CC. The new right-of-way would reduce the number of new access roads and would have the least impact of the alternatives evaluated for the N-5 rebuild.

Alternative six – This alternative would build 36.5 miles of 69 kV line and retire 11 miles of existing 69 kV line. The retirement of the first 11 miles out of Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. The retirement section would also reduce the number of access roads that would be required. This option would still cross the Chippewa River and the Tiffany Wildlife Area.

Alternative seven – Alternative seven Dairyland would build approximately 14 miles of 69 kV line and retire 19 miles of 69 kV line. The retirement of the first 13 miles out of Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. This alternative would require Xcel Energy to build 17 miles of 69 kV line. Xcel's part of the project would not be included in the ER for RUS.

Alternative eight – This alternative would rebuild approximately 30 miles of 69 kV line if the existing ROW is followed. The retirement of the first 13 miles out of Alma would eliminate impacts to the wetlands associated with Mill Creek, Trout Creek and the Buffalo River. The retirement section would also reduce the number of access roads. This option would still cross the Chippewa River and the Tiffany Wildlife Area.

5. Conclusion

The Rock Elm-Alma (N-5) line is over 67 years old. The North Area Maintenance Supervisor has deemed the condition of the N-5 as poor and in need of a rebuild. If the underlying problem of age and condition is not addressed, the Alma-Rock Elm 69 kV line will require additional and continual maintenance leading to increased annual line costs. This could result in decreased reliability of the line in the future. Due to the age, condition and potential increased line

maintenance costs, this study analyzed eight alternate plans to upgrade and rebuild this transmission line to find the most cost effective alternative.

Eight alternatives were analyzed in this report and all the alternatives address the age, condition and performance issues of the Alma-Rock Elm 69 kV line (N-5). Further, they all meet the N-1 performance criteria well into the future. Of all the alternatives, Alternative 8 has the lowest capital cost, less environmental impacts, and performs well for system outages. Therefore, Alternative 8 is the recommended plan.

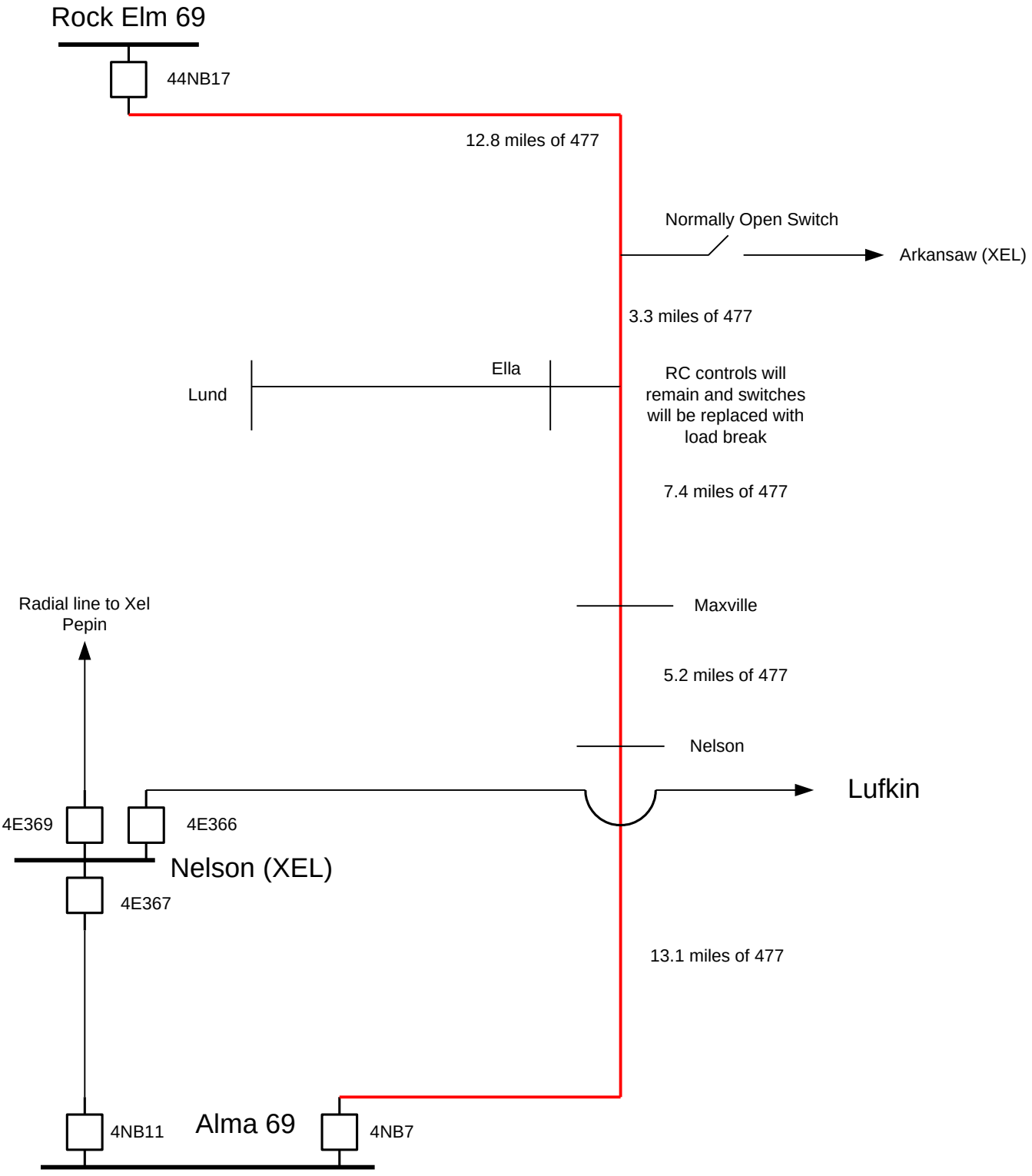
The upgrades for Alternative 8 are:

1. Rebuild 29.8 miles of the N-5 from Rock Elm to XEL's Nelson to Lufkin 69 kV line with 4/0 ACSR.
2. Retire approximately 13.0 miles of the N-5 line between Nelson and Alma
3. Xel installs a 3-Way GOAB at the new interconnection on the Nelson-Pepin 69 kV line..

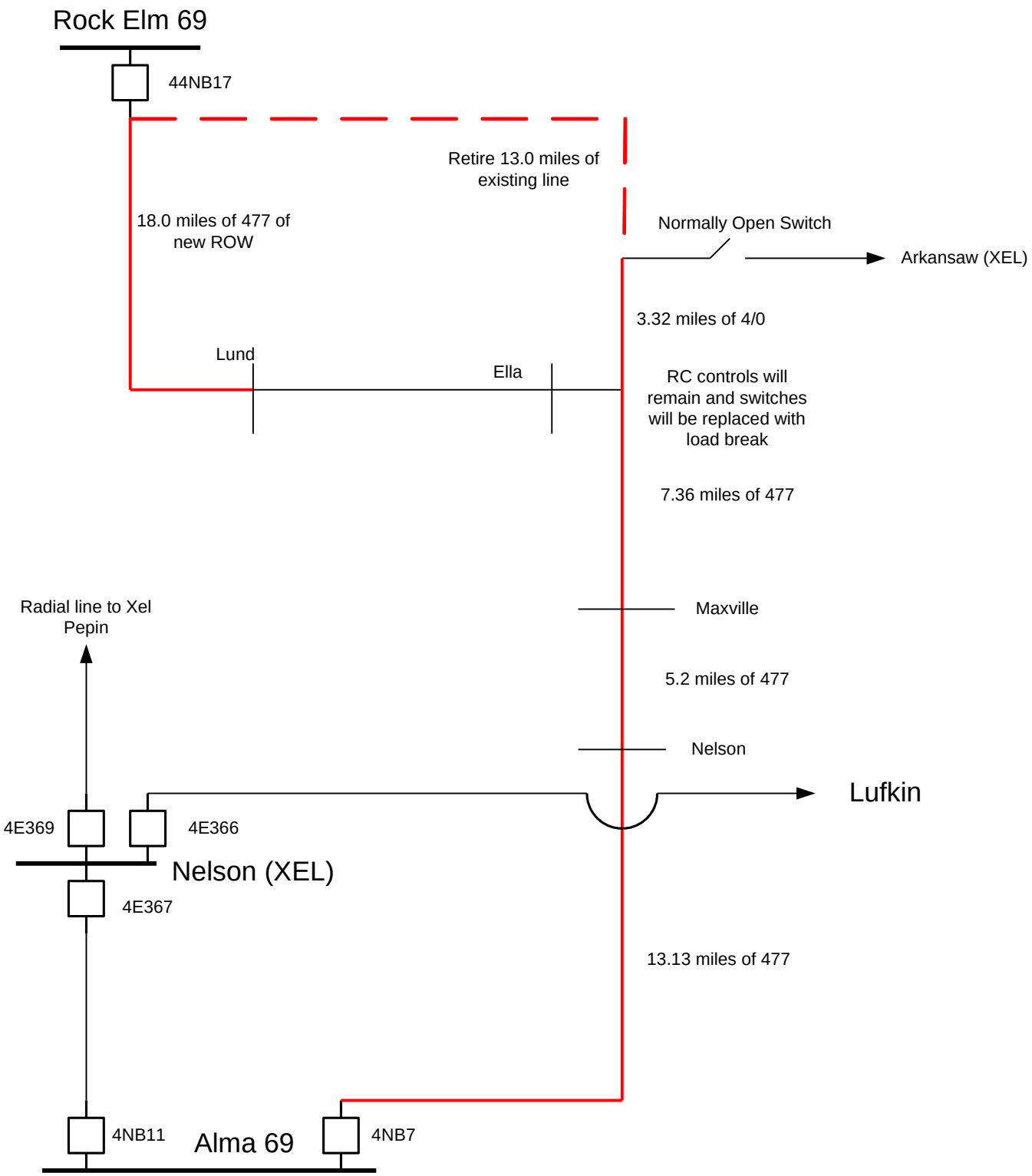
An optional plan to Alternative 8 is Alternative 3, provided XEL is willing to build the line from Pepin to DPC's Lund substation. This is due to approximately a $6 Million dollar adder for Alternative 3. Alterative 3 does provide a second source to XEL's Pepin load, which is served on an 8-mile radial line. This alternative also provides a second source to DPC's Lund substation, which will provide higher transmission reliability to this load even though the cooperative can back-up the Lund substation from other sources. Alternative 3 does provide some benefit for the transmission system during prior outages, but these benefits do not justify the extra cost for DPC. See Alternative 3 in the back of this report.

Appendix A – Alternative Diagrams

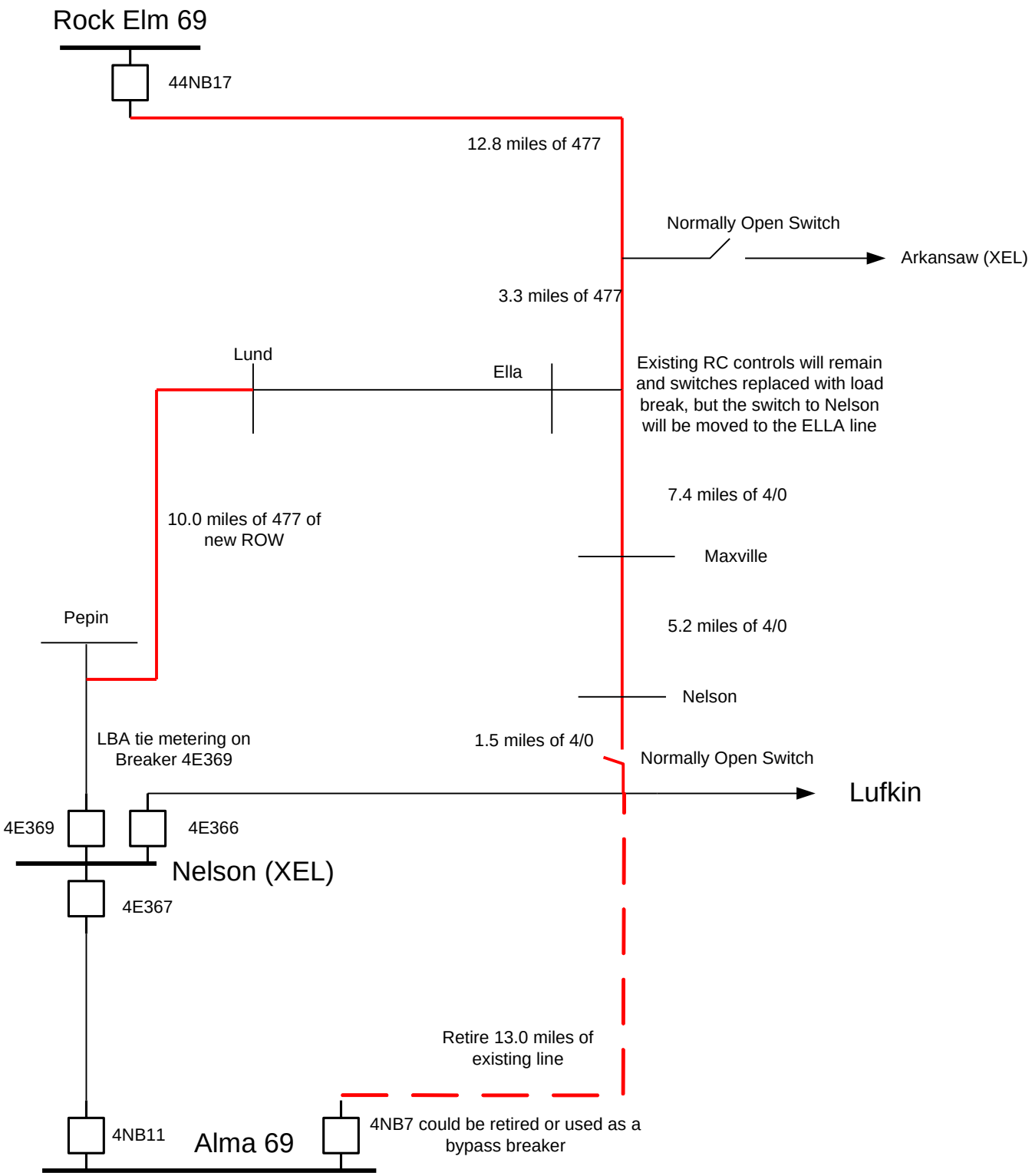
Alternative 1



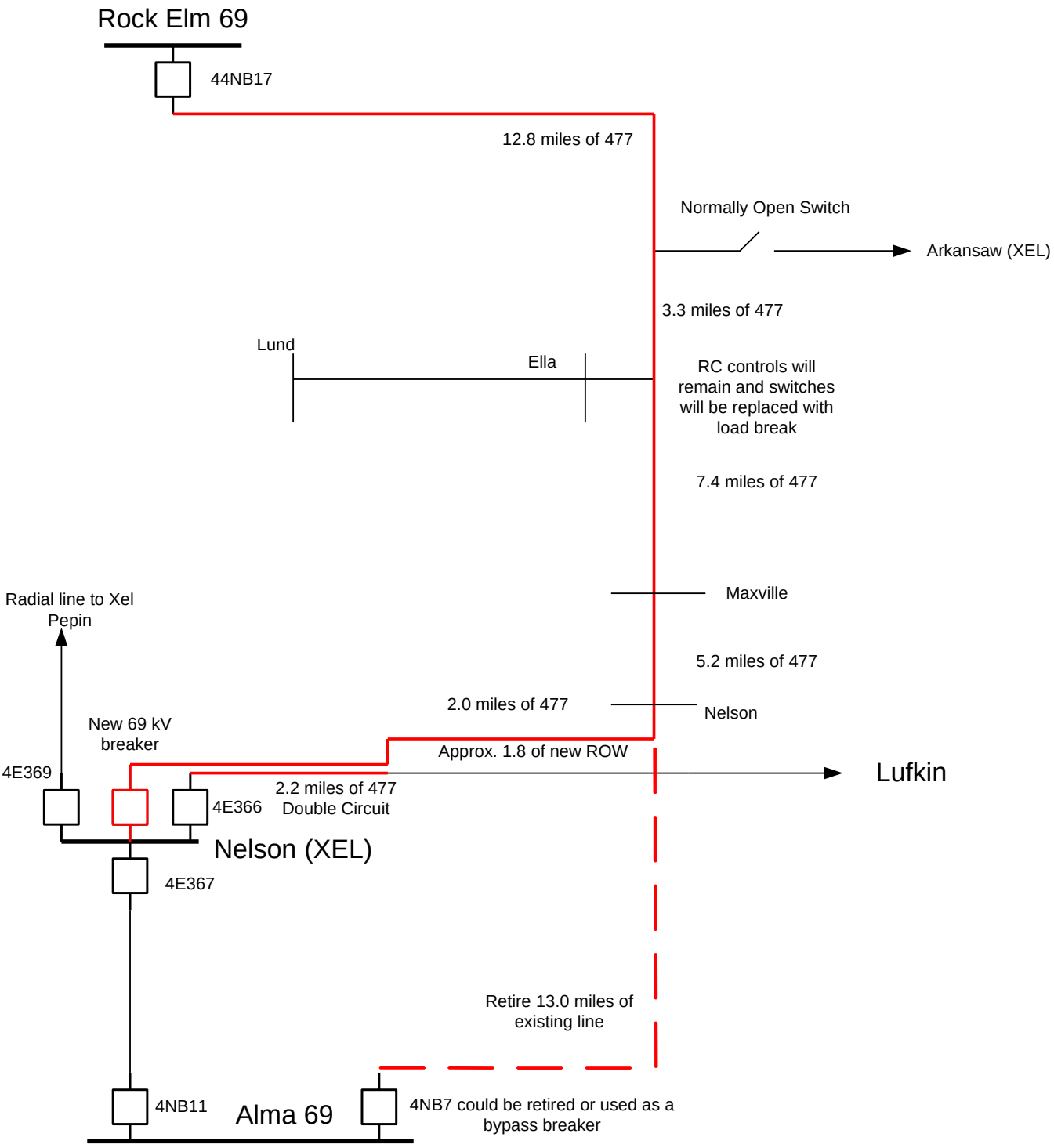
Alternative 2



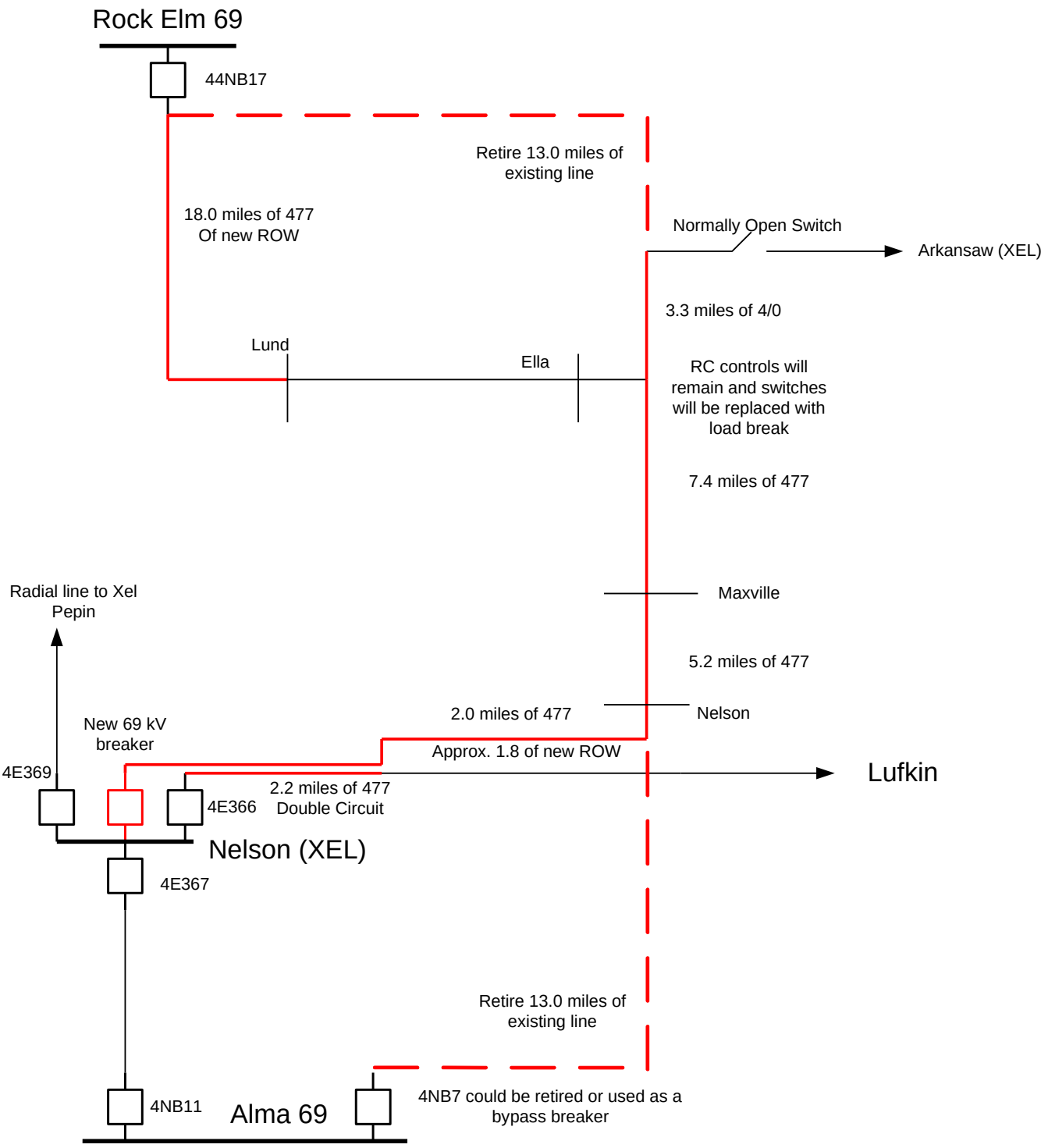
Alternative 3



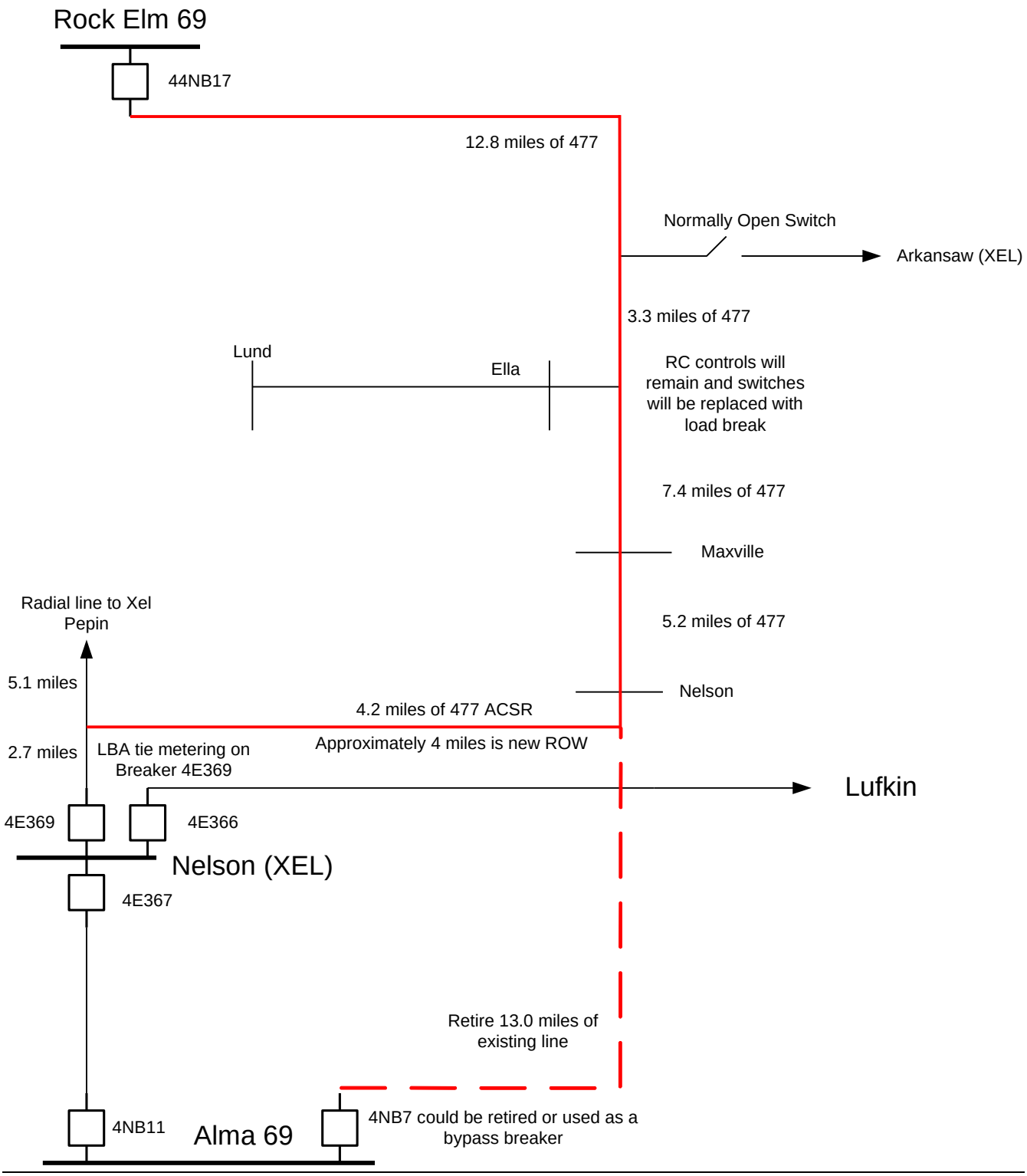
Alternative 4



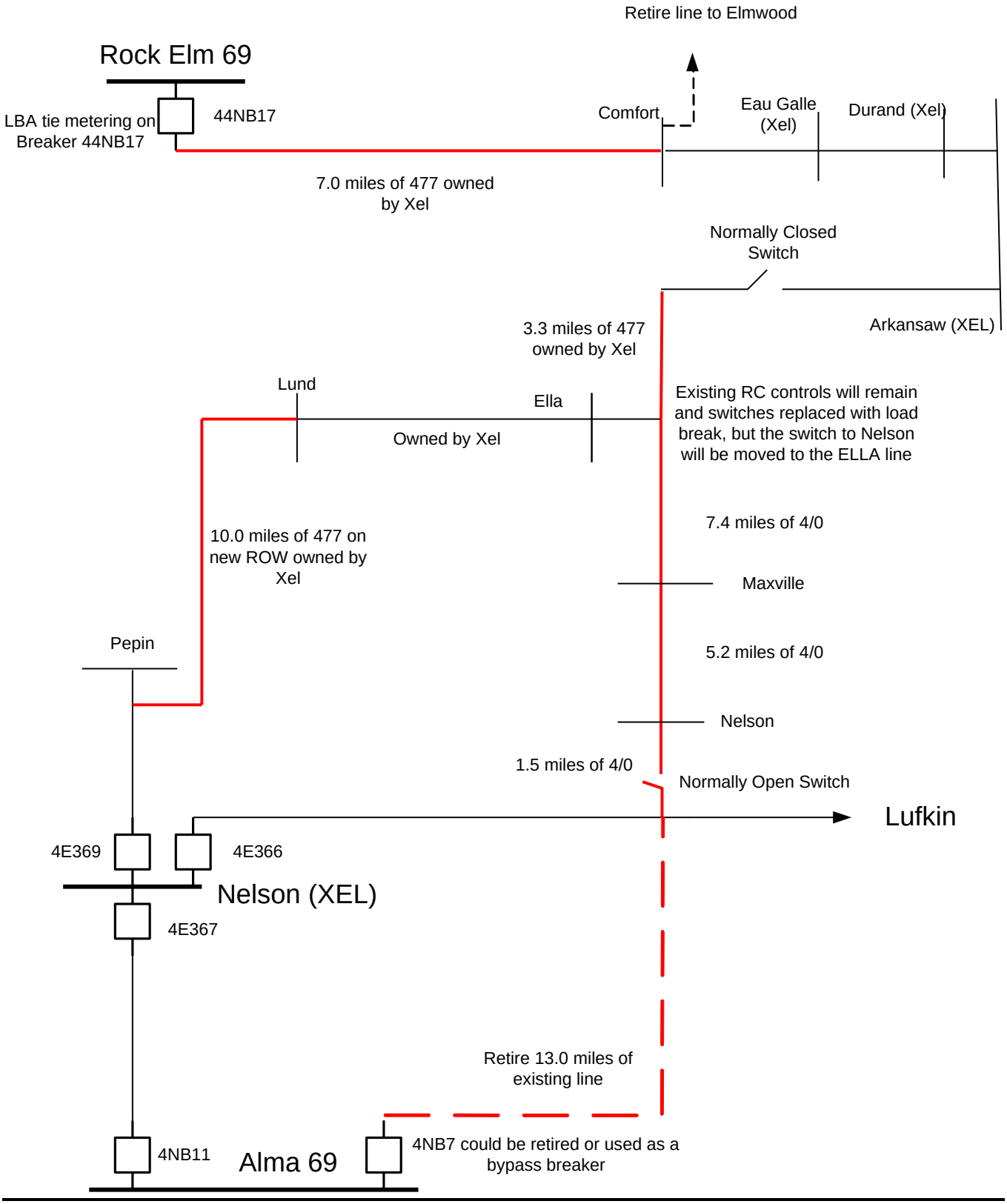
Alternative 5



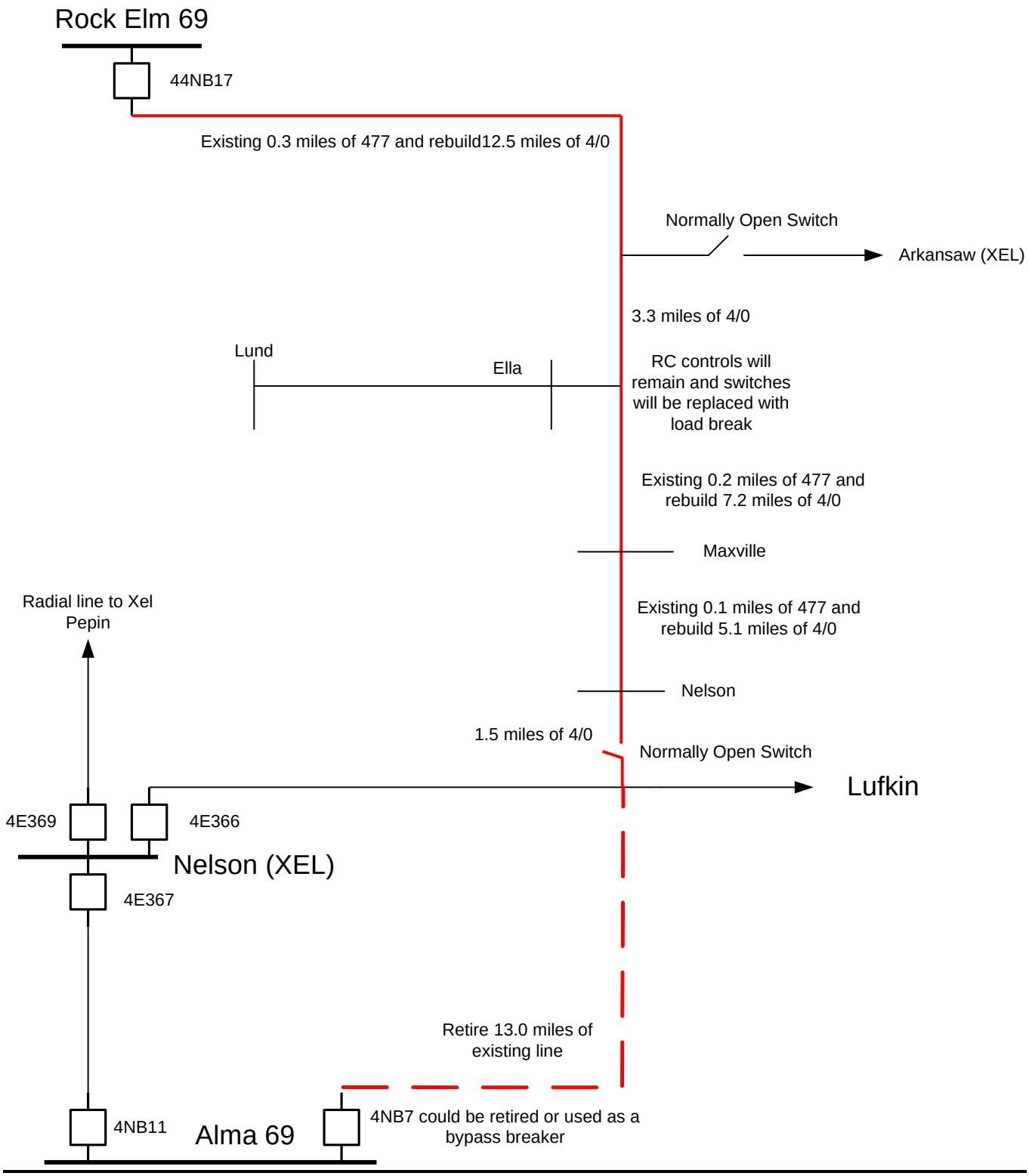
Alternative 6



Alternative 7



Alternative 8



Appendix B – Construction Costs during the 2018 year of each Alternative in 2015 dollars

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 1					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**33.88**	**477 ACSR**	**$285,000**	**$9,655,800**
2 way switch	**69**	**1.00**	**n/a**	**$50,000**	**$50,000**
161/69 Double Cir (795/477)	**69**	**2.78**	**477 ACSR**	**$1,100,000**	**$3,058,000**
Rebuild with 477 ACSR (new)	**69**	**4.60**	**477 ACSR**	**$350,000**	**$1,610,000**
				Total Cost	**$14,373,800**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 2					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**18.07**	**477 ACSR**	**$285,000**	**$5,149,950**
Rebuild with 4/0 ACSR (existing)	**69**	**3.29**	**4/0 ACSR**	**$250,000**	**$822,500**
2 way switch	**69**	**2.00**	**n/a**	**$50,000**	**$100,000**
161/69 Double Cir (795/477)	**69**	**2.78**	**n/a**	**$1,100,000**	**$3,058,000**
Rebuild with 477 ACSR (new)	**69**	**22.60**	**477 ACSR**	**$350,000**	**$7,910,000**
Retire 69 kV line	**69**	**13.00**	**N/a**	**$30,000**	**$390,000**
				Total Cost	**$17,430,450**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 3					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**15.87**	**477 ACSR**	**$285,000**	**$4,522,950**
Rebuild with 4/0 ACSR (existing)	**69**	**13.77**	**4/0 ACSR**	**$250,000**	**$3,442,500**
3-way switches	**69**	**1.00**	**n/a**	**$65,000**	**$65,000**
2 way switch	**69**	**2.00**	**n/a**	**$50,000**	**$100,000**
Rebuild with 477 ACSR (new)	**69**	**10.00**	**477 ACSR**	**$350,000**	**$3,500,000**
Add LBA Tie metering at XEL Nelson substation	**69**	**1.00**	**N/A**	**$50,000**	**$50,000**
Xcel switch for Pepin	**69**	**1.00**	**n/a**	**$250,000**	**$250,000**
Retire 69 kV line	**69**	**13.00**	**N/a**	**$30,000**	**$390,000**
				Total Cost	**$13,005,450**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 4					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**28.13**	**477 ACSR**	**285,000**	**8,017,050**
2 way switch	**161**	**1.00**	**n/a**	**50,000**	**50,000**
Rebuild with 477 ACSR (new)	**161**	**2.00**	**477 ACSR**	**350,000**	**700,000**
69 kV double cir	**69**	**2.20**	**477 ACSR**	**1,147,000**	**2,523,400**
Retire 69 kV line	**69**	**13.00**	**N/a**	**30,000**	**390,000**
Add new breaker at Nelson	**69**	**1.00**	**N/A**	**564,000**	**564,000**
Xcel rebuild of 7.8 miles to Pepin	**69**	**7.80**	**477 ACSR**	**850,000**	**6,630,000**
				Total Cost	**$18,874,450**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 5					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**12.32**	**477 ACSR**	**$285,000**	**$3,511,200**
Rebuild with 4/0 ACSR (existing)	**69**	**3.32**	**4/0 ACSR**	**$250,000**	**$830,000**
2 way switch	**161**	**2.00**	**n/a**	**$50,000**	**$100,000**
Rebuild with 477 ACSR (new)	**161**	**20.00**	**477 ACSR**	**$350,000**	**$7,000,000**
69 kV double cir	**69**	**2.20**	**477 ACSR**	**$500,000**	**$1,100,000**
Add new breaker at Nelson	**69**	**1.00**	**N/A**	**$564,000**	**$564,000**
Retire 69 kV line	**69**	**26.00**	**N/a**	**$30,000**	**$780,000**
				Total Cost	**$13,885,200**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 6					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**28.13**	**477 ACSR**	**$285,000**	**$8,017,050**
3-way switches	**161**	**1.00**	**n/a**	**$65,000**	**$65,000**
2 way switch	**161**	**1.00**	**n/a**	**$50,000**	**$50,000**
Rebuild with 477 ACSR (new)	**161**	**4.20**	**477 ACSR**	**$350,000**	**$1,470,000**
Retire 69 kV line	**69**	**13.00**	**N/a**	**$30,000**	**$390,000**
Add LBA Tie metering at XEL Nelson substation	**69**	**1.00**	**N/A**	**$50,000**	**$50,000**
				Total Cost	**$10,042,050**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 7					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 477 ACSR (existing)	**69**	**10.00**	**477 ACSR**	**$285,000**	**$2,850,000**
Rebuild with 4/0 ACSR (existing)	**69**	**14.00**	**4/0 ACSR**	**$250,000**	**$3,500,000**
2 way switch	**161**	**1.00**	**n/a**	**$50,000**	**$50,000**
Rebuild with 477 ACSR (new)	**161**	**10.00**	**477 ACSR**	**$400,000**	**$4,000,000**
Retire 69 kV line	**69**	**19.00**	**N/a**	**$30,000**	**$570,000**
				Total Cost	**$10,400,000**

Estimated 2015 Costs for Proposed N-5 Area Study Solution Alternative 8					
Activity	Voltage (kV)	Unit Qty or Miles	Conductor Size	$ Cost/Unit	Total Cost ($)
Rebuild with 4/0 ACSR (existing)	**69**	**29.80**	**4/0 ACSR**	**$250,000**	**$7,450,000**
3-way switches	**161**	**1.00**	**n/a**	**$65,000**	**$65,000**
2 way switch	**161**	**1.00**	**n/a**	**$50,000**	**$50,000**
Retire 69 kV line	**69**	**13.00**	**N/a**	**$30,000**	**$390,000**
				Total Cost	**$7,565,000**

Appendix C – Construction Issues

In the table below, the construction sequence and constraints are listed for the recommended plan (Alternative 8). There are no major construction constraints for rebuilding the N-5 main line.

Construction Sequence and Constraints Alternative 8		
Sequence	Facility	Constraints
1	Rebuild Existing 69 kV line from Rock Elm to Arkansas Xel tie.	None
2	Rebuild 69 kV line from Arkansaw tie to the Nelson-Lufkin 69 kV line.	None

In the table below, the construction sequence and constraints are listed for Alternative 3. There are no major construction constraints for rebuilding the N-5 main line.

Construction Sequence and Constraints Alternative 3		
Sequence	Facility	Constraints
1	Rebuild Existing 69 kV line from Rock Elm to Arkansas Xel tie.	None
2	Rebuild 69 kV line from Arkansaw tie to the Nelson-Lufkin 69 kV line.	None
3	Xcel to build New 10 mile line from Pepin to Lund	None