NAC
ENGINEERING

# ELECTRICAL CAPACITY UPGRADE

AE 1483 AE
Eastern Washington University
Cheney, WA

August 12, 2016

>1203 West Riverside Avenue, Spokane, WA 99201-1107
509 838 8240 / nacarchitecture.com
Seattle / Spokane / Los Angeles

NAC
ENGINEERING

## Purpose

Eastern Washington University has undertaken this analysis and report for three main reasons. First, to address the adequacy of the existing 13.2-kV electrical distribution system to support three major projects currently being planned:

Pence Union Building (PUB) Renovation

Interdisciplinary Science Center (ISC)

Central Chiller Plant Expansion

Secondly, to evaluate the impact of the next 10-years of projected campus growth on the electrical distribution system. Lastly, to address improvements to the campus electrical distribution system to enhance operation, maintenance and worker safety.

## Executive Summary

The medium-voltage distribution system at EWU is well maintained and adequately supports the current electrical load. In order to continue to provide a reliable electrical infrastructure, EWU should incorporate the recommendations of this report into its long-range infrastructure planning program. Two proposed capital projects will significantly increase the campus electrical load and actions must be taken to support the increase. As part of an upgrade plan, EWU should incrementally replace existing vacuum switches and 15-kV conductors to enhance future reliability and improve worker safety. EWU should also continue to develop its arc flash safety program. This report discusses existing conditions, expected future loads and recommended actions. The most immediate need is to accommodate the large capital projects planned for the next two years.

## System Overview

EWU owns and operates the medium-voltage system that distributes electrical power to most of the Cheney campus. The campus receives service from the City of Cheney's 13,200Y/7620-VAC distribution system via feeders from two separate substations. Service #1 originates in the Four Lakes Substation north of the campus. Service #2 originates in the Cheney Substation south of the campus. Each of the City's feeders are separately metered and are connected to the University's service switchgear Bus #1 and Bus #2. Four individual feeders, referred to as Feeder 1A, 2A, 1B and 2B, originate at the two switchgear buses and distribute 13.2-kV power to pad-mounted transformers located adjacent to campus buildings through a selective-parallel feeder system. Below-grade, $SF_6$-insulated, vacuum switches allow buildings to be connected to either Bus #1 or Bus #2. Switch locations require EWU staff to enter the tunnel system to operate the switches. This presents a safety concern should staff need to evacuate the switch location if equipment were to fail during a switching operation. Managing $SF_6$ gas may become an environment issue in the future. Rozell Plant, which contains the campus boiler plant and chiller plant, can be connected to either Bus #1 or Bus #2 through feeders dedicated to Rozell. A separate feeder provides power to the chiller equipment to isolate the chiller load from the service switchgear. A diagram of the medium-voltage distribution system is included at the back of this report.

EWU also owns and operates inter-building electrical distribution systems at 480Y/277-VAC and 208Y/120-VAC. However, this analysis and report does not address systems at these lower voltages.

## Master Plan Impacts

The most recent Master Plan suggests a 2% annual growth in campus population over the next two years. With the exception of the PUB and ISC projects, the annual growth is not expected to reflect a corresponding net increase in building area. A

number of buildings are target for replacement but the campus as a whole is not expected to see a continual growth in building area. Utilization rates in classrooms are expected to increase with the population growth. This will result in additional energy consumption but does not necessarily translate to a need for increasing electrical system capacity. However, the load increase projected in this report does include a 2% growth rate in order to be conservative.

The PUB project, which is beginning construction at the time this report was prepared, was designed to have a very small net increase in required electrical demand. For this reason, the Load Model does not include a block load increase for this project. The Load Model does include block load increases for the ISC and the Central Chiller Plant Expansion.

## Methodology

EWU's 2014 Master Plan is the basis for the 10-year campus growth analysis. Interviews were also conducted with Construction & Planning personnel to better understand the Master plan. Growth rates of 0%, 1% and 2% were considered to estimate growth beyond the current major projects. Only the 2% growth rate is included in this report.

Load analyses are based on data provided by the Utility Company, which is the City of Cheney, and EWU. Both entities provided monthly high demand values in kilowatts (kW). EWU was able to provide corresponding power factors. For data obtained from the Utility Company, a power factor of 90% was assumed. Loads were compared to a value that represents 80% of the applicable equipment capacity in order to provide a buffer for load variation.

On-site reviews of existing electrical service and distribution system were conducted to assess equipment and environmental conditions relative to operation, maintenance and worker safety.

EWU recently completed an arc flash study of the medium-voltage distribution system. The purpose of the study was to enhance EWU's electrical safety

procedures. As part of the arc flash study, Schneider Electric, the manufacturer of the medium-voltage switchgear, performed an evaluation of the automatic switchgear controls and the protective relay settings. Schneider made recommendations for control and relay adjustments.

## Existing Electrical System Loads

Data provided by the City of Cheney includes the following high demand values.

| | |
|---|---|
| Service #1: | 6,773-kVA @ 90% power factor |
| | 296-amperes @ 13,200-VAC |
| Service #2: | 3,443-kVA @ 90% power factor * |
| | 151-amperes @ 13,200-VAC |
| | * Excludes the "outlier" identified in the *Load Model* section. |

Demand data provided by Eastern Washington University includes the following high demand values.

| | |
|---|---|
| Feeder 1A: | 1,493-kVA @ 95% power factor |
| | 66-amperes @ 13,200-VAC |
| Feeder 1B: | 1,678-kVA @ 94% power factor |
| | 74-amperes @ 13,200-VAC |
| Feeder 2A: | 2,020-kVA @ 94% power factor |
| | 89-amperes @ 13,200-VAC |
| Feeder 2B: | 1,407-kVA @ 95% power factor |
| | 62-amperes @ 13,200-VAC |

Feeder conductors are generally #2/0, copper, 15-kV rated 230-amperes. Options for accommodating the increased chiller loads do not involve the four building feeders. Therefore the impact to the feeders will be the result of the PUB and ISC projects and the growth escalation. The graph included in the back of this report shows the impact of this growth.

Recorded data for the chiller plant was not available at the time of this report. In an

effort to estimate the chiller electrical demand, the Bus #1 demand values provided by EWU were subtracted from the City of Cheney demand values.

The following estimated demand values are the result.

Chiller demand: 2,888-kVA
127-amperes @13,200-VAC

A graph of the resultant is included at the back of this report. The graph closely matches load estimates evaluated in the *Chiller Plant Capacity Upgrade AE1368* report prepared for EWU by MSI Engineers, Spokane, WA.

## Electrical System Deficiencies

No significant deficiencies requiring immediate attention were noted. The medium-voltage distribution system appears to be in good condition and has been well maintained. Most of the existing vacuum switches are feeding two pad-mounted transformers, the maximum possible amount. This means that while the campus feeders have spare capacity, portions of the feeder would have to be reconfigured in order to use that capacity. Initiatives have been identified to accommodate load growth, maintain reliability and enhance worker safety. Proactive planning for implementation of the initiatives indicated below will help insure a reliable and safe electrical system.

- Implement one of the options for addressing the additional chiller load.
- Incremental replacement of medium-voltage cable over 20-years old.
- Make recommended changes to the controls and relaying in the medium-voltage switchgear.
- Incremental replacement of medium-voltage vacuum switches.
- Expand the arc flash program to the 480-VAC and 208-VAC systems

## Switchgear Relays and Control

The existing medium-voltage switchgear contains electronic relays for providing

various types of system protection. The switchgear also contains a programmable logic controller (PLC) to control the automatic operation of the main circuit breakers and the feeder circuit breakers. EWU has commissioned a report, entitled *Eastern Washington University 13.2kV Main Switchgear Automatic Transfer System Report,* prepared by Schneider Electric, the manufacturer of the switchgear. The purpose of the report was to compare the operational and control settings in the switchgear and compare those settings to the original design intent and settings. The *Report* identifies a number of settings that appear to vary from the original design intent. These deviations may cause the automatic switchgear function to operate differently than expected during power outages. The *Report* contains a number of recommendations for restoring the original control scheme and coordinating protection elements.

The City of Cheney has expressed concerns that timing functions in the automatic switchgear do not coordinate with timing functions in the City's system. The City has asked that all changes to the switchboard automatic control system be reviewed by and coordinated with the City's Engineer to match the City's operations as much as possible.

## Load Model

To evaluate the impact of expected growth, a Load Model was prepared as part of this report. The Load Model is based on electrical demand data provided by EWU and the City of Cheney. Where EWU and the City of Cheney measured the same demand, the two results were compared and found to be reasonably close with the exception of one point recorded by the City of Cheney on Service #2 during the month to April, 2016. The City recorded a data point significantly higher than the preceding and succeeding months and that could not be corroborated with data provided by EWU. For this reason, this value is being considered as an "outlier" and not included in the Load Model. A graph of the Load Model is included in the back of

this report. A second graph showing the disparity in the June, 2016, data points is also included.

The Load Model includes two large incremental load increases related to the expected growth of the central chiller system. The first growth increment appears in 2017 and a second increment appears in the year 2017 in the Model. A total of six options are being considered for increasing chiller capacity. The details of the options are discussed in a separate report entitled *Chiller Plant Capacity Upgrade AE1368*. The Load Model uses the largest of the electrical load estimates contained in the chiller report.

Also included in the model is a load increase in the year 2017 for the ISC project. The loads included in the Model are as follows.

| | |
|---|---|
| Chiller, step one: | 1,875-kVA |
| Chiller, step two: | 1,875-kVA |
| ISC: | 2,250-kVA |

These values reflect expected demand rather than total connected loads.

## Distribution System Options

The medium-voltage distribution system will be significantly impacted by the planned addition to the existing campus chiller plant as well as the Interdisciplinary Science Center. EWU is considering multiple options for increasing chiller capacity. All options increase chiller capacity in two steps; once in the year 2017 and again in 2027. The options differ in the amount of chiller capacity added. This report considers only the largest capacity increases of 1,500-tons at each step. The total electrical impact for each step is estimated to be 1,875-kVA. Three electrical system options were considered for addressing this additional chiller load.

Option A: The existing chiller plant is currently connected to Service #1. This option would replace existing medium-voltage switches with a single, pad-mounted switch that would feed the existing switchgear, the existing chiller plant and the new chiller plant. Service #2 would remain unchanged.

Option B: This option would relocate the service point for existing utility Service #2 from the Red Barn to a location east of Rozell. A new pad-mounted switch would be installed at the new location to serve the existing switchgear and the new chiller plant. Service #1 would remain unchanged.

Option C: This option would modify both Service #1 and Service #2 to feed new medium-voltage switchgear dedicated to Rozell, the existing chiller plant and the new chiller plant. The Rozell transformer and the existing chiller plant transformer would be disconnected from the exiting medium-voltage switchgear and reconnected to the new switchgear. The new chiller plant transformer would also be connected to the new switchgear.

The three options are illustrated on the drawings accompanying this report.

Option A places the new chiller load on the City of Cheney's Four Lakes Substation along with the existing chiller load further increasing the load unbalance on the City's two service feeders. There would be no load impact to the existing switchgear. Option A would require multiple system outages on Service #1.

Option B places the new chiller load on the City of Cheney's Turnbull Substation and would help balance the total campus load across the City's two substations. There would be no load impact to the existing switchgear. Option B would require multiple electrical system outages on Service #2. This option has the advantage of potentially fewer shutdowns during construction while preserving the ability to incorporate Option C in the future.

Option C places the existing chiller load, the new chiller load and Rozell on new switchgear thus reducing the load on the existing medium-voltage switchgear. In the normal operating mode, the existing chiller load would remain on Service #1, the new chiller load would be added to Service #2 and Rozell would be connected to Service #1. This option has the advantage of removing load from the existing switchgear and slightly increasing the switchboard capacity for building services. A graph showing the load effects for each of the options is included in the back of this report.

All three options will require the City of Cheney to increase the size of the overhead service conductors, particularly those coming from the Cheney Substation located south of the campus. The City of Cheney may require EWU to pay part or all of the costs for increasing the conductor size.

## Recommendations

Medium-voltage Conductor Replacement: EWU should plan for the incremental replacement of the 15-kV feeders beginning with the conductors installed in the early 1990's. A proactive approach to conductor replacement will help minimize the possibility of conductor failure interrupting campus service. Conductor replacement should occur in conjunction with the replacement of the vacuum switches as suggested below.

Medium-voltage Vacuum Switch Replacement: EWU should plan for the incremental replacement of the existing 13.2-kV, below-grade vacuum switches with above-grade, air-insulated, pad-mounted switches. Replacing the vacuum switches will significantly improve safety during switch operation be moving switching operations to above grade. Air-insulated switches will eliminate possible environment requirements and constraints that may be imposed in the future. The above-grade switches, when used in conjunction with pad-mounted sectionalizing cabinets offer increased flexibility for distribution system reconfiguration to accommodate future buildings.

Distribution System Capacity Upgrade: EWU should consider implementing Option B as described in the *Medium-voltage Distribution System Options* section above. This option address the needed capacity for the first step of the chiller plant increase and allows the University to plan for the eventual implementation of Option C prior to adding the second chiller load step.

Medium-voltage Switchgear Adjustments: The recommendations of Schneider Electric regarding the automatic transfer system and the protection scheme of the existing medium-voltage switchgear should be considered and

applicable recommendations adopted. The recommendations involve changing relay settings and timing sequences in the programmable logic controller. The recommendations should be coordinated with the City of Cheney's Electrical Engineer to make the City's and the University's systems operate as complimentary as possible.

Arc Flash Modeling: EWU has recently completed an arc flash analysis of the 13.2-kV distribution system. This analysis calculated arc flash values at the secondary side of all University-owned, pad-mounted transformers connected to the 13.2kV system. This information should be made available to design teams when renovations to campus buildings are undertaken. For buildings not planned to be renovated in the near term, EWU should extend the arc flash study from the secondary side of the pad-mounted transformers to the building distribution system. EWU should incorporate the arc flash data into its electrical safety program so Electric Shop staff and Contractors are better prepared to safely work on University electrical systems. EWU should maintain and update the arc flash study recently completed and should continually update the study to reflect current campus conditions. This could be accomplished by maintaining the electronic model internally or working with an external consultant. Regardless of which approach is taken, each project should include a requirement to provide updated information to the University's arc flash model. Arc flash labeling should also be a requirement for each new building project and for projects which include modifications to building services.

## Costs

The following schematic level costs are intended to provide a guide for budgeting future projects. The costs are expressed in year 2016 dollars. Not included in the costs are possible utility connection charges that may be levied by the City of Cheney.

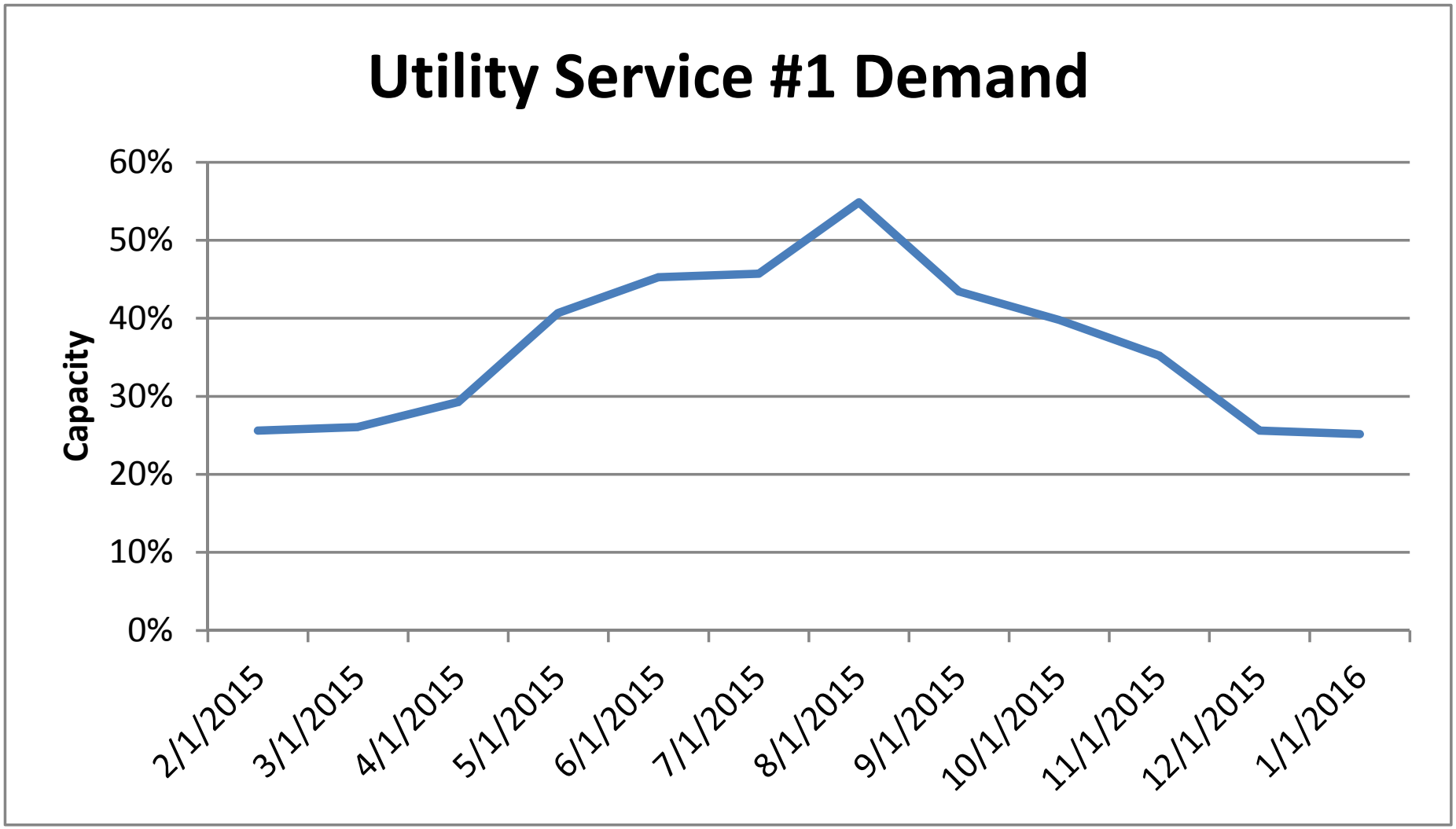
Medium-voltage conductor replacement: $4,000,000

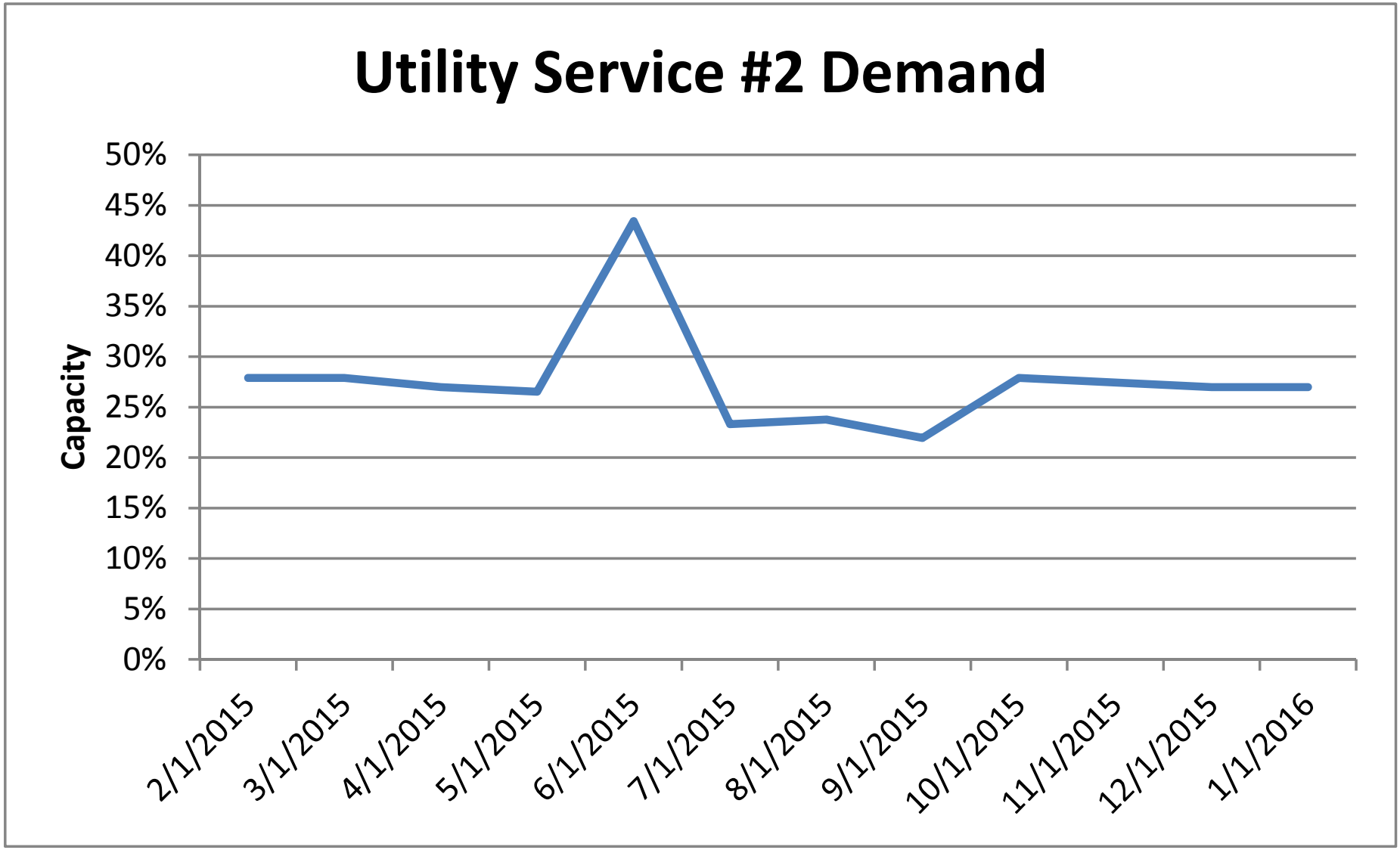
Medium-voltage vacuum switch replacement: $1,600,000

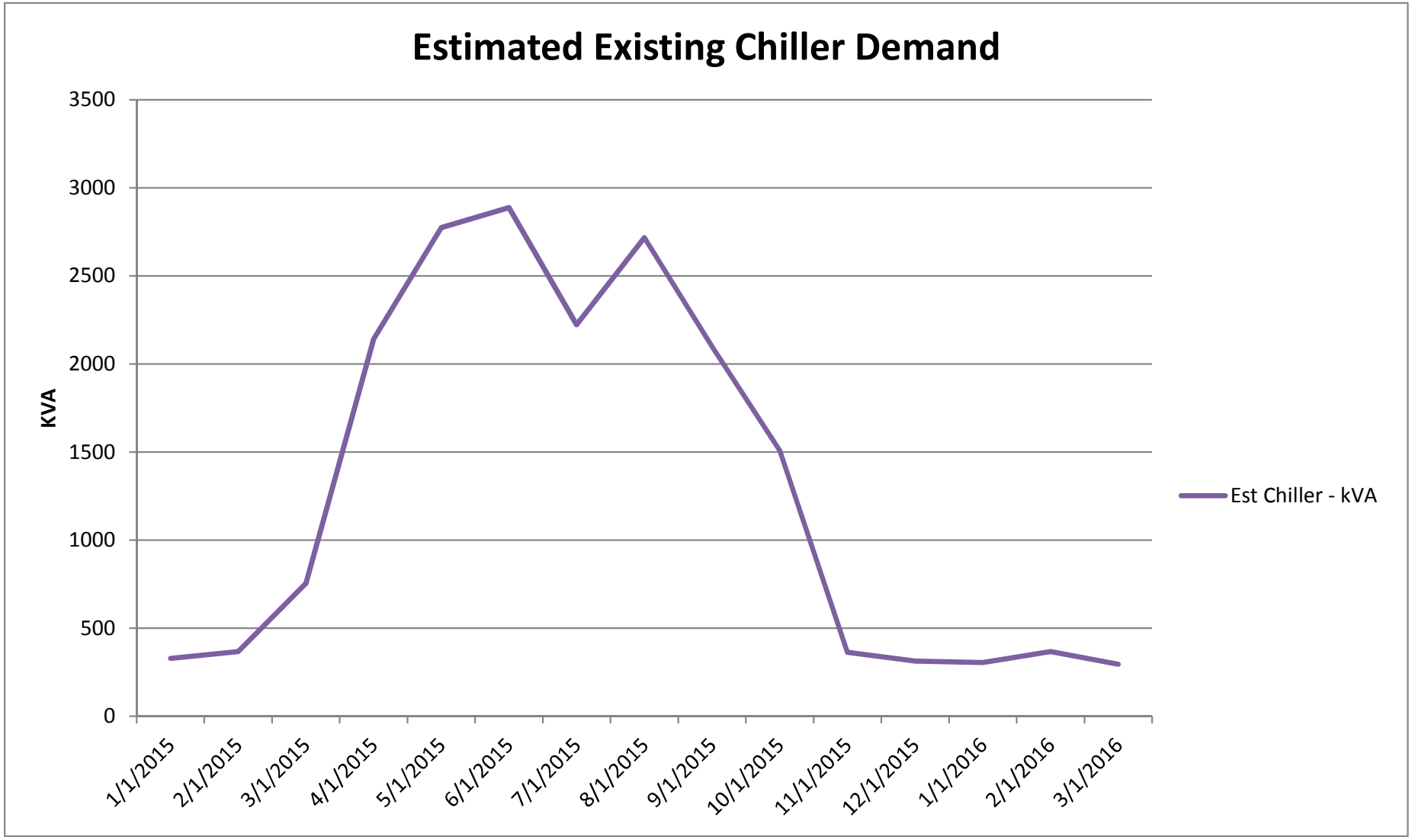
Distribution system capacity upgrade, Option A: $ 100,000
Option B: $ 250,000
Option C: $1,700,000

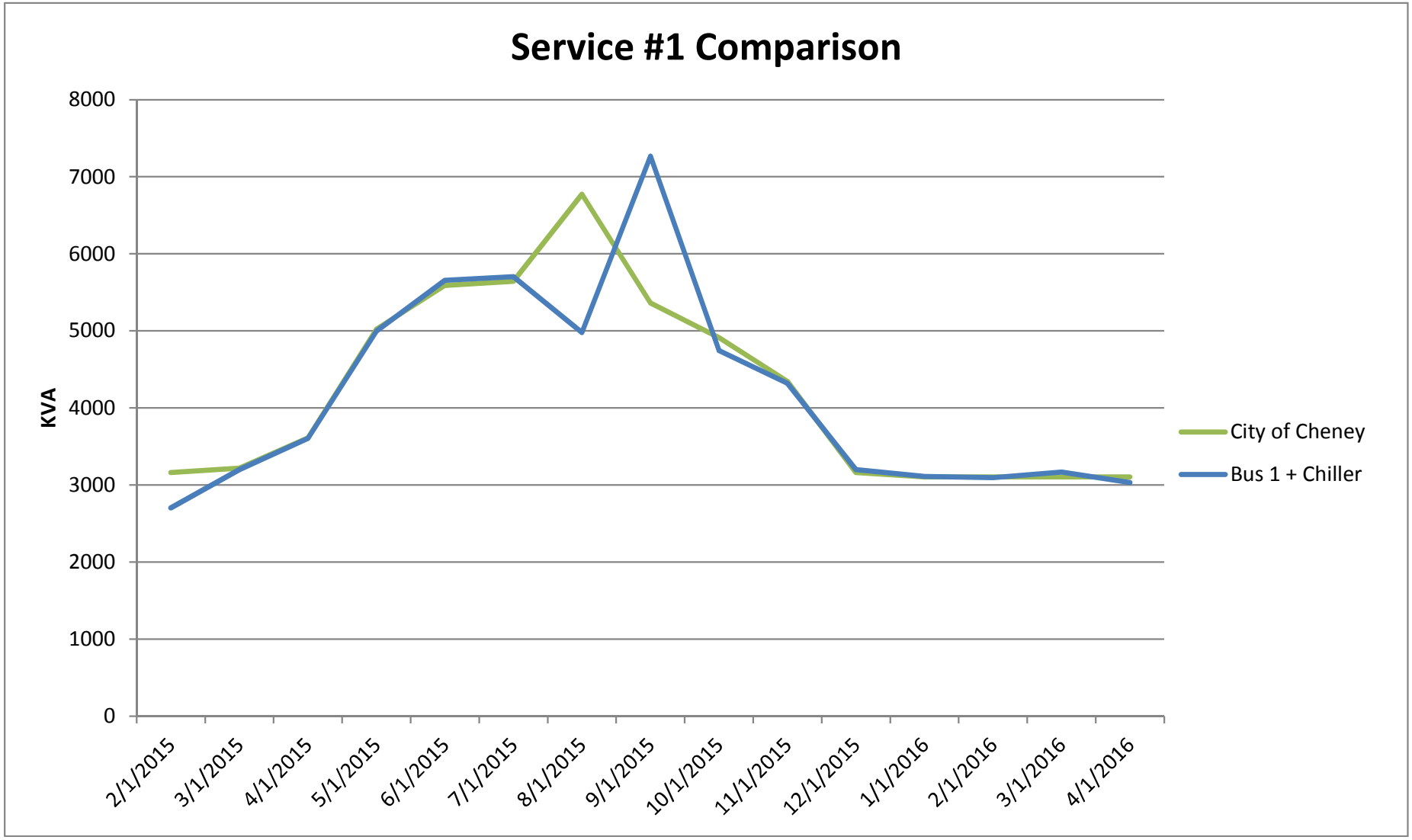
Medium-voltage switchgear adjustments: $100,000

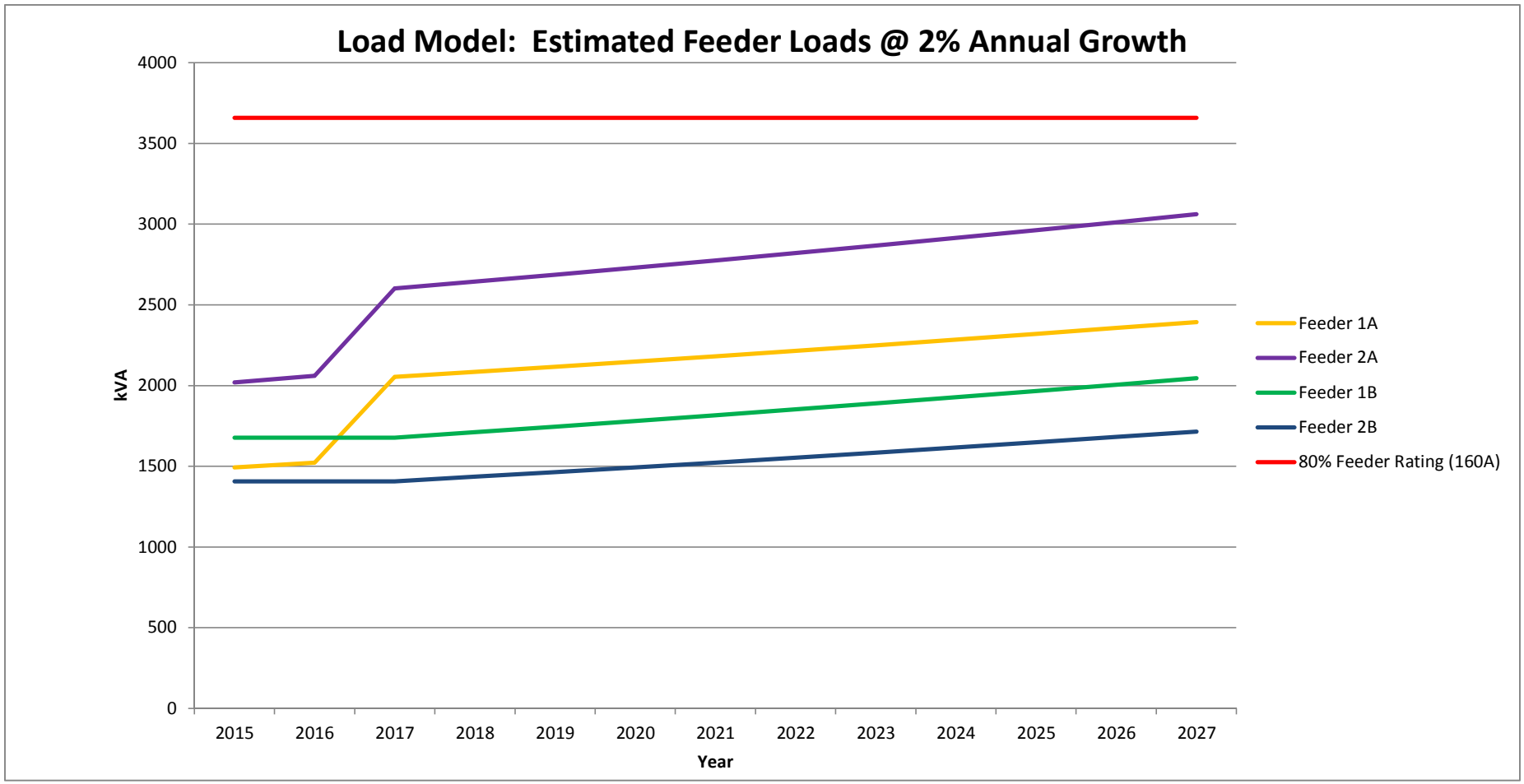
Arc flash modeling: $400,000

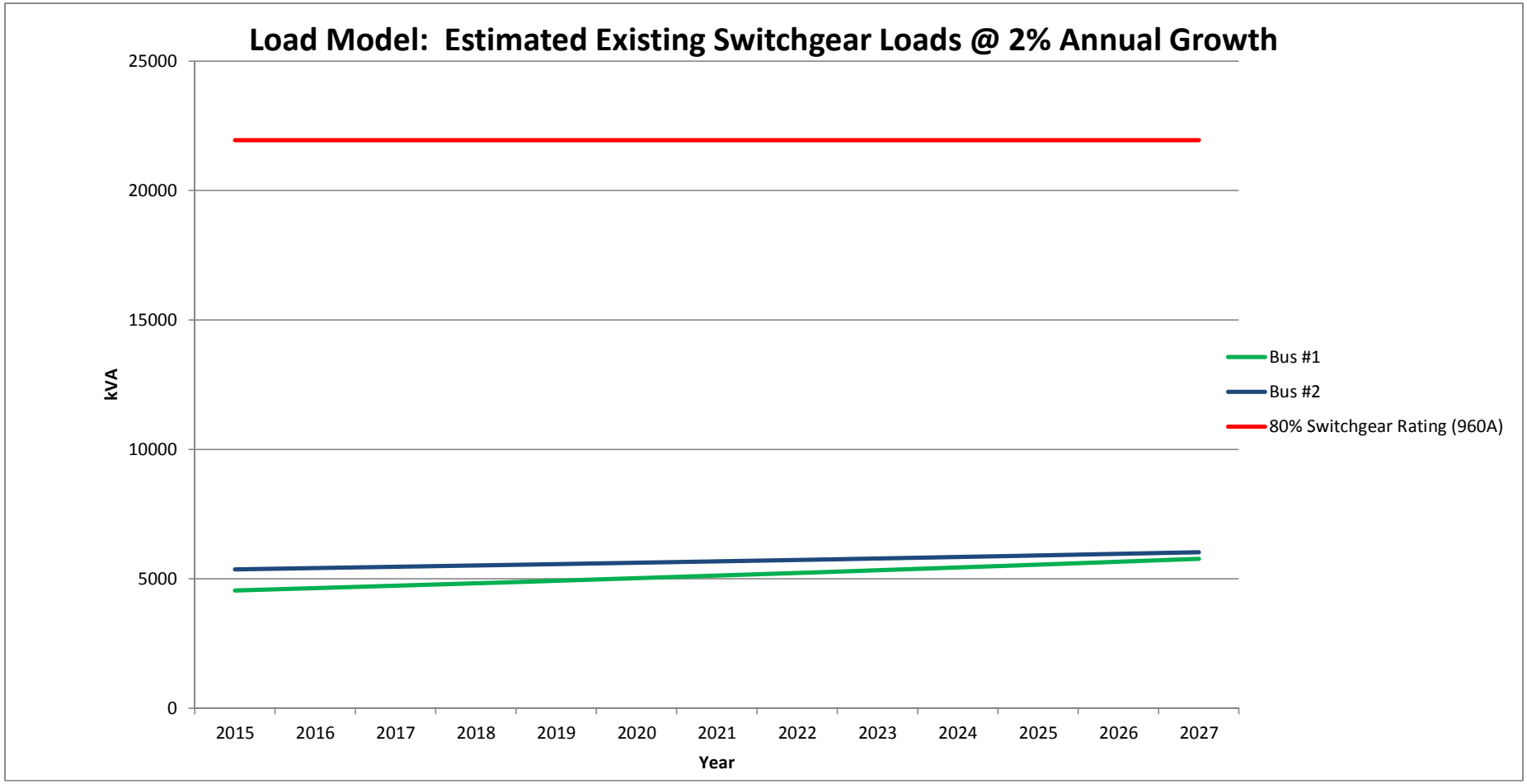

Utility Service #1 Demand
Capacity
60%
50%
40%
30%
20%
10%
0%
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
1/1/2016

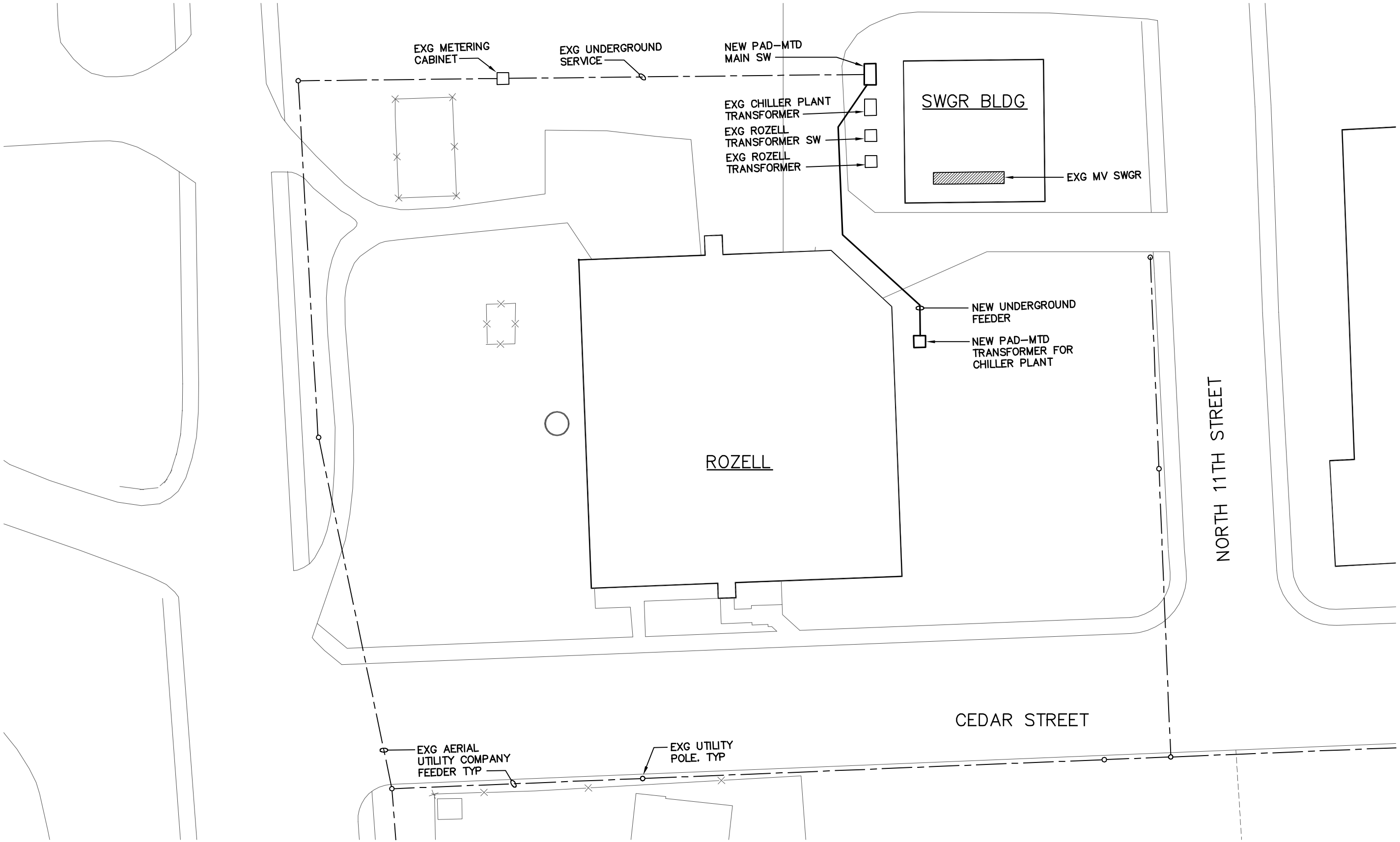

Utility Service #2 Demand
Capacity
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
1/1/2016


Estimated Existing Chiller Demand
KVA
3500
3000
2500
2000
1500
1000
500
0
1/1/2015
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
1/1/2016
2/1/2016
3/1/2016
Est Chiller - kVA


Service #1 Comparison
KVA
8000
7000
6000
5000
4000
3000
2000
1000
0
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
1/1/2016
2/1/2016
3/1/2016
4/1/2016
City of Cheney
Bus 1 + Chiller


Load Model: Estimated Feeder Loads @ 2% Annual Growth
4000
3500
3000
2500
2000
1500
1000
500
0
kVA
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
Year
Feeder 1A
Feeder 2A
Feeder 1B
Feeder 2B
80% Feeder Rating (160A)


Load Model: Estimated Existing Switchgear Loads @ 2% Annual Growth
25000
20000
15000
10000
5000
0
kVA
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
Year
Bus #1
Bus #2
80% Switchgear Rating (960A)

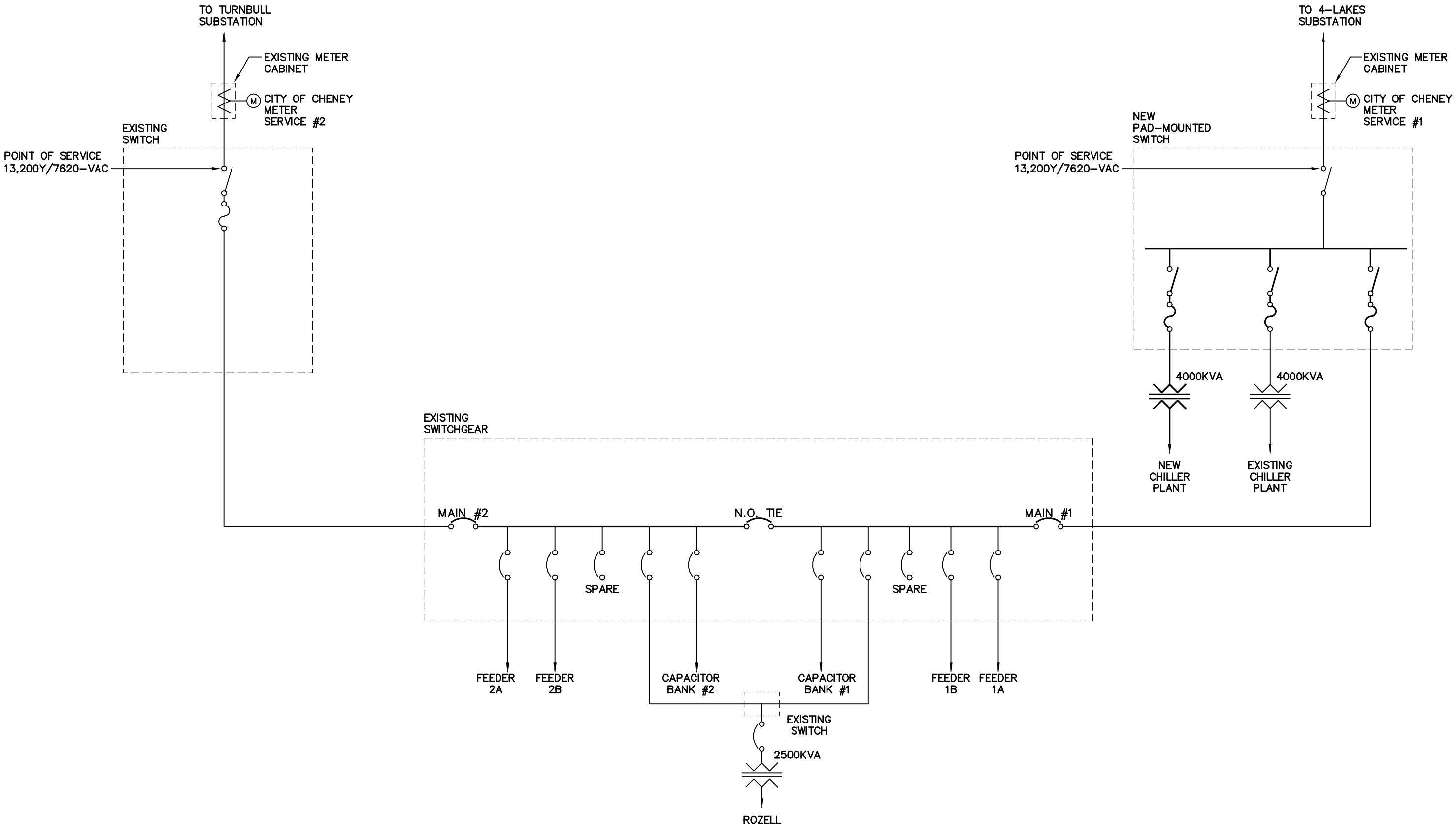



N

# DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION 'A'

Scale: 1" = 40'-0"

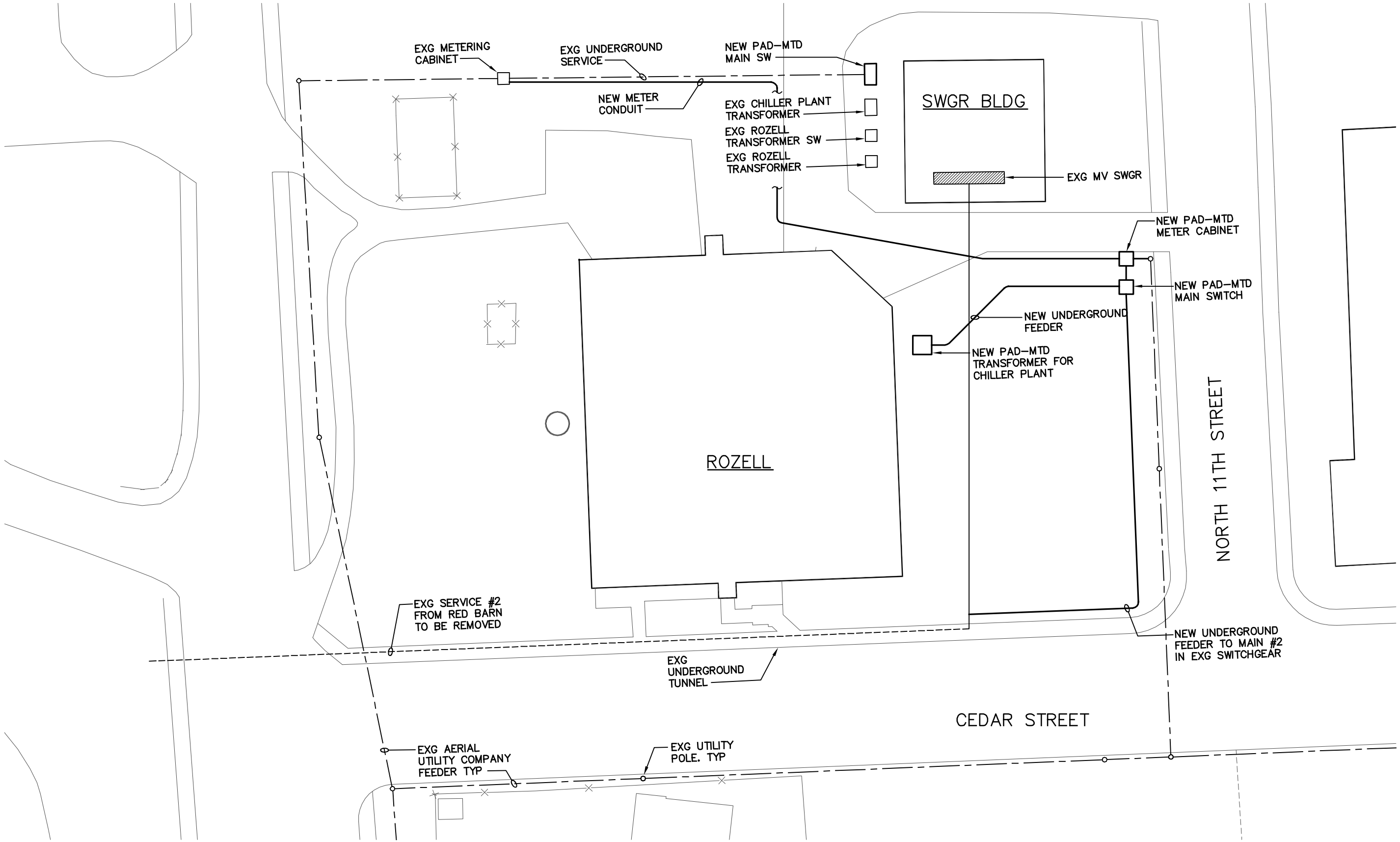
15518XESITE-A




# 1 DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION A

NO SCALE

15518–DI001A

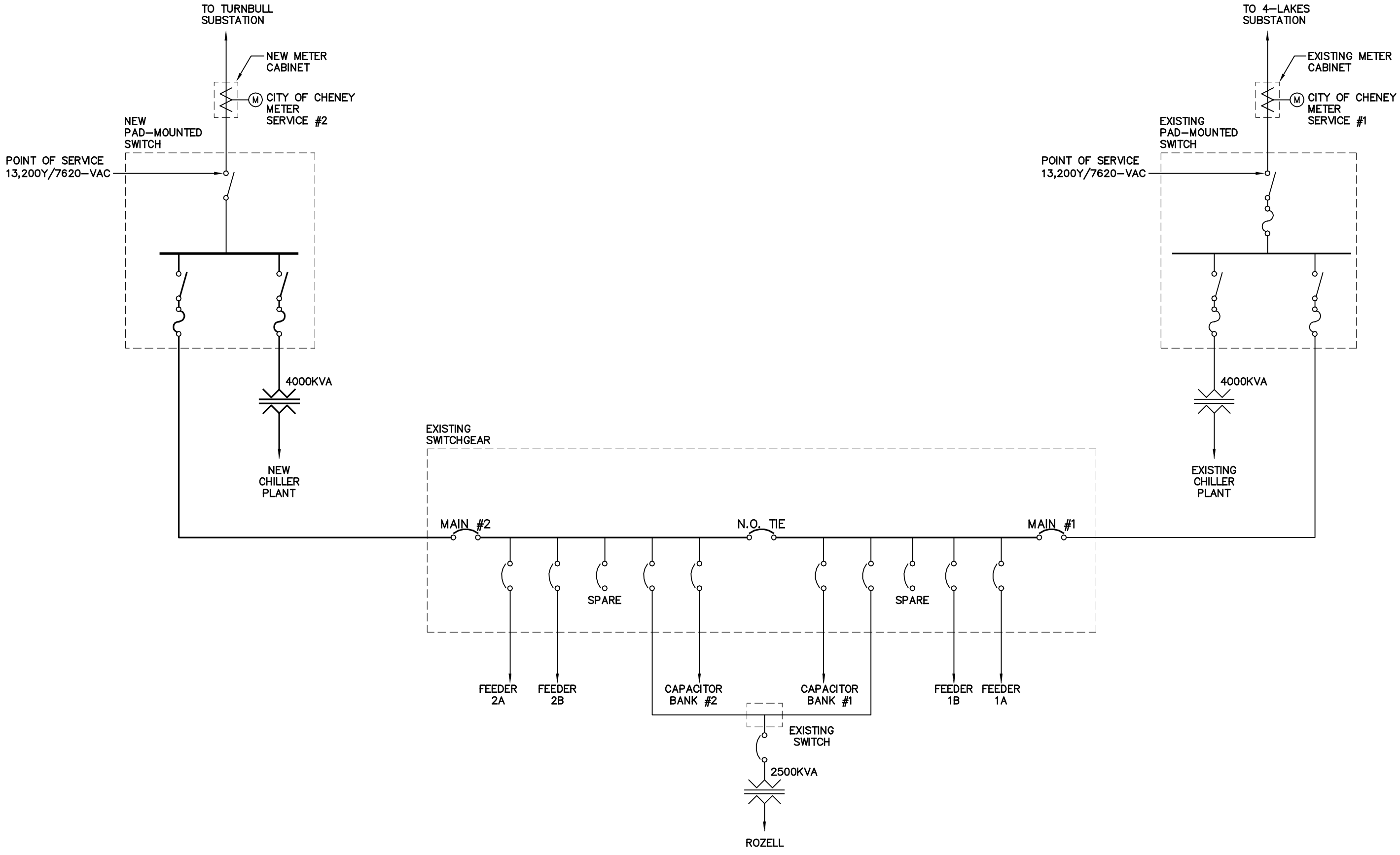



N

# DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION 'B'

Scale: 1" = 40'-0"

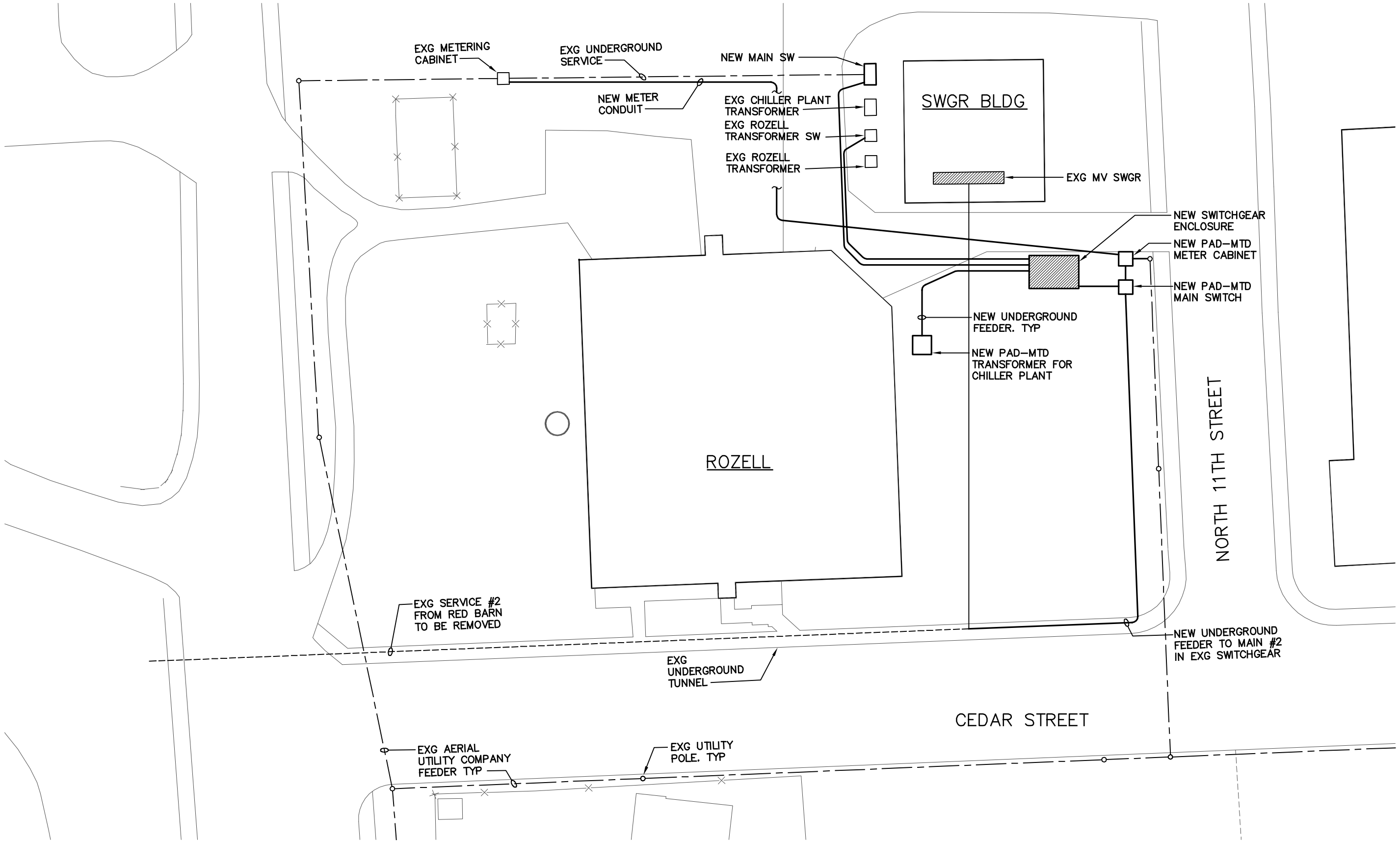
15518XESITE-B




## 2 DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION 'B'

NO SCALE

15518–DI001B

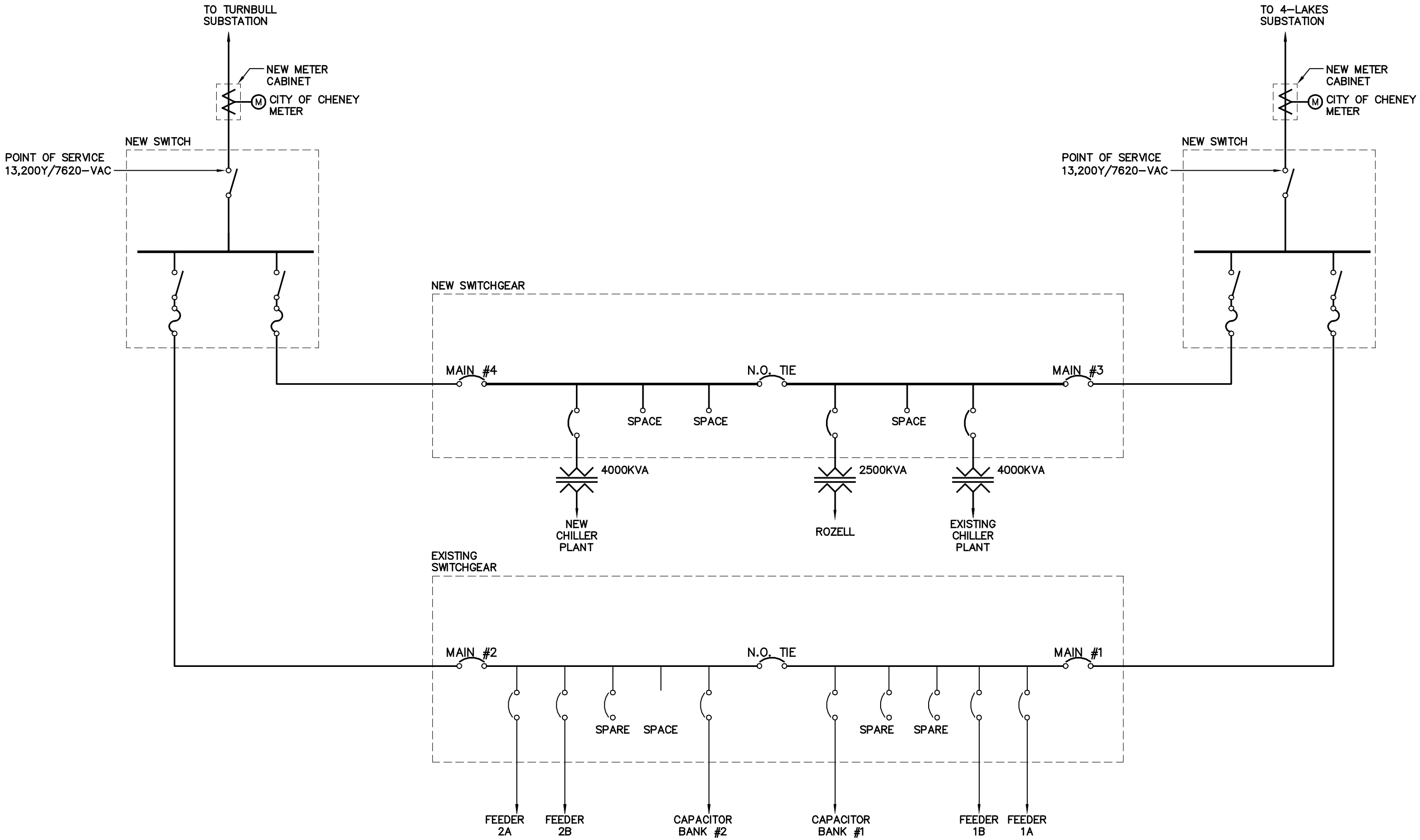



N

# DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION 'C'

Scale: 1" = 40'-0"

15518XESITE-C




# 3 DISTRIBUTION SYSTEM CAPACITY UPGRADE - OPTION C

NO SCALE

15518-DI001C