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PROVISIONING THE POWER SYSTEM FOR THE PORTER FARMS P.D.

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ABSTRACT

This report presents the design for the power system of the Porter Farms Planned Development (Porter Farms P.D.). The design proposal is a response to the request of John Porter with JMP Investments, Inc. requesting Memphis Light, Gas and Water (MLGW) to provide electric utilities. It involves direct coordination with the developer to create an optimum design given all applicable standards. The report incorporates codes and regulations encountered in electric distribution into the system design.

1.0 INTRODUCTION

1.1 Purpose

This design project aims to satisfy the energy requirements for the Porter Farms P.D. while complying with design standards, codes and regulations. The proposed design has to conform to MLGW's engineering design and construction standards, the National Electric Code (NEC), National Electric Safety Code (NESC), National Fuel Gas Code, and the City of Collierville's development standards [1]. It must provide cost-effective, reliable and efficient energy service.

1.2 Background

Porter Farms P.D. is divided into two areas (Figure 1 in Appendix): Area 1 has 69 subdivision lots with an average house size of 2500 square feet [2]; and Area 2 has 52 apartment units plus a club house [3]. The apartments will be developed first before any construction starts on the subdivision. MLGW will provide the required utilities for both the subdivision and the apartments located in Collierville, Tennessee, between Poplar Avenue and Winchester Road, east of Bailey Station Road (Figure 2 in Appendix) [4; 5].

The request for electric utilities was submitted on February 11, 2004. The developer requested the utilities to be installed and energized by May 11, 2004. On March 2004, the due date was changed to November 15, 2004 by the developer. With the new due date, the final electric design had to be presented to John Porter by September 27, 2004.

1.3 MLGW Standards

The MLGW electric engineering and construction standards are based on codes, regulations, ordinances and policies of governmental and private industry which govern the electric power system of MLGW [1]. These standards were created to meet or exceed the most current code edition. They are specifically based on the NESC, NEC, Memphis and Shelby County Electrical Code (MSCEC), MLGW Electric Service Policy Manual (ESPM), and other miscellaneous requirements like railroad guidelines.

2.0 REQUIREMENTS SPECIFICATION

The following lists the realistic constraints involved in this project.

- Technical – The Porter Farms P.D. needs a power system to meet the demand of 11.73kVA [1] for each subdivision lot based on the projected square footage of the houses, and 25.20kVA [3] for each apartment unit, including the clubhouse, based on the energy requirements submitted by the developer's electrician.
- Economic – The developer expects an electric cost of less than the 2003 average cost per subdivision lot of $1,594.00 [6], and less than the 2003 average cost per apartment unit of $679.00 [6]. Moreover, the electric system needs to be completely installed and energized by November 15, 2004.
- Reliability and Maintenance – MLGW engineering and construction standards will be incorporated into the design to guarantee a reliable and maintainable electric system.

- Ethical – The developer expects to be protected from any charge for unnecessary electric system improvement that is not needed to meet the demand of the development. Any system improvement proposed should benefit the developer, not benefit MLGW alone.
- Health and Safety – This design project requires consideration of the company's engineering and construction standards [1] that are based on the National Electric Code, National Electric Safety Code, and the National Fuel Gas Code. Health and safety consideration protects the MLGW construction and maintenance crews and the public.
- Environmental/Social/Political – The City of Collierville and the homeowner's association of an adjacent development strongly object any additional tree trimming, or any proposal affecting adjacent developments. Moreover, the City of Collierville requires the electric system to be installed underground [7]. No poles will be installed inside the development.

3.0 METHODOLOGY

This design project was approved by MLGW on June 14, 2004, and paid by John Porter on June 25, 2004. The deadline was met by focusing on the tasks set when the request was made.

These are the completed tasks:

1. Obtain Engineering Information – Project specifics were gathered from the developer which include electrical load for each of the apartment units, electrical load for the club house, approved apartments and subdivision plats containing building and lot layouts, and a set of construction plans for each of the areas.
2. Research and Field Inspection – This includes gathering information from MLGW's mapping system showing what utilities are present around the site of the project, and more specific information like pole numbers and sizes, and primary wire sizes. The field inspection was done to confirm the information gathered from MLGW's mapping system. It also includes detailed inspections of existing pole construction and tree locations.
3. Generate Electric Loop Layout – The submitted plats and construction plans were used to determine transformer locations and meter locations. With the transformer and meter locations finalized, the loop layout was easily generated. A loop system is used to ensure reliable electric service and less power interruptions during maintenance. Figure 3 in Appendix illustrates an electrical loop. The loop has two taps off the overhead source. The taps will be installed at two different poles.
4. Determine Source of Feed – After establishing the loop, the next step is to determine how to feed the loop. With the economic, environmental, political and social issues involved in this project, three designs were generated. These design options are discussed further in the next section.
5. Generate Design Specifications – The design specifications for the final design were entered into the MLGW's Management Support System (MSS) application [8], which supports the planning, application, utilization, and monitoring of all resources involved in the implementation of the design. The MSS keeps track with the labor, materials, equipments, time and money involved in the design and implementation of a project [1].
6. Submit Finished Design to Lead Engineer – The electric layout for the subdivision was given to a drafter to prepare a detailed drawing for the design prior to submission to the

lead engineer. Because of time restrictions and developer demands, the designer prepared the detailed drawing for the apartments. The drawings were submitted to the lead engineer for approval, then sent to the chief clerk to write a quote letter for each area, and finally, sent to the developer with the quote letters.

4.0 DESIGN OPTIONS

Here are the three preliminary designs to supply the loop:

1. Design 1 (Figure 4 & 5 in Appendix) – Because the apartments will be constructed before the subdivision, the electric circuit for the apartments will be looped separately from the subdivision. The apartments will be fed from an existing 23kV double circuit, 3-phase overhead line between Poplar Avenue and the railroad track on the north side. The electric underground primary will cross the railroad track by directional bore. The electric underground loop for the subdivision will be fed from an existing 23kV double circuit, 3-phase overhead line on Winchester Road.
2. Design 2 (Figure 6 in Appendix) – Like design 1, the apartments will be looped separately. The existing overhead line on Winchester Road will still supply the loop for the subdivision. For the apartments, a single phase 23kV overhead line will be installed following the route of an existing single phase line. The existing overhead line already crosses the railroad track on the west side of the project, across a community lake. After crossing the railroad track, the new single phase line will be extended along the railroad track and along the community lake up to the perimeter of the apartments to feed the underground loop.
3. Design 3 (Figure 7 in Appendix) – The apartments and the subdivision will have one underground electric loop. Since the apartments are on the north side of the subdivision and the feed will be coming from Winchester Road on the south side, a temporary 23kV single phase pole line will be installed to feed the apartments. After the apartments are developed and the subdivision is ready for its electric utility, the temporary pole line will be removed, and the electric loop established in the apartments will be connected to the loop of the subdivision creating one loop.

5.0 DESIGN ANALYSIS

Obtaining railroad crossing easement in areas with no dedicated right of way was originally free of charge. While processing railroad easement application for design 1, MLGW's Right of Way (ROW) department indicated that it will take at least 90 days for the railroad company to process the application with a minimum cost of $75,000, based on previous railroad crossing cases [9]. The developer does not have 90 days to spare, or a budget of $75,000 for railroad crossing. Design 1 had to be modified to avoid this issue with the railroad company, and design 2 was generated. For design 2, the overhead extension was not approved by the City of Collierville [7]. The city only allows overhead power lines on major streets, and will not approve additional tree trimming or removal. Moreover, the homeowners association in the Village of Bailey Station considered the overhead line an eyesore and objected to the overhead extension along their community lake [7]. Even if the city and the association agreed, design 2 still faces the same issue encountered in design 1. Although the existing single phase line already crossed the railroad track, upgrading the line into two phases will need a new approval from the railroad company.

With the issues involved in acquiring an easement from the railroad company, the developer made a suggestion to install an overhead line at the future Shea Road [7], which crosses the railroad track on the east side of the development. Since the railroad company already dedicated an easement for Shea Road, the developer will not have to pay any easement fee to the railroad company. With the cost requirement in mind, the developer was notified that, even though MLGW plans to install an overhead line on the future Shea Road as part of MLGW's electric system improvement, the developer will still be responsible for running the overhead line on Shea Road needed to feed the apartments.

With the problems encountered in getting power from the north side of the development to the apartments, a source of power on Winchester Road, which is south of the development, was examined. Since the subdivision is between the apartments and Winchester Road, it will be impractical and costly to route a separate loop for the apartments. If the load of the apartments and subdivision can be connected in one loop, then a second loop is not necessary. The first two design options involve two separate loops to accommodate the developer's plan of developing the apartments before the subdivision. A loop fused at 100A has a maximum load of 1320kVA [1]. Since the apartments already have a calculated load of 525kVA, the subdivision could only have a maximum load of 795kVA. The subdivision at its original setup has a total load of 825kVA. In order to connect the apartments and subdivision in one loop, the transformers were relocated in order to feed more lots and use maximum capacity. With the transformer modification, the total load for the subdivision decreased to 775kVA, which makes one loop possible for the whole development.

Design 3 was the final design quoted to the developer. It involves an additional cost of $10,000 for installing and removing the temporary overhead line [8], but it is still more cost-effective and time-efficient than the first two designs. A $10,000 additional cost is $65,000 savings compared to the minimum railroad fee of $75,000. Moreover, design 3 eliminates the 90-day waiting time for railroad approval, and further dealings with the City of Collierville and the homeowners association.

6.0 SPECIFICATIONS

The following lists the specifics of the final design.

- Fuse – Since the loop will be connected to a main distribution line which is directly connected to an MLGW substation, it is MLGW's standard to fuse any tap off the main distribution line with a 100A fuse. The loop will be using two 100A fuses, one on each tap, to be able to feed the loop in either direction. It is MLGW's engineering practice to install the fuses at two different poles to provide a reliable system.
- Transformers – The apartments and subdivision will be using 3 50kVA, 14 75kVA, and 1 100kVA transformers. Calculations involved in determining the transformer sizes to be used are presented in the next section.
- Cables and Conduits – The power system for this development project will use the standard cable sizes of #2 insulated copper for the primary and 350kCM triplex for the

secondary to be protected by 2in and 3in conduits, respectively. The cables and conduits are going to be buried 4ft deep [10].

- Meter Sockets – Since the apartment buildings will be ready during the installation of the electric facilities, meter sockets will be issued for the apartments. No meter socket will be included in the subdivision design because the houses are not going to be ready for their electric service. The apartments will need 12 6-gang meter sockets, 2 2-gang meter sockets, and 1 single meter socket. Figure 8 in Appendix is a 6-gang meter socket. The bottom view shows where the electric secondary riser is going to feed the meter socket.
- Secondary Riser Location (Figure 9 in Appendix) – Detailed electric and gas riser locations, like Figure 9, were given to the developer's electrician and plumber to avoid any code violation. Electric panels are going to be installed above the electric meters, and are considered source of ignition for the gas service. The gas code requires that sources of ignition need to be at a minimum distance of 3ft from gas risers and meters [11, p. 61]. The electric and gas riser locations were determined based on the 3ft restriction.
- Transformer Locations (Figure 10 & 11 in Appendix) – For the apartments, the transformer and primary cable locations depend on the existence of a sidewalk and grassplot. The transformer is 14ft from the back of the curb in areas where there is a sidewalk and grassplot; otherwise, it is 6ft from the curb. For the subdivision, the transformer and handhole are 11.5ft from the back of the curb. A handhole is where a secondary service splits to feed two subdivision lots.

7.0 CALCULATIONS

- Primary Cable Tension – The maximum allowable tension on the primary cables is 850 lbs as required by MLGW [1]. This is to guarantee that the cable will not brake when pulled through the conduit. The cable tensions, for each primary spans connecting each transformer, were software-calculated. Among the primary cable spans, the maximum tension in this project is 831 lbs [12].
- Transformer Size (Apartments) – The transformer sizes are based on the loads given by the developer's electrician. To calculate the transformer load, the load per unit is calculated first. The following table shows the calculated load per unit using Eq. 1.

Table 1. Total Load per Unit

	Load from Electrician, kVA	Demand Factor	Projected Load, kVA
Lighting	4.00	0.5	2.00
Receptacle	4.00	0.4	1.60
Range	7.00	0.6	4.20
Dryer	6.00	0.6	3.60
HVAC	3.50	0.8	3.92
		Total Load per Unit	**15.32**

$$\text{Total Load per Unit} = \Sigma\,(\text{Load from Electrician})(\text{Demand Factor}) \qquad \text{Eq. 1}$$

With the calculated load per unit, the transformer load can be calculated and the transformer size determined as shown in Table 2 using Eq. 2.

Table 2. Transformer Load and Size

No. of Buildings	No. of Units	Demand Factor	Transformer Load	Transformer Size
1	4	0.8	49.024	50 kVA
2	8	0.7	85.792	100 kVA

$$\text{Transformer Load} = (\text{Total Load per Unit})(\text{No. of Units})(\text{Demand Factor}) \quad \text{Eq. 2}$$

Applying the demand factor gives the maximum expected load by MLGW. Since not all loads are going to be energized at the same time, the demand factor is used to estimate the maximum possible load.

- Transformer Size (Subdivision) – The transformer loads and sizes are based on the average square footage of the houses to be built in the subdivision. There was no calculation needed. Table 3 shows that connecting 4 lots give a total transformer load of 36.72kVA [1], which implies a transformer size of 50kVA. A 50kVA transformer can feed 4 to 5 lots, while a 75kVA can feed 6 to 10 lots. MLGW's standard transformer sizes used in residential developments are 100kVA, 75kVA, 50kVA, and 25kVA.

Table 3. Subdivision Transformer Size & Load [1]

No. of Lots	Load Based on Sq. Ft., kVA	Transformer Size
4	36.72	50 kVA
5	44.56	
6	52.36	75 kVA
7	61.58	
8	65.69	
9	68.62	
10	70.38	

8.0 COST ANALYSIS

The cost for this project is software-generated. The specifications were entered into the MSS application, and the total cost for each area was automatically calculated. The MSS calculates labor costs, materials, equipment costs, market contingency, salvage credit, future cost of service, meter cost, and revenue credit for both the subdivision and apartments.

The cost of the Porter Farms P.D. project is tabulated on the following page. The electric utility cost per lot for the subdivision is $1,592.48 which is less than the average cost per subdivision lot of $1,594.00 in 2003 [6]. For the apartments, the cost per unit including the clubhouse is $1,239.66 which is more than the average cost per apartment unit of $679.00 in 2003 [6]. The developer believed that this difference is attributed by the electric pole line which will temporarily feed the apartments until the subdivision is developed to complete the electrical loop for the whole development. The cost calculated for installing and removing the temporary pole line is only $10,000. It was explained to the developer that the cost is approximately twice as much as the average cost because of the number of units per building, not the temporary pole line.

Table 2. Total Cost [8]

	Subdivision, Area 1	Apartments, Area 2
Labor	$61,252.08	$43,586.85
Materials	$40,451.90	$23,291.59
Equipment	$10,494.59	$7,895.41
1% Market Contingency	$1,121.98	$747.35
Salvage Credit	-$541.47	$0.00
Future Cost of Service	$26,358.00	$0.00
Meter Cost	$20,079.00	$4,927.10
Total Revenue Credit	-$49,335.00	-$14,746.45
Total	$109,881.08	$65,701.85
Grand Total	**$175,582.93**	

The typical number of units in an apartment building for 2003 is eight. In this project, each apartment building has only four units. Figure 12 in Appendix shows the number of transformers and length of secondary cable in a project with 4-unit buildings and another project with 8-unit buildings. The cost in each project is tabulated in Table 4 with variable C representing the cost of the primary cable in the loop, which is the same in each project.

Table 4. 4-Unit Versus 8-Unit Building Costs [8]

	Transformer		Secondary Cable		Primary Cable Cost
	Quantity	Cost, $	Length, ft.	Cost, $	
Project 1	1	2586	200	1710	C
Project 2	2	5170	80	844	C

Using the costs in Table 4, the cost per unit for each project was calculated using Eq. 3. The calculated values prove that the cost per unit for an apartment project with 8-unit buildings is approximately half as much as the project with 4-unit buildings.

$$COST/UNIT = \frac{(Transformer\ Cost) + (Secondary\ Cable\ Cost) + (Primary\ Cable\ Cost)}{Number\ of\ Units} \quad \text{Eq. 3}$$

$$COST/UNIT_{PROJECT\ 1} = \frac{\$2586 + \$1710 + C}{4} = \$1074 + C/4$$

$$COST/UNIT_{PROJECT\ 2} = \frac{\$5170 + \$844 + C}{8} = \$751.75 + C/8 \approx \frac{COST/UNIT_{PROJECT\ 1}}{2}$$

9.0 CONCLUSION

This design project met the deadline in presenting a final design with a quote letter to the developer on June 14, 2004. With the due date of November 15, 2004 for the utilities to be energized, MLGW's construction department had five months to install and energize the needed utilities. Furthermore, all the requirements were met.

APPENDIX

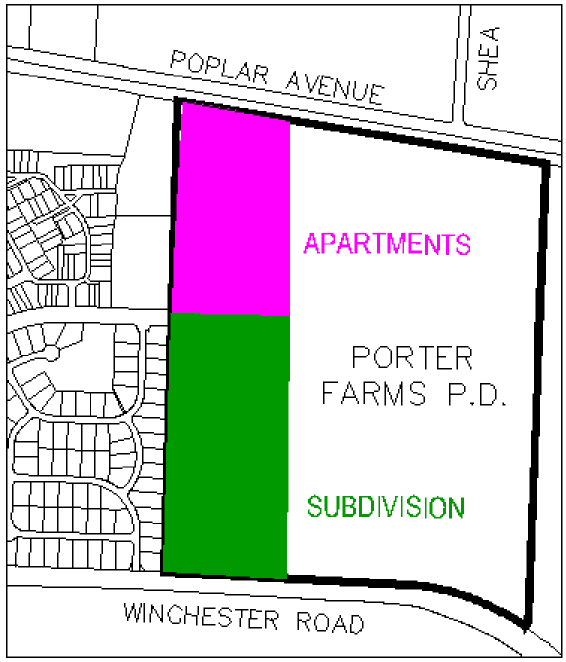

Figure 1. Apartments and Subdivision Locations

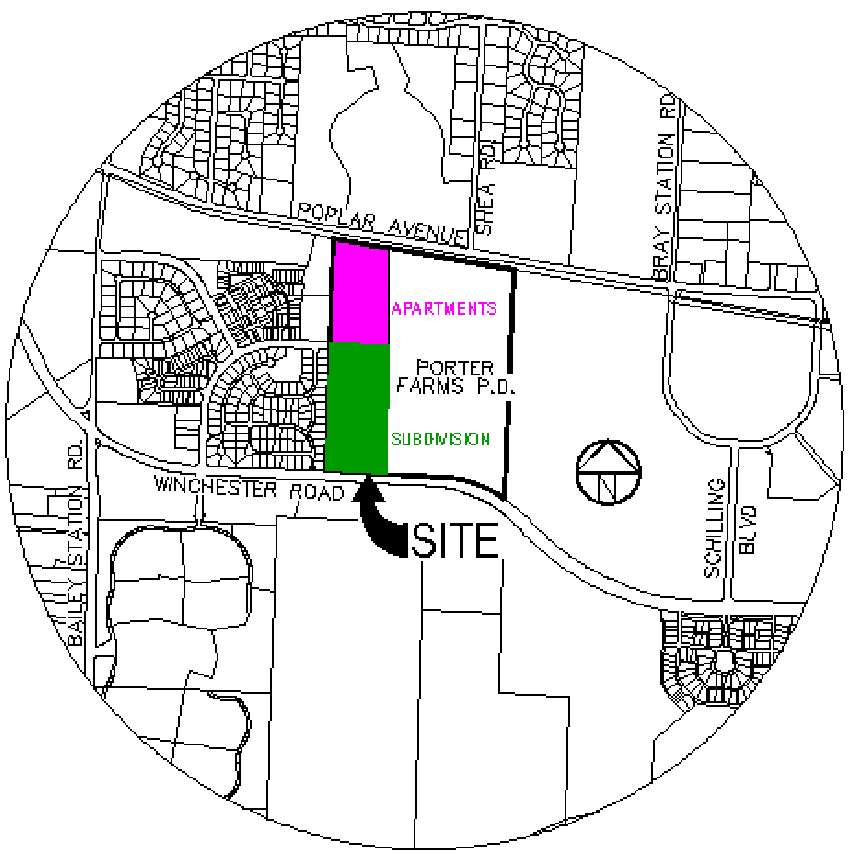

Figure 2. Project Location

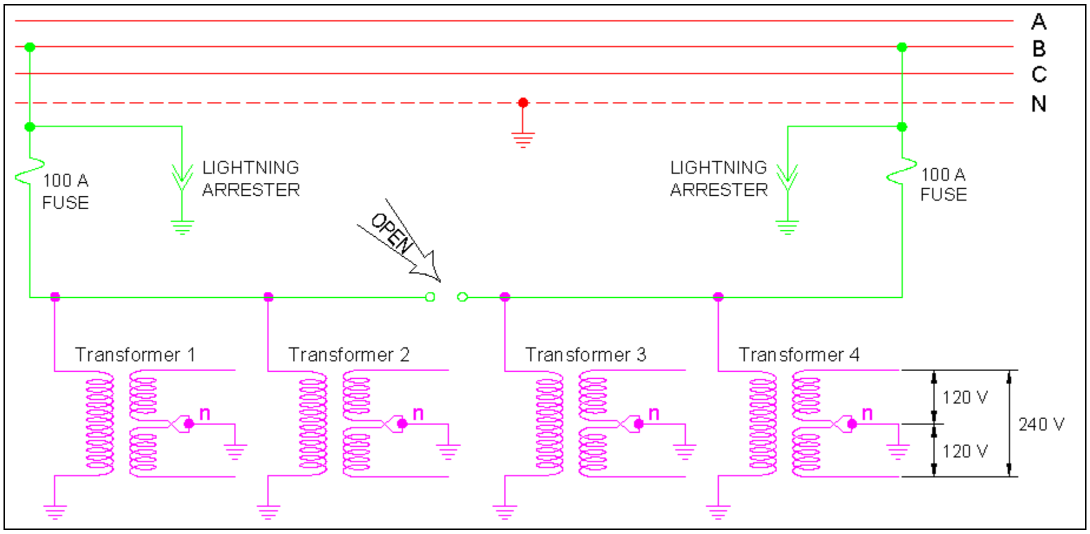

Figure 3. Electrical Loop

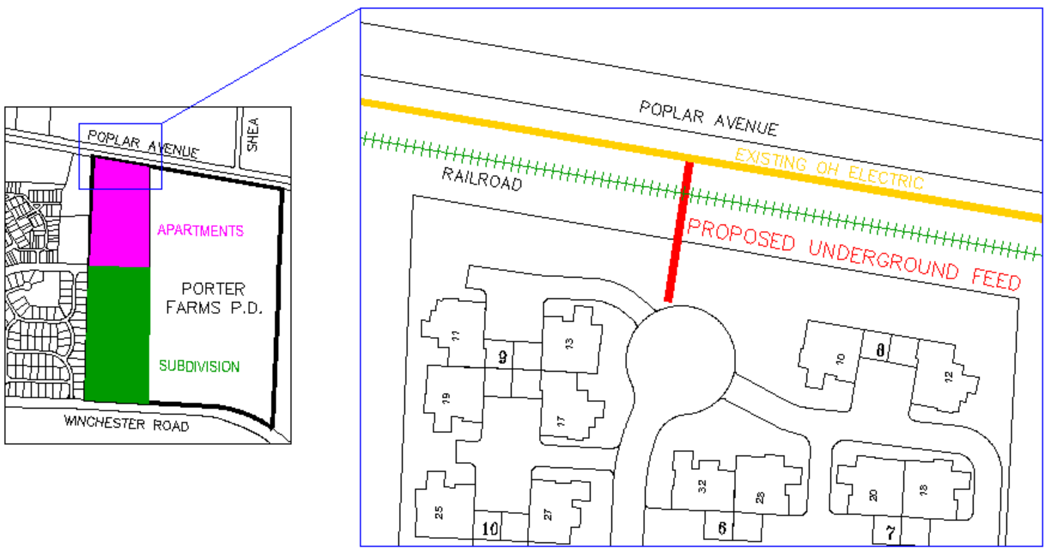

Figure 4. Design Option 1 – Loop 1

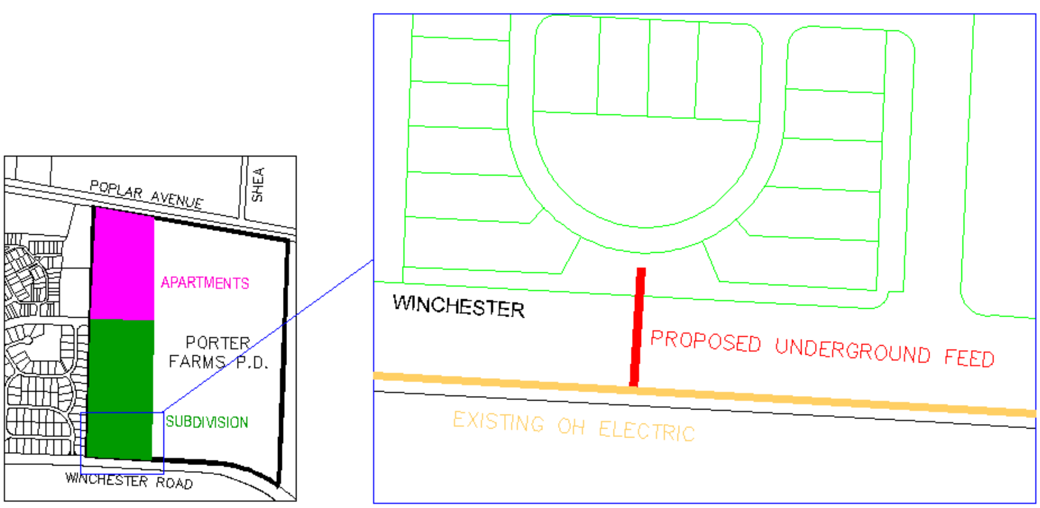

Figure 5. Design Option 1 – Loop 2

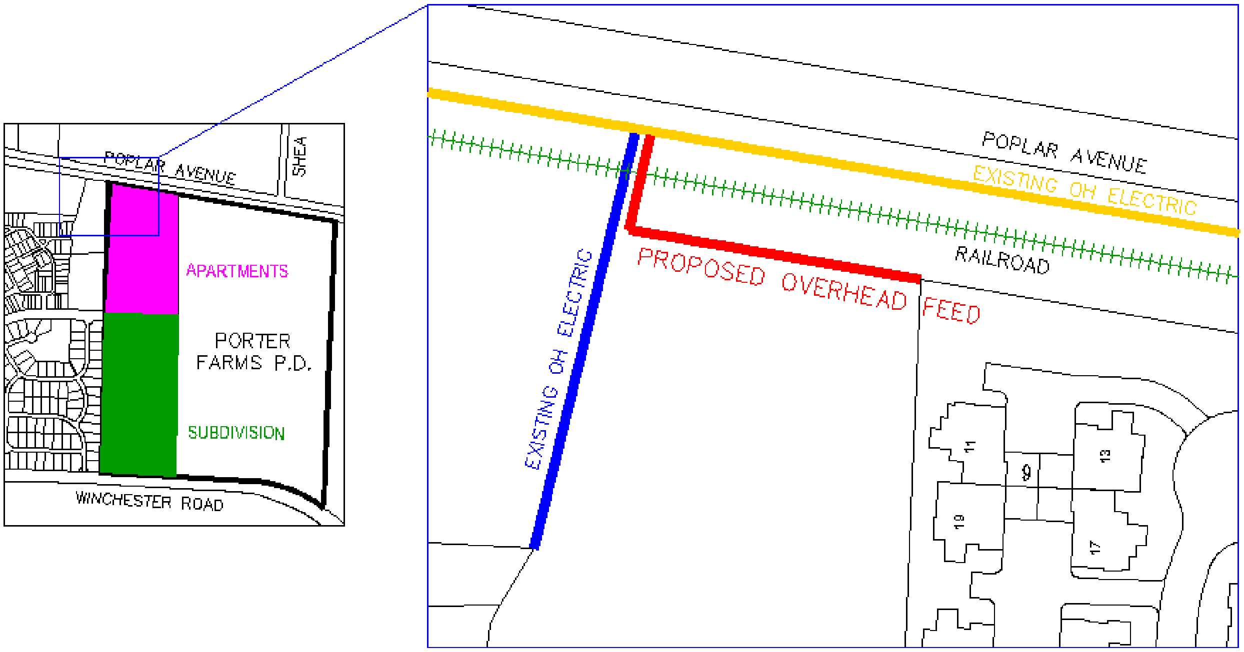

Figure 6. Design Option 2

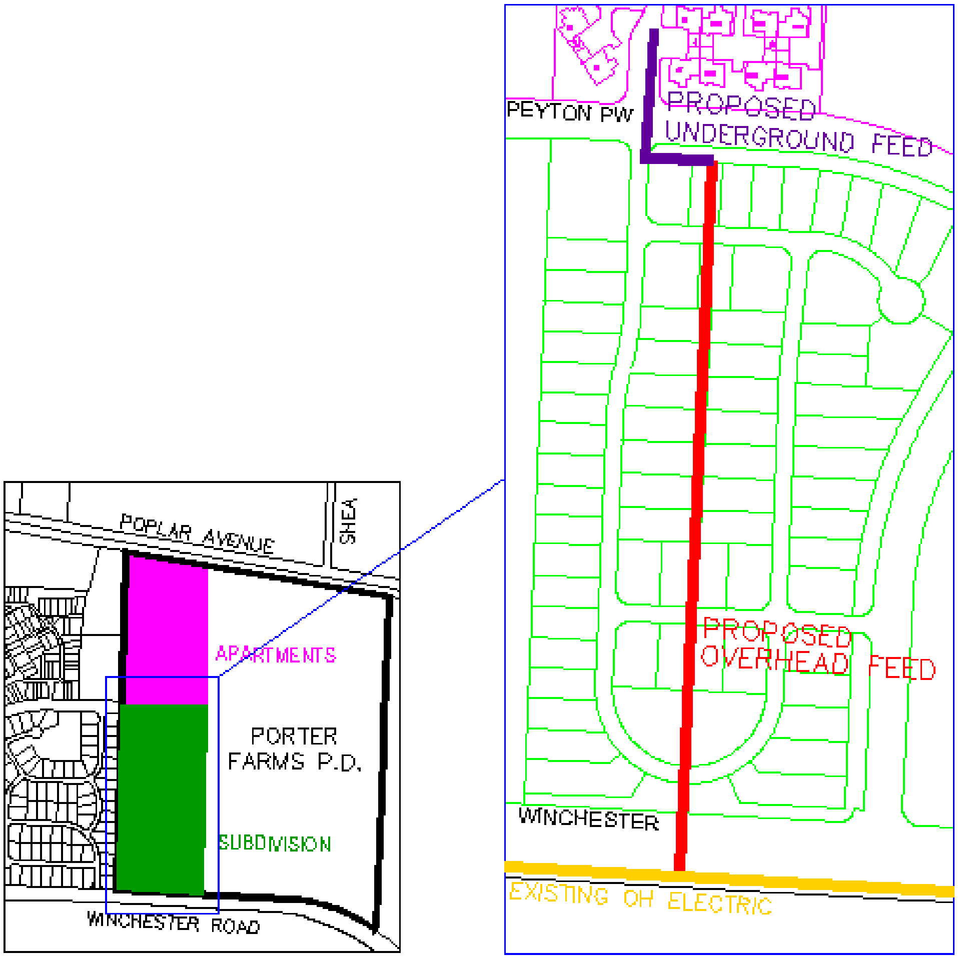

Figure 7. Design Option 3

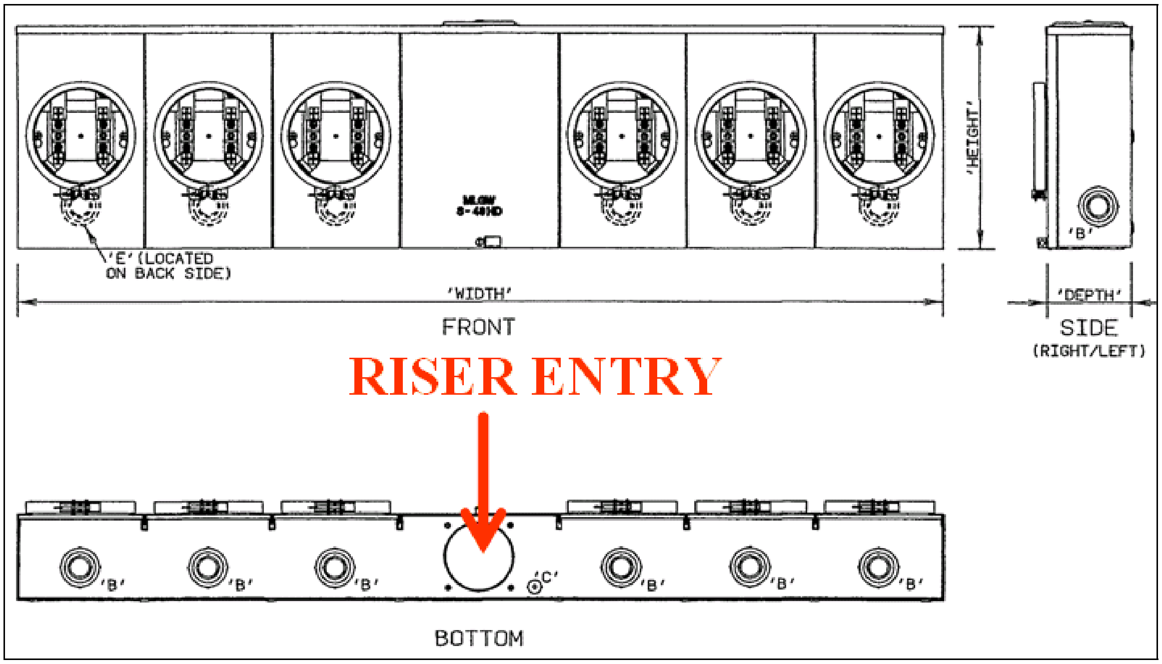

Figure 8. 6-Gang Meter Socket

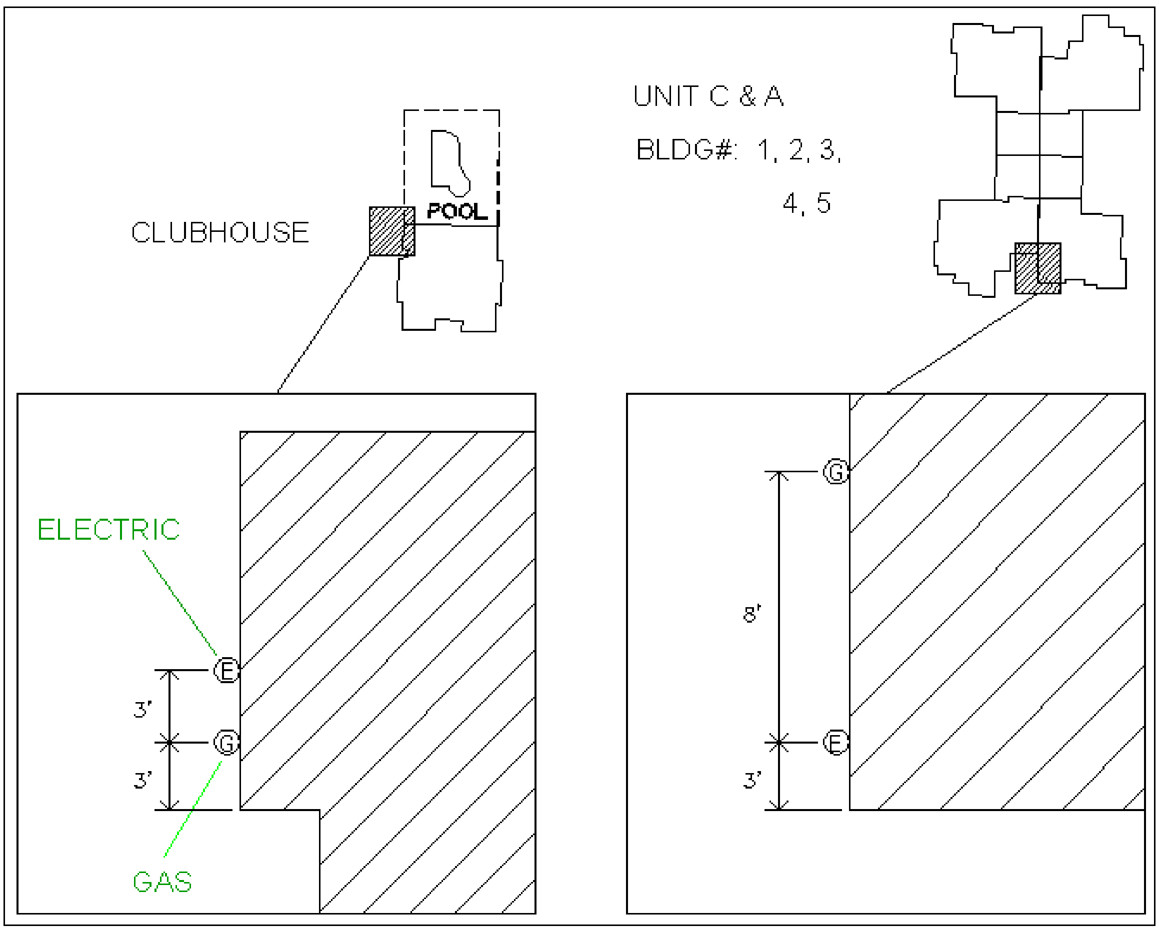

Figure 9. Electric and Gas Risers Location

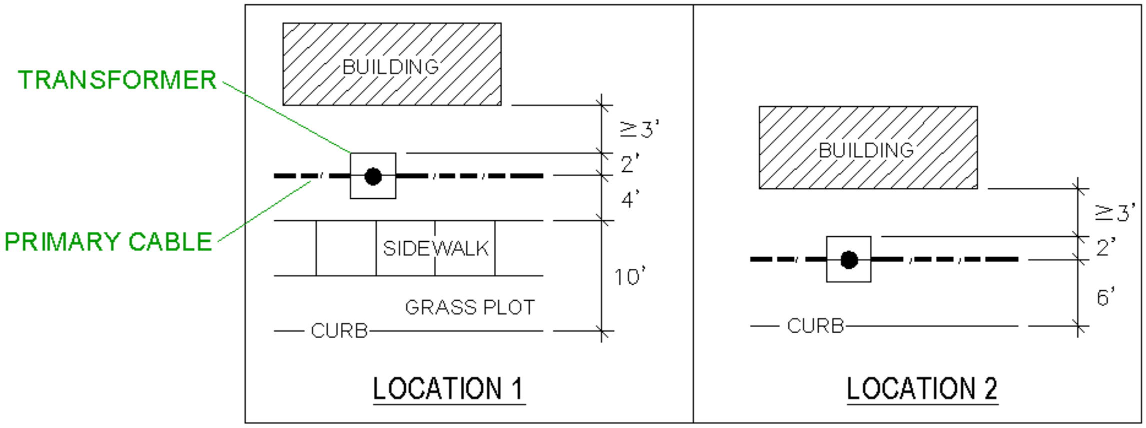

Figure 10. Transformer Locations – Apartments

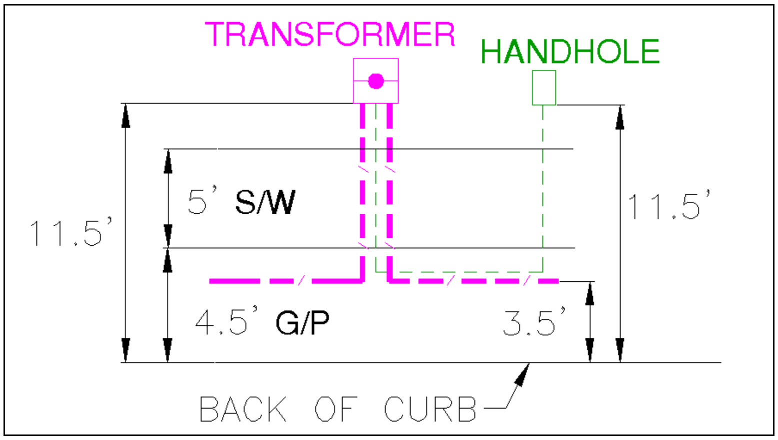

Figure 11. Transformer and Handhole Locations – Subdivision

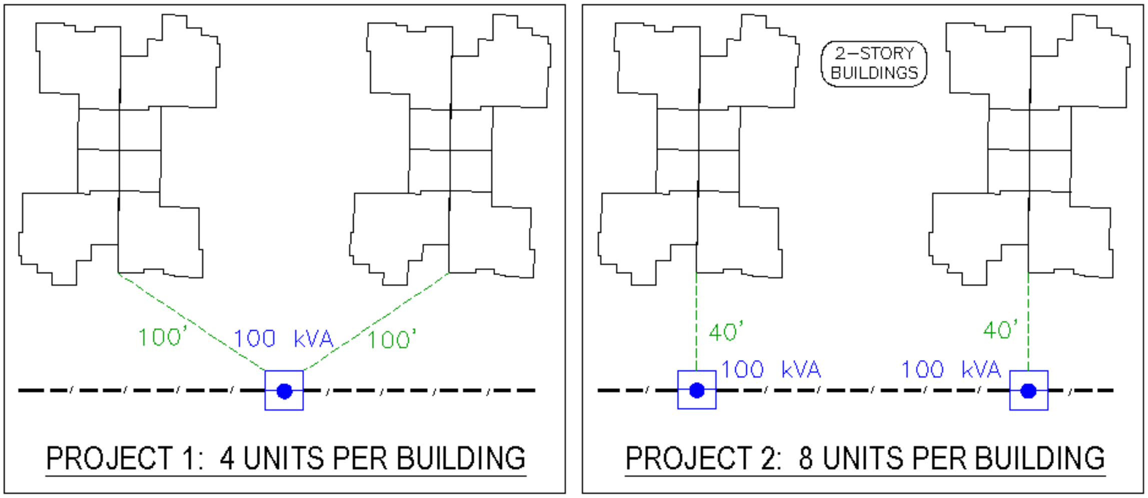

Figure 12. 4-Unit Versus 8-Unit Apartments

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