4. TRANSMISSION LINE ENGINEERING AND OPERATIONAL DESIGN

This section describes the design of the proposed high voltage transmission lines required for the Project and its operation. The names attached to the plans and routes discussed in this section are provided in Table 2.2-1 in Section 2.2.2.3.

4.1 ELECTRICAL DESIGN CONSIDERATIONS AND SWITCHYARDS

4.1.1 Turbine Generator Output

Electric power for each of the two phases of the IGCC Power Station will be produced by two combustion turbine generators (about 220 MW each) and by one steam turbine generator (up to 300 MW). The voltage level characterizing the electrical output of the combustion turbine generator and steam turbine generator (16.5kV and 18kV, respectively) will be below the level needed to transmit the Station's net electric output to its POI. Transformation to the appropriate voltage will occur prior to the Power Station's switchyard. The design and cost of the IGCC Power Station are currently based on such transformation delivering to the switchyard at a voltage of 230kV.

4.1.2 Conductor Capacity and Generator Outlet HVTLs

Based on the Station's nominal net electric output of 606 MW at a 0.90 power factor, one bundled conductor 230kV transmission line rated at 1,585 Amperes is sufficient to carry the peak electrical output of Mesaba One or Mesaba Two. A single 345kV bundled conductor rated at 2,113 Amperes could carry the full 1,212 MW net electric power output from Mesaba One and Mesaba Two. However, a minimum of three 230kV HVTLs, two 345kV HVTLs, or a combination of two 230kV HVTLs and one 345kV HVTL would be required to satisfy the single failure criterion design element (that is, loss of one GO HVTL could occur without interrupting the Phase I and II IGCC Power Station's delivery of its peak output power to the POI).

4.1.3 Interconnection Voltage

The choice between transforming the output power of Mesaba One and/or Mesaba Two to 230kV or 345kV is not solely dependent upon the distance between the Power Station and its POI (although distance is important because power losses increase with increasing distance from the POI). The choice is also dependent upon voltage levels at which the substation currently operates (the electrical equipment required to transform power from one level to another is very expensive) and existing "down stream" power flow constraints.

4.1.3.1 Operating Voltage of Regional Electric Transmission System

The regional high voltage transmission system on the Iron Range operates mainly at 115kV and 230kV. Efforts to bolster Minnesota's ability to exchange power between regions and with fewer attendant losses will dictate that new transmission developments in the region operate at higher voltages. The Applicant believes that 345kV will be the future standard on which such transmission developments on the Iron Range and elsewhere will be focused and has based its

decision for the IGCC Power Station's interconnection voltage on that premise. The results of MISO's Interconnection Studies (see Section 1.8.1.4, 1.8.1.5, and 1.8.2.1) will confirm whether the Applicant's decision regarding the likelihood of future 345 kV development at the two substations is appropriate.

4.1.3.2 Flexibility Required Pending MISO's Decision-Making

Until such time as MISO confirms its decision on the interconnection voltage for Mesaba One and Mesaba two, the Applicant is requesting an HVTL Route Permit that allows flexibility to change its West Range interconnection voltage plans (use of 345kV at the East Range Power Station is dictated due the increased power losses that would otherwise occur if the system was operated at 230kV). In Section 2.2.2, the Applicant identified two HVTL plans to deal with uncertainties related to MISO's decision-making on the West Range interconnection request. The first plan, identified as Plan A, is based on the presumption that future 345kV developments in Northern Minnesota are imminent. The second plan, defined as Plan B, is based on a potential MISO determination that the region's electrical transmission system is best served by maintaining the Blackberry Substation's electrical connections to the grid at 230kV. If MISO decides otherwise, the addition of a 345kV bus at the substation is likely and the Applicant would implement Plan A (see Section 2.2.2 for a detailed explanation of the Applicant's Preferred Plan A and Contingent Plan B).

4.1.3.3 IGCC Power Station Developments Required to Operate At 345kV

The layout of the IGCC Power Station switchyard is shown in Figures 4.1-1 and 4.1-2. This layout is applicable to both West and East Range developments. Increasing the voltage at which the IGCC Power Station delivers its output power to the POI will require the addition of a 345kV bus at the POI and autotransformers at the Station's switchyard.

4.1.4 West Range Switchyard

4.1.4.1 Plan A

Phase I and II Developments would include interconnecting to the POI with two 345kV HVTLs placed on single steel pole structures and initially operating at 230kV during Phase I. The length of the radial HVTLs required to reach the Blackberry Substation from the southern boundary of the Buffer Land is approximately 8.5 miles. The line losses associated with operation of the 345kV GO HVTLs at 230kV are acceptable and therefore 230kV represents the preferred interconnection voltage for Mesaba One. To avoid increased power losses that would occur upon start up of Mesaba Two, the interconnection voltage will be converted to 345kV commencing with its operation.

The electrical layout of the switchyard for Mesaba One is currently designed for 230kV. Prior to commencing operation of Mesaba Two, additional autotransformers, a 345kV busbar and associated breakers will be added to the IGCC Power Station's switchyard to convert the Phase I GO facilities outlets to 345kV operation. The switchyard serving Mesaba Two will connect that unit's generators to one of the two 345kV GO HVTLs delivering the IGCC Power Station's output power to the grid. Figure 4.1-3 shows the configuration of the West Range IGCC Power Station switchyard commencing with operation of Mesaba Two.

Figure 4.1-1 Conceptual One Line Diagram for West Range and East Range Sites Depicting 230kV Switchyard

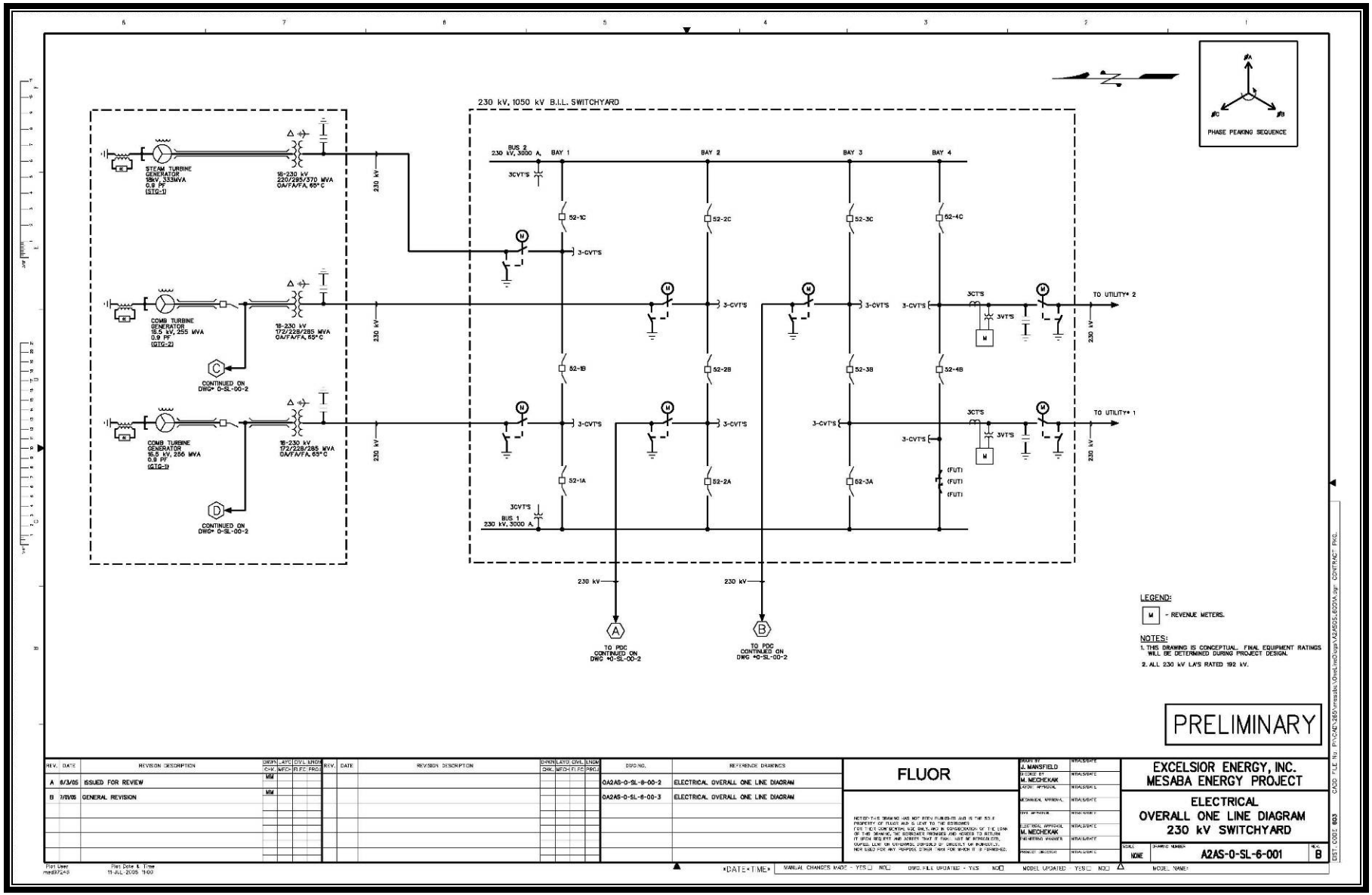


Figure 4.1-2 Conceptual One Line Diagram for West Range and East Range Sites Depicting 230kV Feeds to ASU, Power Block, and IGCC Substation

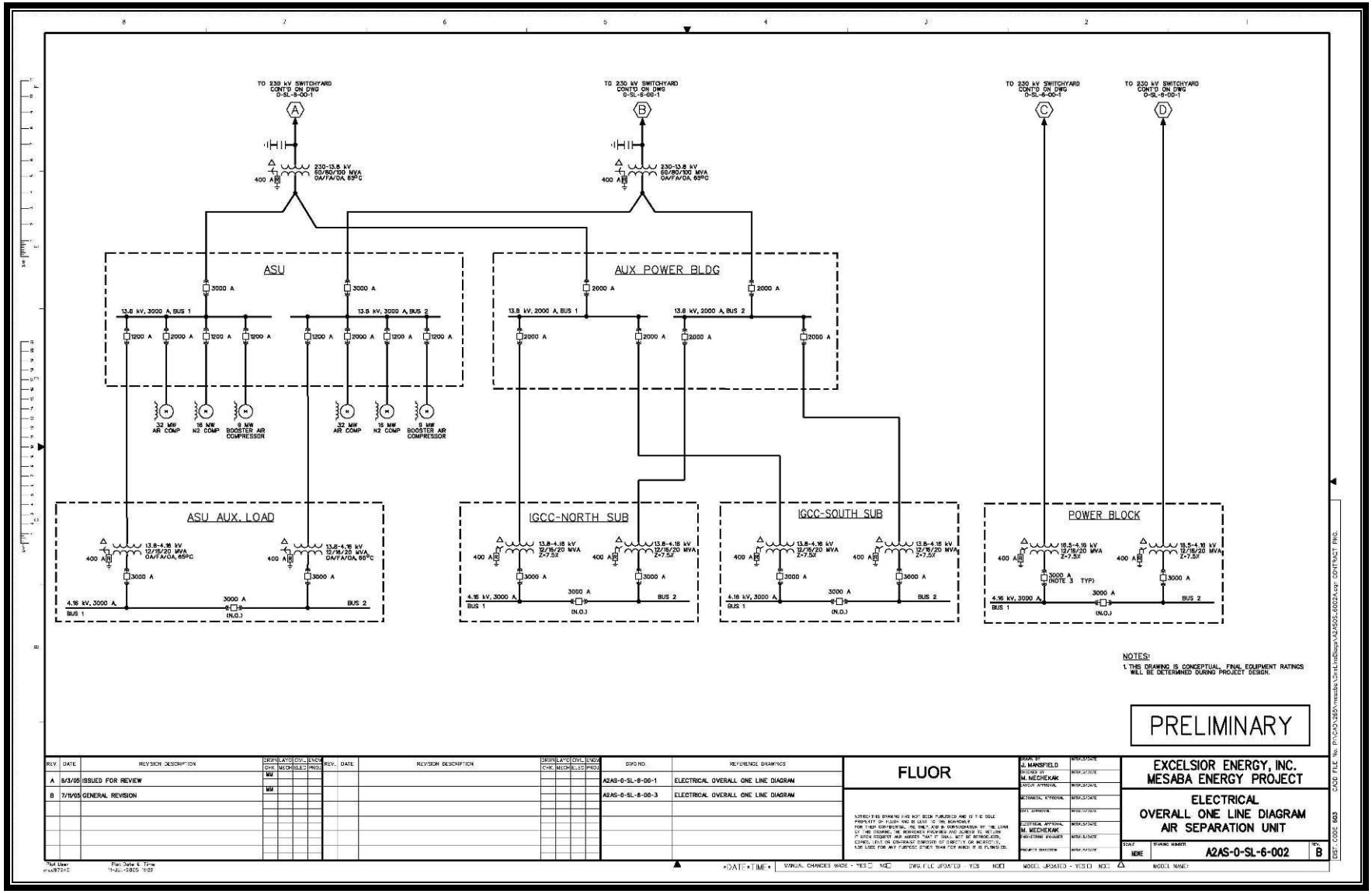
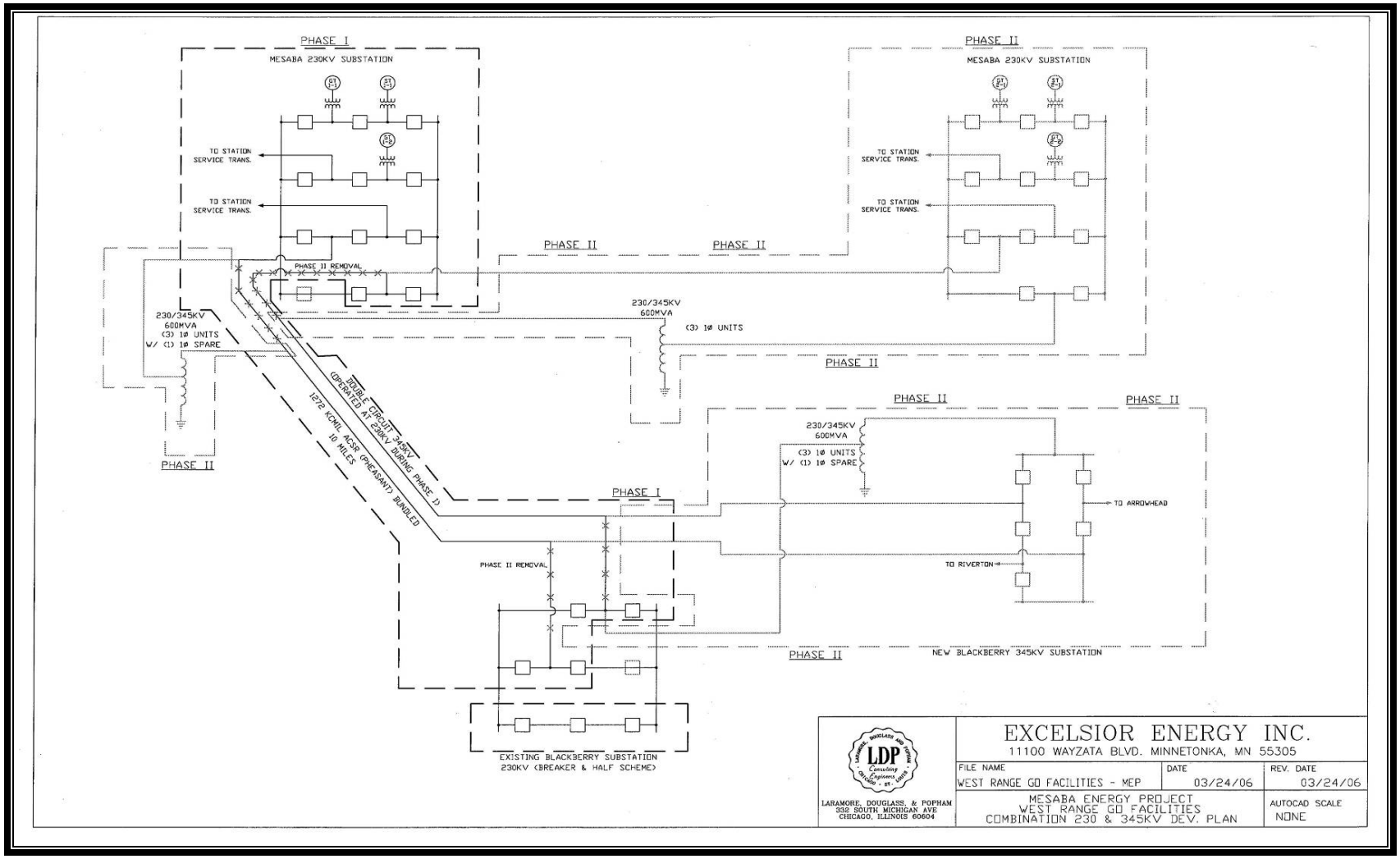


Figure 4.1-3 West Range Plan A Phase I and II IGCC Power Station Switchyard Design



4.1.4.2 Plan B

4.1.4.2.1 Plan B Phase I Preferred Route (WRB-1)

Phase I Developments under Plan B would include interconnecting to the POI with two 230kV HVTLs placed on single steel pole structures. As previously noted, these double circuited lines would not be sufficient to meet the single failure criterion with the addition of Mesaba Two.

The output voltage rating of the single HVTL required to provide the necessary redundancy for the Phase II developments would depend upon the route identified through the PPSA process. The preferred Route WRB-2 would allow the Phase II HVTL to be developed at 230kV. The alternate Route WRB-2A would require the Phase II HVTL to be developed at 345kV. As noted in the following two subsections, these two options would require different substation designs.

4.1.4.2.2 Plan B Phase II Preferred Route WRB-2

The switchyard design assuming the preferred route (for Phase II) is approved during the PPSA process is shown in Figure 4.1-4.

4.1.4.2.3 Plan B Phase II Alternate Route WRB-2A

The switchyard design assuming the alternate route (for Phase II) is approved during the PPSA process is shown in Figure 4.1-5.

4.1.5 East Range IGCC Power Station Switchyard

The high voltage switchyard for the East Range IGCC Power Station will be configured at 345kV to serve Mesaba One. The decision to operate the switchyard at 345kV commencing with startup of Mesaba One is based on net line losses totaling about 5 MW less than that which would otherwise occur if the GO facilities were operated at 230kV (losses of 3.5 MW compared with 8.4 MW for the 230kV approach). Over the project life, the capacity gain associated with 345kV development relative to the 230kV option more than offsets the 345kV development's higher capital cost.

The high voltage switchyard required to transmit the entire output from Mesaba One and Mesaba Two to the POI with minimum line losses will be installed to serve Mesaba One. Although work will be required in the switchyard to connect Mesaba Two to the GO HVTLs and to provide station power back to Mesaba Two, no further development of the GO HVTLs will be required.

The East Range IGCC Power Station switchyard design is shown in Figure 4.1-6.

Figure 4.1-4 West Range Plan B Phase II Preferred Route (WRB-2) IGCC Power Station Switchyard Design

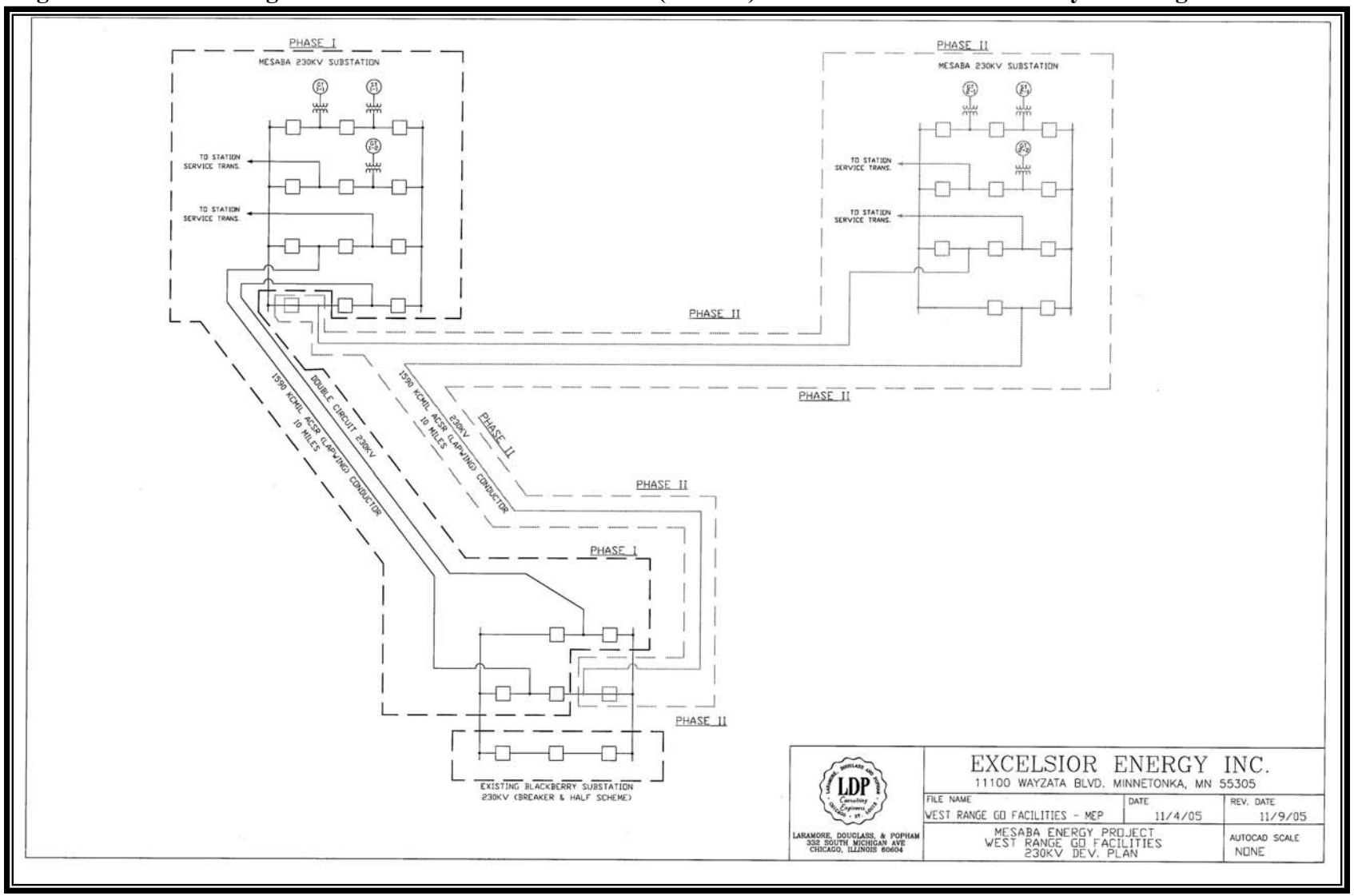


Figure 4.1-5 West Range Plan B Phase II Alternate Route (WRB-2A) IGCC Power Station Switchyard Design

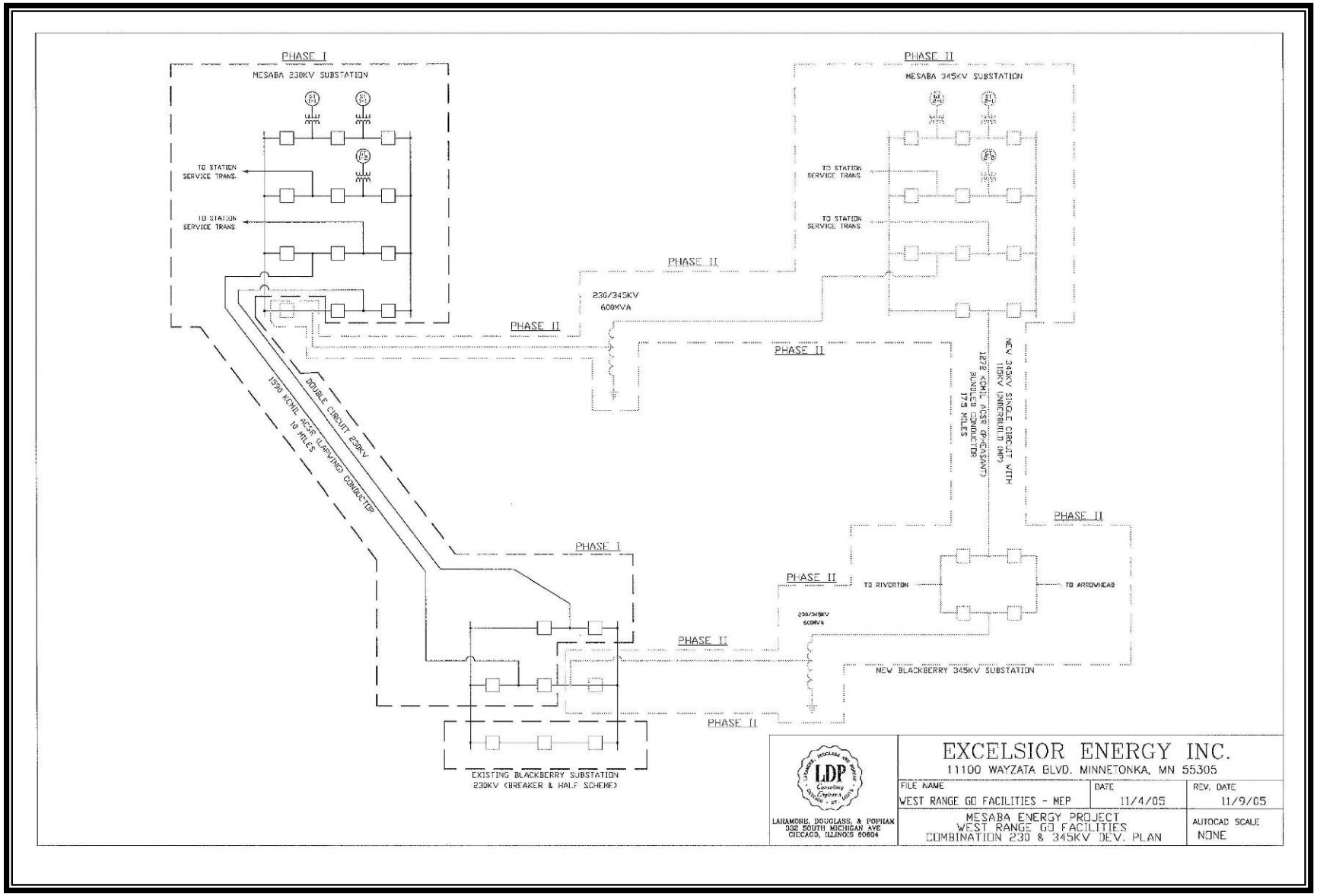
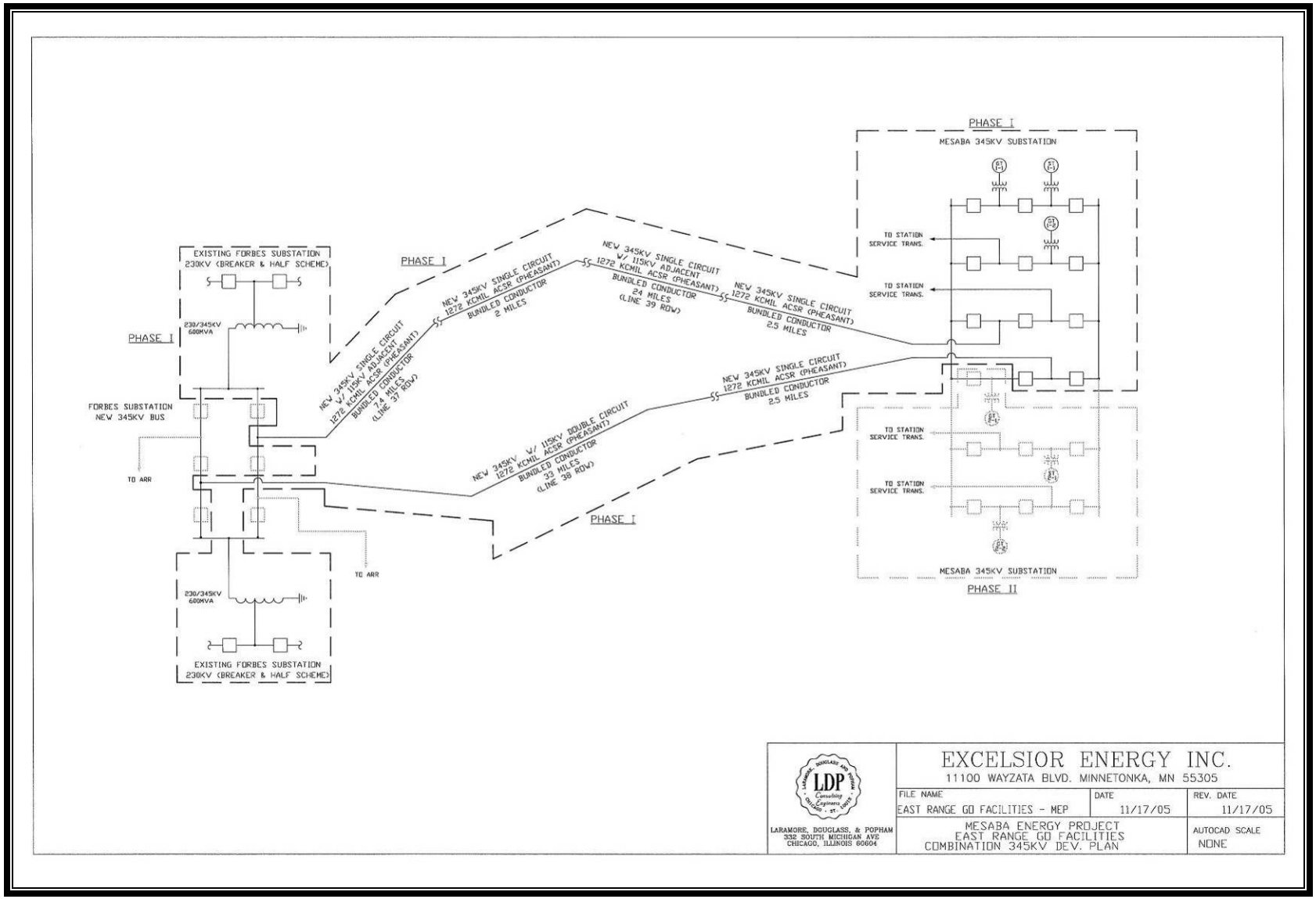


Figure 4.1-6 East Range IGCC Power Station Switchyard Design



4.2 GENERATOR OUTLET ROUTES: SPECIAL CONSIDERATIONS

4.2.1 West Range Site

4.2.1.1 Preferred Plan A

As noted, the proposed approach to providing generator outlets for the West Range Site consists of constructing a double circuit 345kV HVTL from the IGCC Power Station to the Blackberry Substation, operating such HVTLs at 230kV for Phase I, and thereafter converting the operating voltage of both circuits to 345kV for Phase II. This approach offers, at a relatively small marginal cost, the needed redundancy to meet the single failure criterion and accommodate the entire output of Mesaba One and Mesaba Two though use of just two HVTLs.

Wherever practical, the Applicant has sought to use existing routes for the GO HVTLs. Whenever the GO HVTLs are routed along existing HVTL corridors with active HVTLs present, the 345kV double circuit HVTL structures would be configured to carry existing HVTLs (the configuration and dimension of such structures is presented in Section 4.3).

The Plan A preferred Route WRA-1 and alternate Route WRA-1A are shown in Figure 2.2-1 and special considerations are described in the paragraphs below.

4.2.1.1.1 Preferred GO HVTL Route (WRA-1)

Figures 2.5-3 through 2.5-5 show the preferred Route WRA-1 for Plan A. This double circuit 345kV option would travel east from the Phase I IGCC Power Station's switchyard about 9.8 miles to MP's existing 45L ROW and then follow existing ROW south about 1.6 miles to the retired Greenway Substation. The HVTL route would continue south on double circuit 345kV structures approximately 6.2 miles from the Greenway Substation over new ROW to intersect MP's 83L and 20L. The route would follow the existing MP ROW about 1.1 miles east to the Blackberry Substation using a double circuit 345kV line with 115kV under build to carry the 20L along. This route provides a direct path between the IGCC Power Station and the POI, traverses mostly remote areas, and minimizes impacts on residences. The double circuit configuration of the structures requires the narrowest ROW width for two circuits. This smaller ROW footprint results in less tree trimming, less easement cost and generally has fewer landowner impacts when compared to other configurations. Special considerations along this route appear to be minimized given the remote nature of the surroundings, minimal number and length of water crossings, and generally level topography.

The new ROW traverses both forested areas and wetlands. Tree clearing will be required along the forested portion and special considerations will need to be applied to the wetland areas. Easements must be negotiated with several property owners, at which time the routing may be subject to minor changes. The existing, but abandoned, section of 45L will be removed. The 115kV 20L must be overbuilt or moved to the existing cross arms under the 83L. The line changes in the 83L/20L ROW will likely result in one mile of taller transmission structures for the double circuit 345kV line with its 115kV underbuild. The only disadvantage of the Plan A 345 kV double circuit is that it will afford less route diversity than two separate circuits on

individual ROWs. However, the slight disadvantage is overcome by the many advantages the 345kV plan offers.

The structures to be used along preferred Route WRA-1 are identified in Section 4.3.1.1.

4.2.1.1.2 Alternate HVTL Route (WRA-1A)

Figures 2.5-6 through 2.5-8 show the alternate Route WRA-1A. This route is described in Section 2.5.3.1.2. Special considerations along this route include an increased number and length of crossings of the Swan River, topographical challenges where hills meet open water, and an increased number of spans across open areas (these areas include cleared fields and gravel mining operations).

In general, the double circuit structures carrying the two 345kV HVTLs on the alternate Route WRA-1A will be identical to those used in the Plan A preferred route.

4.2.1.1.3 Plan A Routing Summary

Table 4.2-1 below compares the preferred and alternate routes considered under Plan A.

Table 4.2-1 West Range Transmission Line Design Summary: Plan A

HVTL SEGMENT DESCRIPTION	EXISTING HVTL RATING	EXISTING CORRIDOR WIDTHS	APPROX. LENGTH	WIDENING OR NEW CORRIDOR NEEDED?	HVTL STRUCTURE TYPE	CONDUCTOR TYPE
Preferred 345kV Route WRA-1 (see Figure 4.3-3)						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-4, 4.3-4, and 4.3-6	1272 KCMIL ACSR (Pheasant) Conductor
82/20L	230kV	150 ft	1.0 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	6.3 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline		
Alternate 345 kV Route WRA-1A (see Figure 4.3-7)						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-4, 4.3-5, and 4.3-6	1272 KCMIL ACSR (Pheasant) Conductor
62L/63L	230kV	150 ft	0.9 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	5.8 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline		

4.2.1.2 Contingent Plan B

If the Applicant must abandon Plan A as a result of MISO's Interconnection Studies, it will implement Plan B developments as identified in Table 4.2-2 below. The basis for these options is described in the narrative presented in the subsections below.

Table 4.2-2
Plan B HVTL Routing Options

Route Name (see Table 2.2-1)	Plan B Phase I and II Routing Options		
	Preferred Option 1 (see Figures 2.2-2 and 4.3-8)	Alternate Option 2 (see Figure 2.2-3)	Alternate Option 3 (see Figure 2.2-4)
WRB-1	Phase I		Phase I
WRB-1A or WRB-2	Phase II (WRB-2)	Phase I (WRB-1A)	
WRB-2A		Phase II	Phase II

4.2.1.2.1 Phase I

4.2.1.2.1A Preferred Route (WRB-1)

The Plan B preferred Route WRB-1 is identical to the preferred Plan A Route WRA-1 with the exception that 230kV HVTLs will be used to deliver output power from Mesaba One to the POI. The double circuit 230kV structures will be shorter in height by approximately 30 ft (110 ft for the 230kV structures vs. 140 ft for the 345kV structures). The double circuit 230kV with underbuild will be shorter by the same amount (125 ft for the 230kV structures vs. 155 ft for the 345kV structures). The structure summary is provided in Figure 4.3-9 along with the appropriate ROW calculations for each structure in Figures 4.3-11 and 4.3-12.

4.2.1.2.1B Phase I Alternate Route (WRB-1A)

The Plan B Phase I alternate Route WRB-1A is identical to the alternate Plan A Route WRA-1A with the exception that 230kV HVTLs will be used to deliver output power from Mesaba One to the POI. The structures for this route are identical in configuration to those shown in Figure 4.3-9.

Table 4.2-3 West Range Transmission Line Design Summary: Plan B Phase I

HVTL SEGMENT DESCRIPTION	EXISTING HVTL RATING	EXISTING CORRIDOR WIDTHS	APPROX. LENGTH	WIDENING OF CORRIDOR NEEDED?	HVTL TOWER TYPE	CONDUCTOR TYPE
Preferred 230kV Route WRB-1 (see Figure 2.2-2)						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-11 and 4.3-12	1590 KCMIL ACSR (Lapwing) Conductor
82/20L	230kV	150 ft	1.0 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	6.3 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline; 150 ft when two structures occupy one corridor		
Alternative 230 kV Route WRB-1A (see Figure 2.2-2)						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-11 and 4.3-12	1590 KCMIL ACSR (Lapwing) Conductor
62L/63L	230kV	150 ft	0.9 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	5.8 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline; 150 ft when two structures occupy one corridor		

4.2.1.2.2 Phase II

4.2.1.2.2A Preferred Route (WRB-2)

The Plan B Preferred Route WRB-2 will be the route not selected for Phase I as noted above in Section 4.2.1.2.1. The ROW calculation for the double circuit and the single circuit structures sharing the same corridor are shown in Figure 4.3-10. The ROW calculations for the separate single circuit structure are shown in Figures 4.3-13 and 4.3-14.

4.2.1.2.2B Alternate Route (WRB-2A)

If the Plan B Preferred Route WRB-2 for Phase II is not selected, the Applicant will use two existing corridors with a combined length almost twice that required to reach the POI using the preferred route (about 18 miles in length versus 9 miles in length for the preferred route). Because of the increased length of this route to the POI, a 345kV HVTL rated at 1,212 MW would be required to avoid significant line losses and power flow imbalances.

The 345kV Alternate Route WRB-2A would travel east from the Phase I and II IGCC Power Station to the 45L corridor and then north about 1.2 miles from the point of intersection on single circuit wood "H" frame or delta structures to the point where it intersects with 28L. The route would then follow 28L east approximately 7.8 miles to a point nearby the intersection of 28L and 62L just north of Pengilly. At this point, a short new ROW will be required (see Figure 4.3-15 and the following paragraph). The Applicant's new HVTL would then travel southwest approximately 6.7 miles to the Blackberry Substation on single circuit 345kV delta configured structures with a 115kV underbuild to carry 62L. Utilization of the alternate route would provide route diversity as it is completely separated from the 230kV double circuit route specified under either of the Plan B Phase I alternatives (see Figure 2.2-2 to view the Plan B Phase I alternatives).

The width of the ROW associated with the existing 28L corridor is currently 145 feet. The width of the ROW for the 62L/63L corridor varies between 160 and 340 feet for most of its length (see Figure 4.2-1). A 0.7 mile segment of the 62L/63L corridor located about 3.7 miles from the Nashwauk Substation narrows significantly and will require special towers and new ROW to carry the lines traversing this segment. Figure 4.2-1 illustrates how the 62L/63L ROW varies as a function of distance from the Nashwauk Substation. This is the only special consideration along this existing route. The structure summary for the Plan B Phase II Alternate Route WRB-2A is shown in Figure 3.4-16. The ROW calculations for the 345kV double circuit structures are provided in Figures 4.3-17, 4.3-18a, and 4.3-18b.

4.2.1.2.3 Plan B Phase II Routing Summary

Table 4.2-4 below compares the preferred and alternate routes considered under Plan B.

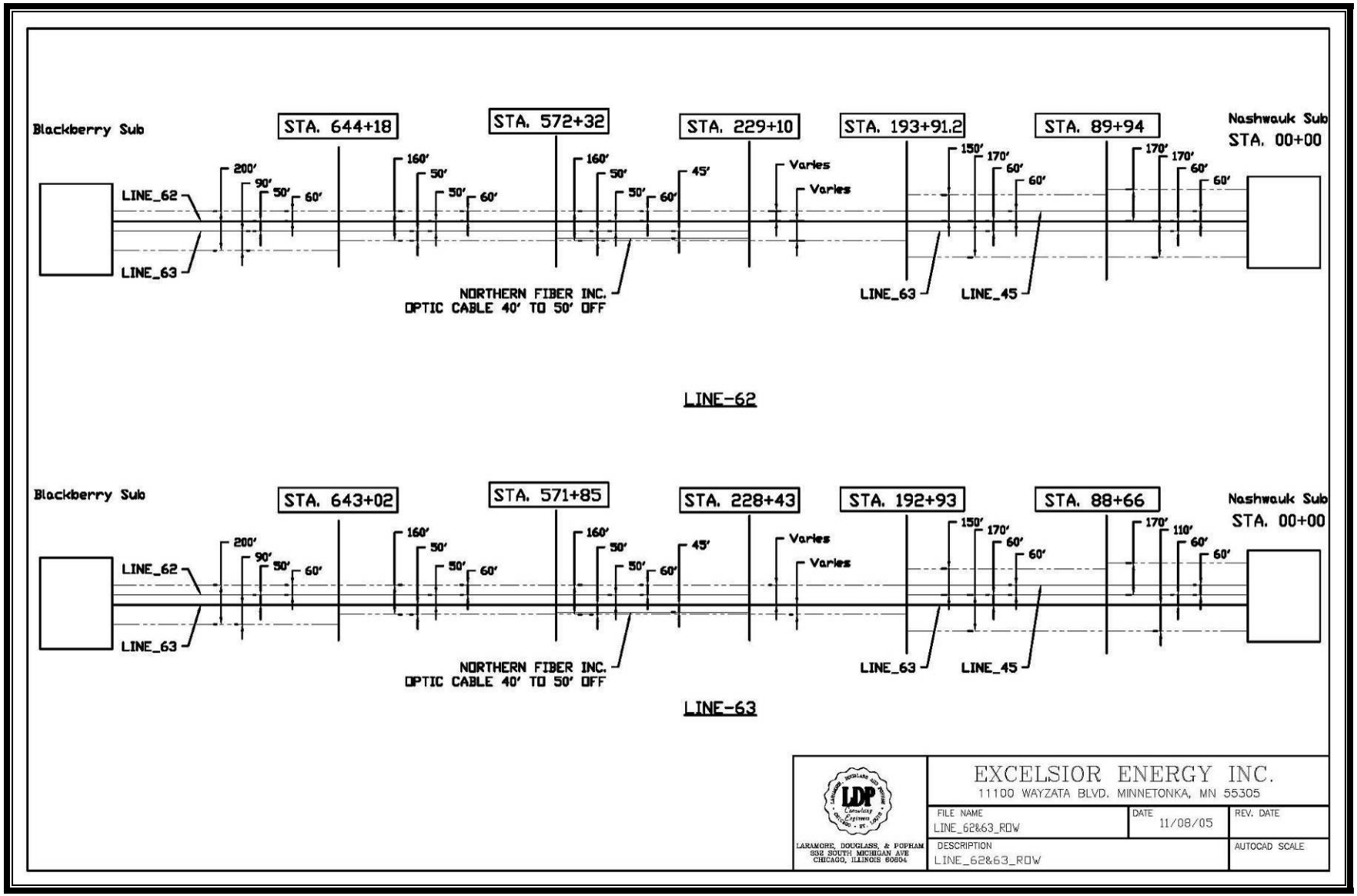
Table 4.2-4
West Range Transmission Line Design Summary: Plan B Phase II

HVTL SEGMENT DESCRIPTION	EXISTING HVTL RATING	EXISTING CORRIDOR WIDTHS	APPROX. LENGTH	WIDENING OF CORRIDOR NEEDED?	HVTL TYPE	CONDUCTOR TYPE
Preferred 230kV Route WRB-2 (Figure 4.3-8)						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-13 and 4.3-14	1590 KCMIL ACSR (Lapwing) Conductor
62L/63L	230kV	150 ft	0.9 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	5.8 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline; 150 ft when two structures occupy one corridor		

HVTL SEGMENT DESCRIPTION	EXISTING HVTL RATING	EXISTING CORRIDOR WIDTHS	APPROX. LENGTH	WIDENING OF CORRIDOR NEEDED?	HVTL TYPE	CONDUCTOR TYPE
OR (Figure 2.2-4)*						
45/28L	115Kv	145 ft	1.6 miles	No	See Figures 4.3-13 and 4.3-14	1590 KCMIL ACSR (Lapwing) Conductor
82/20L	230kV	150 ft	1.0 miles	No		
New ROW between Greenway & Blackberry Substations	Not Applicable	Not Applicable	6.3 miles	100 ft; 150 ft when sharing ROW with natural gas pipeline; 150 ft when two structures occupy one corridor		
Alternate 345 kV Route WRB-2A (Figure 4.3-15)						
45/28L	115kV	145 ft	8.8 miles	No	See Figures 4.3-15, 4.3-17, 4.3-18a and 4.3 18b	1272 KCMIL ACSR (Pheasant) Conductor
62/63L	115kV	160-340 ft	8.7 miles	No		
New ROW 28L between 62L/63L	Not Applicable	Not Applicable	0.5miles	100 ft		

*This route is unlikely because it represents the overall preferred route for Plan Phase I. That said, it is shown as a potential selection in Phase II for the sake of completeness

Figure 4.2-1 ROW Widths Along Existing 62L/63L HVTL Corridor



4.2.1.3 East Range Site

The proposed approach to providing generator outlet facilities for the East Range Site consists of constructing two new 345kV HVTLs from the IGCC Power Station to the Forbes Substation. Both new lines will be constructed during Phase I to meet the single failure criterion and provide the capacity to meet the GO requirements for both Mesaba One and Mesaba Two. Each line would follow existing 115kV HVTLs (39L/37L and 38L) along most of their length. Where the new HVTLs parallel existing HVTLs, the existing HVTLs would be transferred to the new HVTL structures, resulting in new single structure, double circuit (345kV/115kV) HVTLs. The proposed transmission line routes are shown in Figure 2.2-5. Table 4.2-1 includes a summary of the East Range transmission line design information under this generator outlet approach.

Table 4.2-1
East Range Transmission Line Design Summary

HVTL SEGMENT DESCRIPTION	EXISTING HVTL RATING	EXISTING CORRIDOR WIDTHS	APPROX. LENGTH	WIDENING OF CORRIDOR NEEDED?	HVTL TOWER TYPE & NUMBER	CONDUCTOR TYPE
43L Route						
New ROW parallel to 43L	NA	NA	2.5 miles	100 feet	See Figure 3.4-5	1272 KC MIL ACSR (Pheasant conductor)
Preferred 39L/37L Route						
39L	115kV	100 feet	23.6 miles	30 feet	See Figures 4.3-23b, 4.3-24a, 4.3-24b, and 4.3-25	1272 KC MIL ACSR (Pheasant conductor)
New ROW		Not Applicable	2.0	100 feet		
37L	115kV	100 feet	7.4 miles	100 ft		
38L Route						
38L	115kV	100 feet	33.0	No	See Figures 4.3-17 and 4.3-18a & b	1272 KC MIL ACSR (Pheasant conductor)

The 345kV HVTLs would be constructed along the existing 38L and 39L/37L HVTL routes minimize environmental impacts associated with the development of new ROWs. The proposed construction sequence for the preferred route is as follows.

- The Applicant will acquire an additional 30 feet of ROW along the entire length of the existing 39L/37L HVTL.
- Using the additional ROW width, the Applicant will construct a structure type that allows for the MP 115kV lines (39L and 37L) to be transferred to an available circuit position on the steel pole paralleling the 345kV position. The initial 345kV circuit would be installed and energized at 115kV.

- After the first circuit is energized at 115kV, the "H" Frame structures on the 39L/37L ROW would be removed, and an additional circuit of 115kV would be installed in the open circuit position paralleling the 345kV conductor.
- The energizing of the second 115kV circuit will allow for the de-energizing and removal of the existing 38L 115kV line, and the subsequent construction of the second new 345kV/115 kV double-circuit line within the existing 38L ROW.
- After construction of the two new lines is completed, each line would be energized with 345kV/115kV double-circuits. The net increase will be two new 345kV lines to provide the necessary GO for the East Range IGCC Power Station.

If the alternate route is selected the construction sequence would be similar, with the actions on the 39L/37L and 38L lines reversed.

4.3 STRUCTURES AND RIGHT-OF-WAY REQUIREMENTS

The Applicant is proposing to use single steel pole structures along most of its transmission line segments. The foundation design for these structures is provided in Figure 4.3-1. Different foundations are needed in poorly drained, compressible soils. In such instances foundations similar to that presented in Figure 4.3-2 will be used.

Steel light duty "H" frame structures may be proposed for a portion of the transmission line segments on the Buffer Land and/or where other demands warrant their placement (see Section 4.3.1.3). The selection of structure type and required height are dictated by the line voltage, the number of circuits carried by the structure, clearance requirements, environmental impacts, and economic considerations. Right-of-way requirements are dependent on the structure configuration and are described in this section.

4.3.1 West Range

4.3.1.1 Plan A

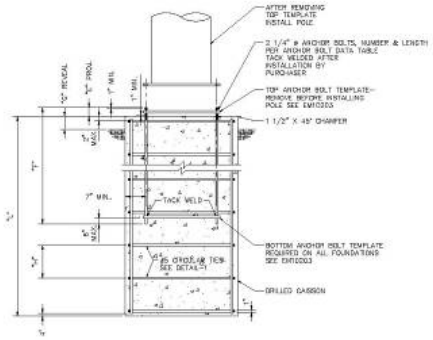
4.3.1.1.1 Preferred Route WRA-1

Figure 4.3-3 shows the 345kV double circuit preferred route line segments. A preliminary summary of the HVTL structure configurations and heights that would be used along the 345kV preferred Route WRA-1 are provided in Figure 4.3-4. A detailed analysis showing the ROW required for each of the structures and the dimensions upon which the ROW calculation is based is provided in Figure 4.3-5 and Figure 4.3-6. The height of the new structures would exceed that of the existing "H" frame 115kV towers by a maximum of 70 to 85 feet depending upon which double circuit configuration is utilized (that is, double circuit or double circuit with underbuild).

4.3.1.1.2 Alternate Route WRA-1A

Figure 4.3-7 shows the 345kV double circuit alternate route line segments. The summary of the HVTL structure configurations and heights that would be used along the 345kV Alternate Route WRA-1A are provided in 4.3-3 (the structures are identical in configuration to those used for the Preferred Route WRA-1, but would number a few less).

Figure 4.3-1 Single Pole Steel HVTL Structure Foundation Design

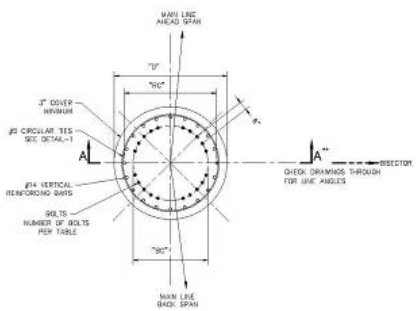


SECTION A–A

SCALE: NONE

DETAIL – 1

TYPICAL BENDING DIAGRAM FOR #5 CIRCULAR TIE BARS



FOUNDATION PLAN
FOUNDATION ORIENTATION SHOWN W.R.T. AHEAD & BACK SPAN

SCALE: NONE

ANCHOR BOLT DATA							FOUNDATION DETAIL				
NO. OF BOLTS 2 1/4" DIA.	NO. OF # 14 VERTICAL RE-BARS	DIMENSIONS					CAISSON DIAM. "D"	OVERALL LENGTH "L"	SPACING BETWEEN BOLTS ON "BC"	DIAM. "RC"	CLEAR SPACING BETWEEN RE-BARS ON "RC"
		"BC"	"E"	"F"	"G"	"H"					
44	40	81	1"	120"	1"	18"	10'	40.5'	6"	109"	7"
16	16	59	1"	93"	1"	18"	7'	19.5'	6"	73"	12.5"
16	16	61	1"	101"	1"	18"	7'	18'	6"	73"	12.5"
16	16	60	1"	97"	1"	18"	7'	24.5'	6"	73"	12.5"
16	16	60	1"	97"	1"	18"	7'	33.5'	6"	73"	12.5"
16	16	61	1"	101"	1"	18"	7'	34'	6"	73"	12.5"
60	54	118	1"	120"	1"	18"	12'	56' *	6"	133"	6"

NOTE:
TYPICAL FOUNDATION FOR REFERENCE ONLY.

LDP Consulting Engineers

LARAMORE, DOUGLASS, & POPHAM
332 SOUTH MICHIGAN AVE
CHICAGO, ILLINOIS 60604

EXCELSIOR ENERGY INC.
11100 WAYZATA BLVD. MINNETONKA, MN 55305

FILE NAME	DATE	REV. DATE
FOUNDATION	10/04/05	
DESCRIPTION: TYPICAL FOUNDATION		AUTOCAD SCALE

Figure 4.3-2 Pile Foundations for Poorly Drained, Compressible Soils

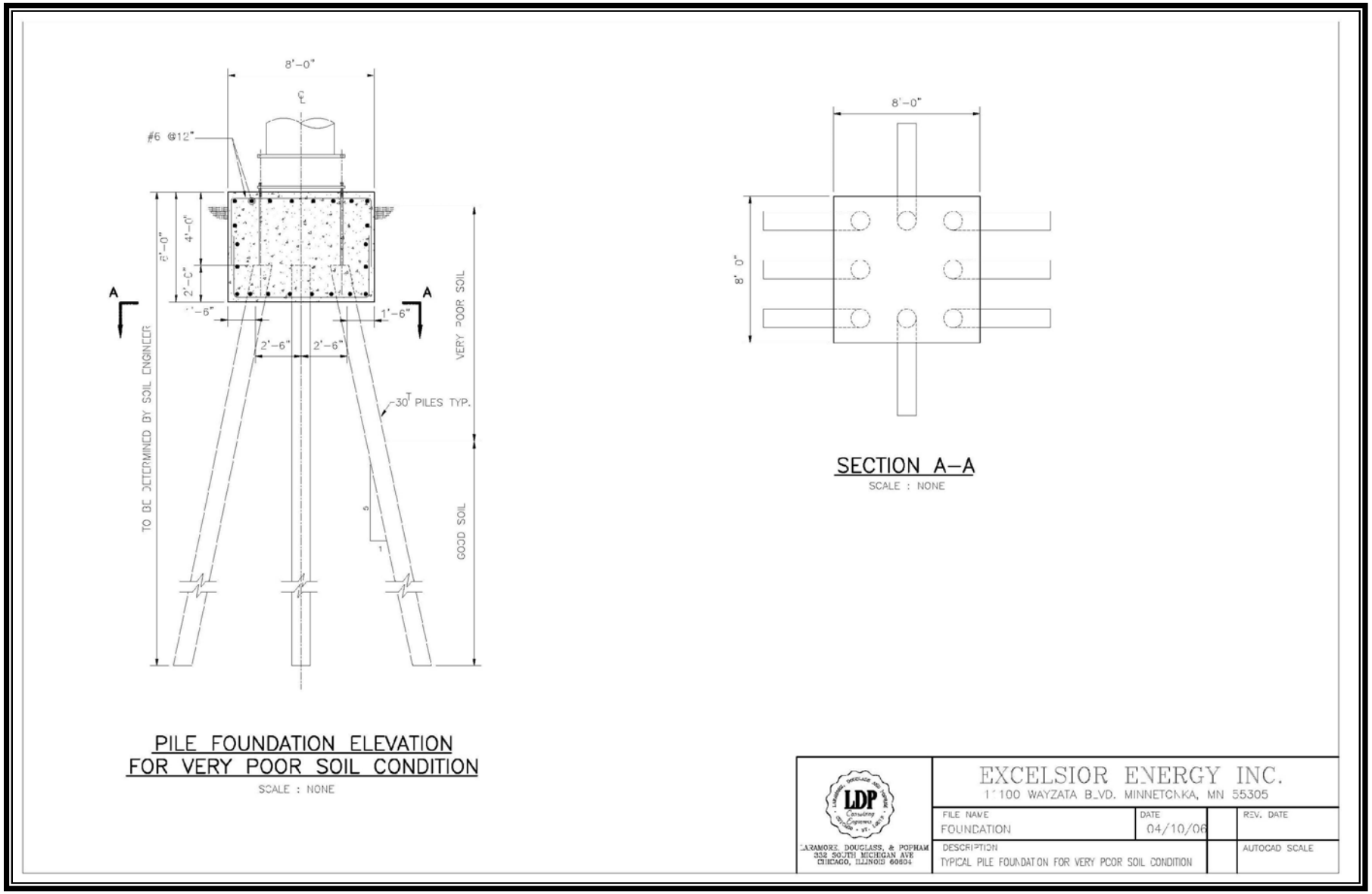


Figure 4.3-3 345kV HVTL Double Circuit Structures Along West Range Plan A Preferred Route (WRA-1)

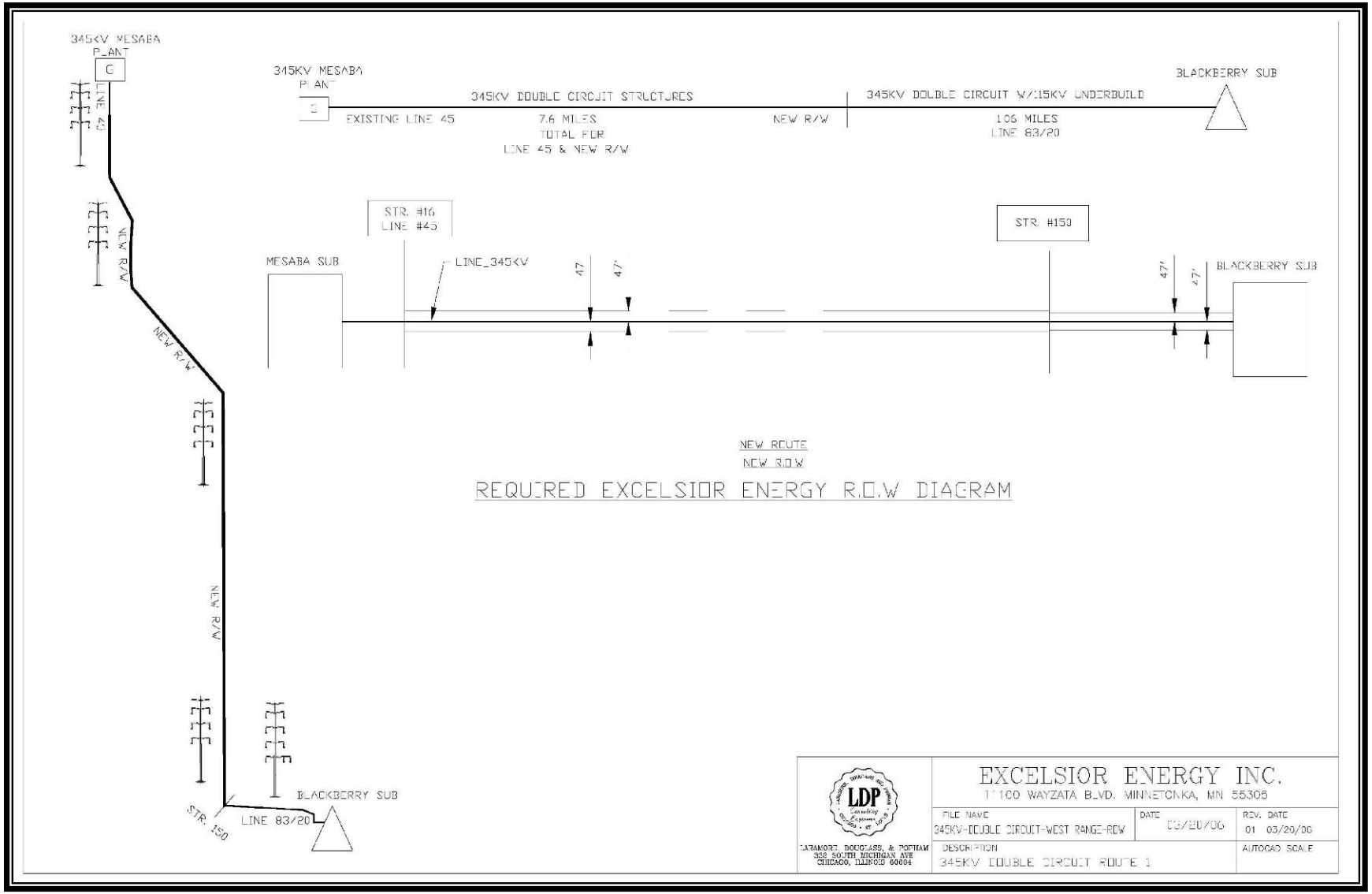
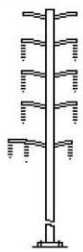
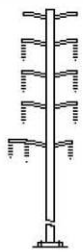
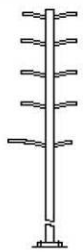
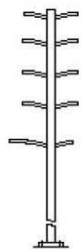
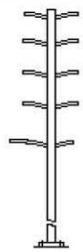
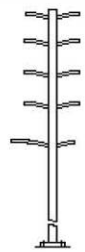
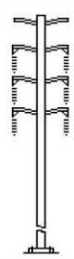
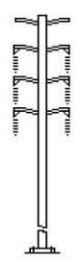
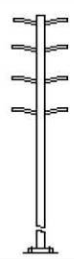
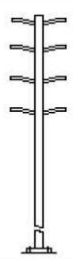
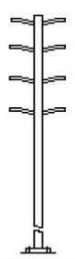


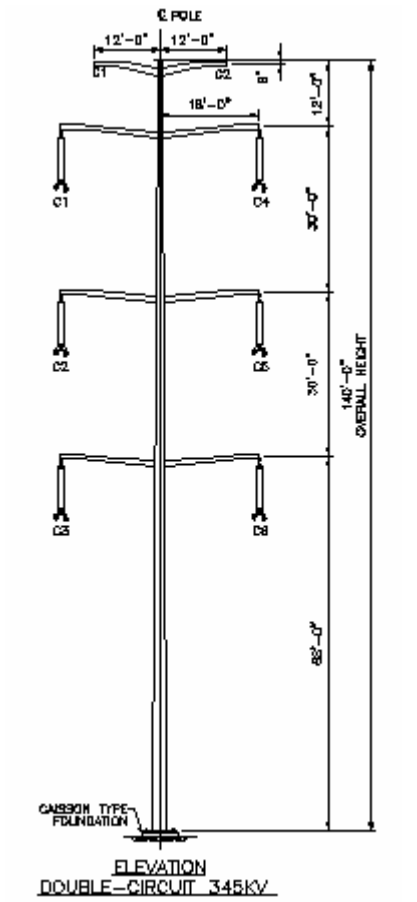
Figure 4.3-4 345kV HVTL Double Circuit Structure Summaryfor West Range Plan A Preffered Route (WRA-1)

Mesaba Energy Project
Preliminary Corridor Structure Design for the Diamond Lake Site Route
345kV Preliminary Structure Summary

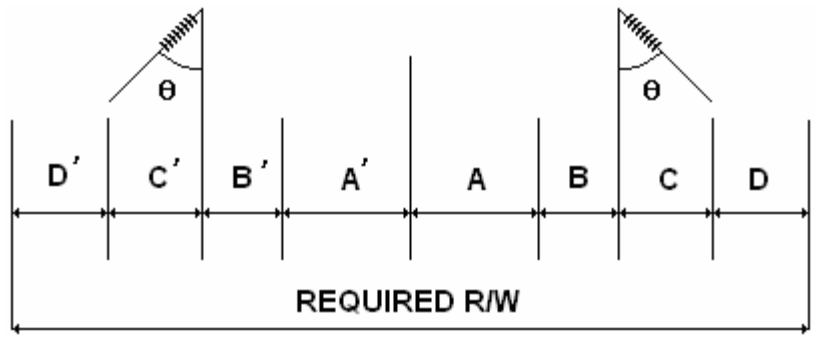
	Structure Type											
												
Height	SUS1_UB	SUS2_UB	STR1_UB	STR2_UB	DED1_UB	DED2_UB	SUS1	SUS2	STR1	STR2	DED1	DED2
	0°- 2°	2°- 6°	6°- 15°	15°- 30°	30°- 60°	60°- 90°	0°- 2°	2°- 6°	6°- 15°	15°- 30°	30°- 60°	60°- 90°
132										3	6	
140							57					
147				1	0	3						
150							2				0	1
153	6											
168	1											
Total	7	0	0	1	0	3	59	0	0	3	6	1

80 Structures

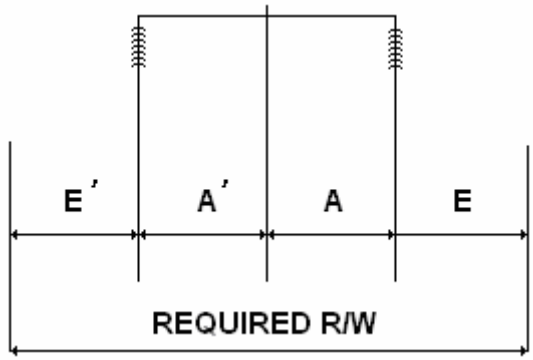
Figure 4.3-5 ROW Calculations for 345kV HVTL Structures Along West Range Plan A Preferred and Alternate Routes (WRA-1 and WRA-1A)



Case 1

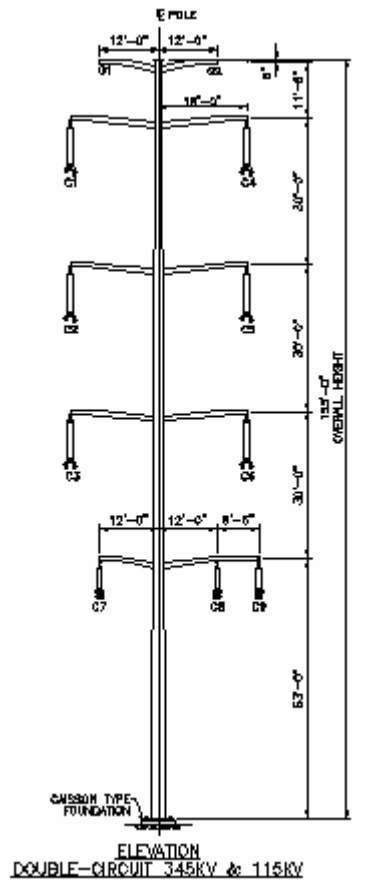


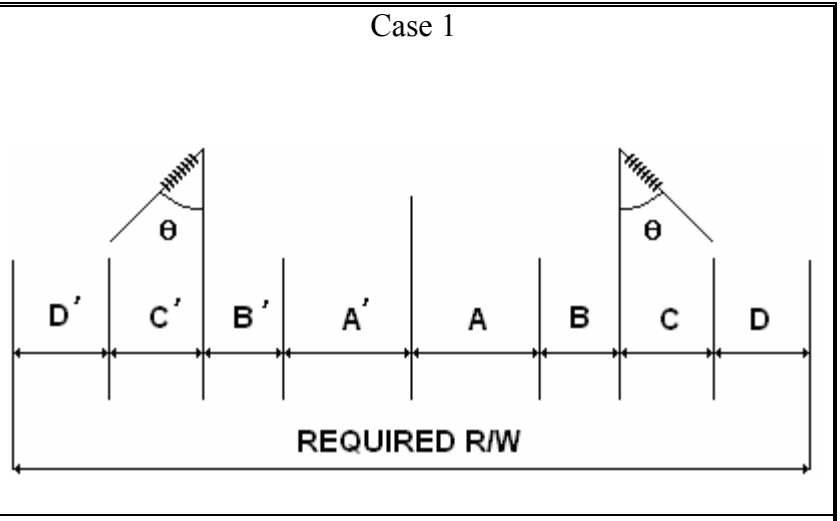
Case 2

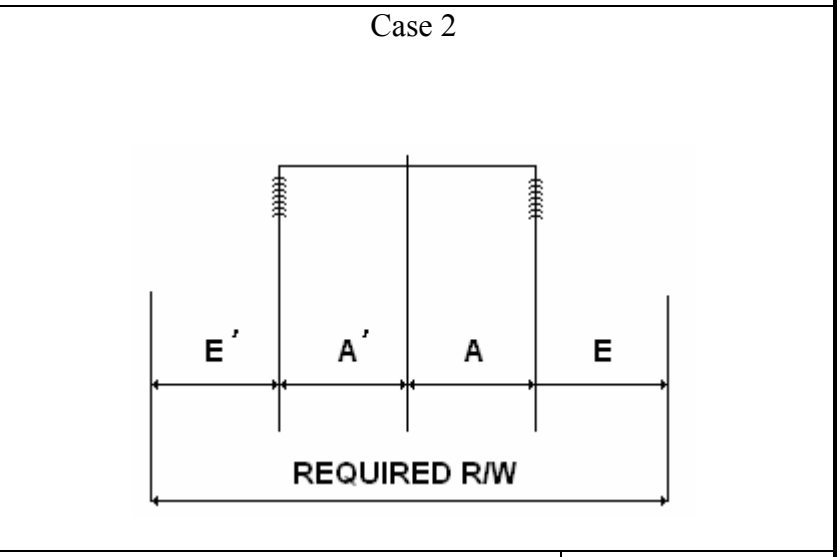


Required Distance (Right side of structure)		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	18
B	Structure attachment deviation due to deflection	5
C	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2) **A + B + C + D**	**91.6**

Figure 4.3-6 ROW Calculation for 345kV Double Circuit Structure with 115kV Underbuild Along West Range Plan A Preferred and Alternate Routes (WRA-1 and WRA-1A)

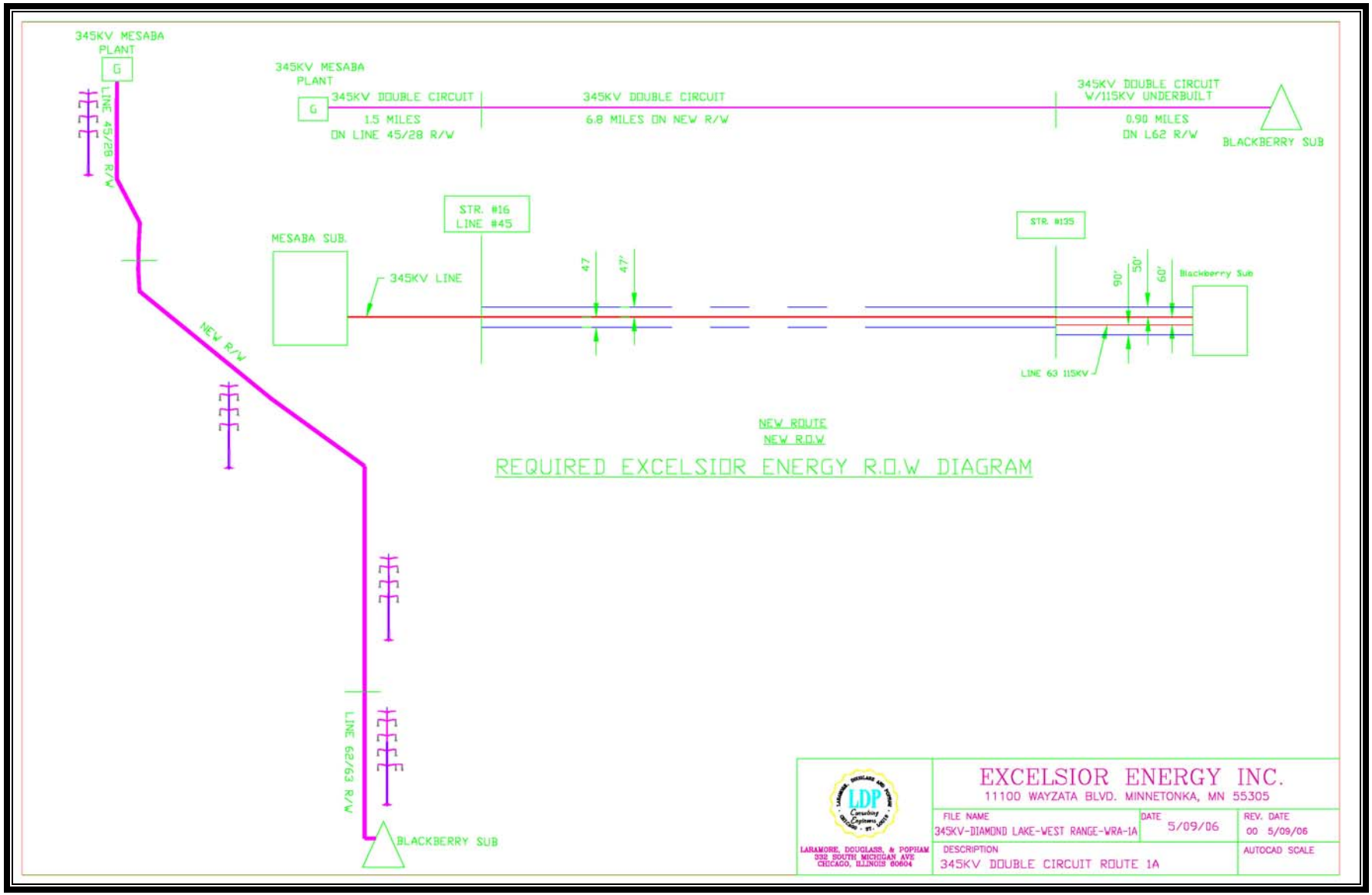






Required Distance (Left Side of Structure)		Width (ft)
A'	Distance between end of arm conductor attachment and center of structure (345kV arm)	18
B'	Structure attachment deviation due to deflection	5
C'	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D'	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E'	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2). **A' + B' + C' + D'**	**91.6**

Figure 4.3-7 345kV HVTL Double Circuit Structures Along West Range Plan A Alternate Route (WRA-1A)



4.3.1.2 Plan B

4.3.1.2.1 Preferred Routes: Phase I and II

The Applicant's preferred option for Plan B involves the combination of the two shortest, most direct routes between the IGCC Power Station and its POI. This combination includes the preferred Route WRB-1 for Phase I and the preferred route WRB-2 for Phase II. The routing schematic showing the HVTL structures used along the line segments is shown in Figure 4.3-8. Structure summaries for the double circuit 230kV and single circuit delta 230kV structures are provided in Figure 4.3-9. The layout and required width of the ROW along the line segment within which the double circuit and single circuit 230kV HVTLs traverse the same corridor is illustrated in Figure 4.3-10. The width of ROW and the methodology used in calculating it for each of the structure types are provided in Figures 4.3-11, 4.3-12, 4.3-13 and 4.3-14 for the 230kV double circuit, the 230kV double circuit with 115kV underbuild, and the 230kV single circuit HVTL, and 230 kV single circuit with underbuild, respectively.

4.3.1.2.2 Alternate Routes: Phase I and II

Table 4.2-2 above identifies two alternatives (Option 2 and Option 3) to the Plan B preferred option described in the preceding section. Figures 2.2-3 and 2.2-4 provide the routing schematics generally indicative of Option 2 and Option 3. The structure summary for the first phase will be identical configuration to that shown in Figure 4.3-9 for the preferred combination route identified in Section 4.3.1.2.1 above. The 230kV double circuit structure types used have been shown in Figures 4.3-11 and 4.3-12. The structure summary for the alternate 345kV HVTL Route WRB-2A that would traverse the existing 28L and 62L/63L corridors is shown in Figure 4.3-16. The ROW calculations for the single circuit 345kV with 115kV underbuild single pole structures are shown in Figure 4.3-17 (for spans of 750 feet or shorter) and Figures 4.3-18a and 4.3-18b (for spans up to 1,100 feet). The ROW calculations for the single circuit 345kV delta configuration structures are presented in Figure 4.3-25.

1.1.1.1 "H" Frame Structures

The Applicant may opt to use "H" frame structures for stretches of the HVTL that traverse its property and/or where aesthetic concerns demand use of shorter, less visible structures. The dimensions and basis for the ROW calculations for 230kV and 345kV "H" frame structures are presented in Figures 4.3-19 and 4.3-20, respectively.

Figure 4.3-8 230kV HVTL Double Circuit Structures Along West Range Plan B Phase I and II Preferred Routes (WRB-1 + WRB-2) See Table 4.2-2 for Option 1

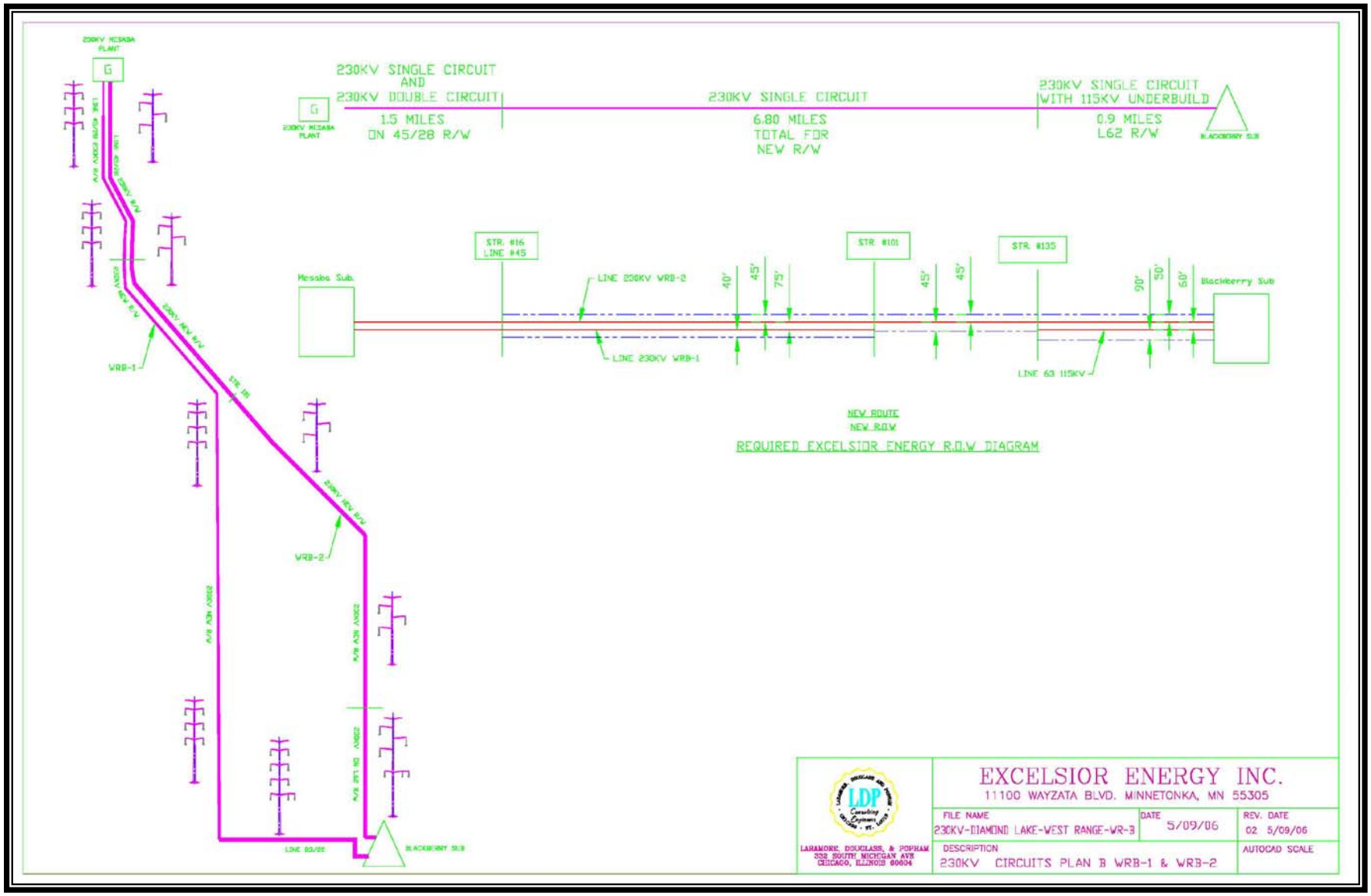
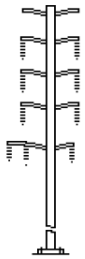
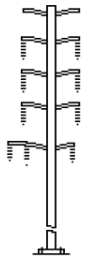
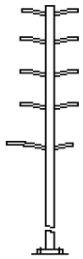
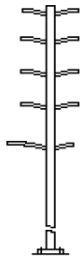
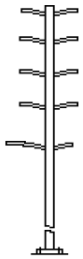
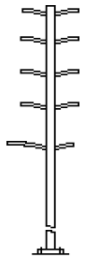
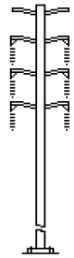
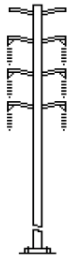
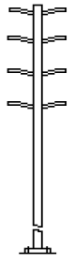
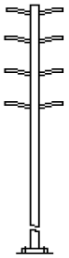
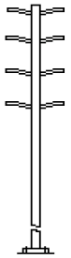
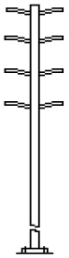


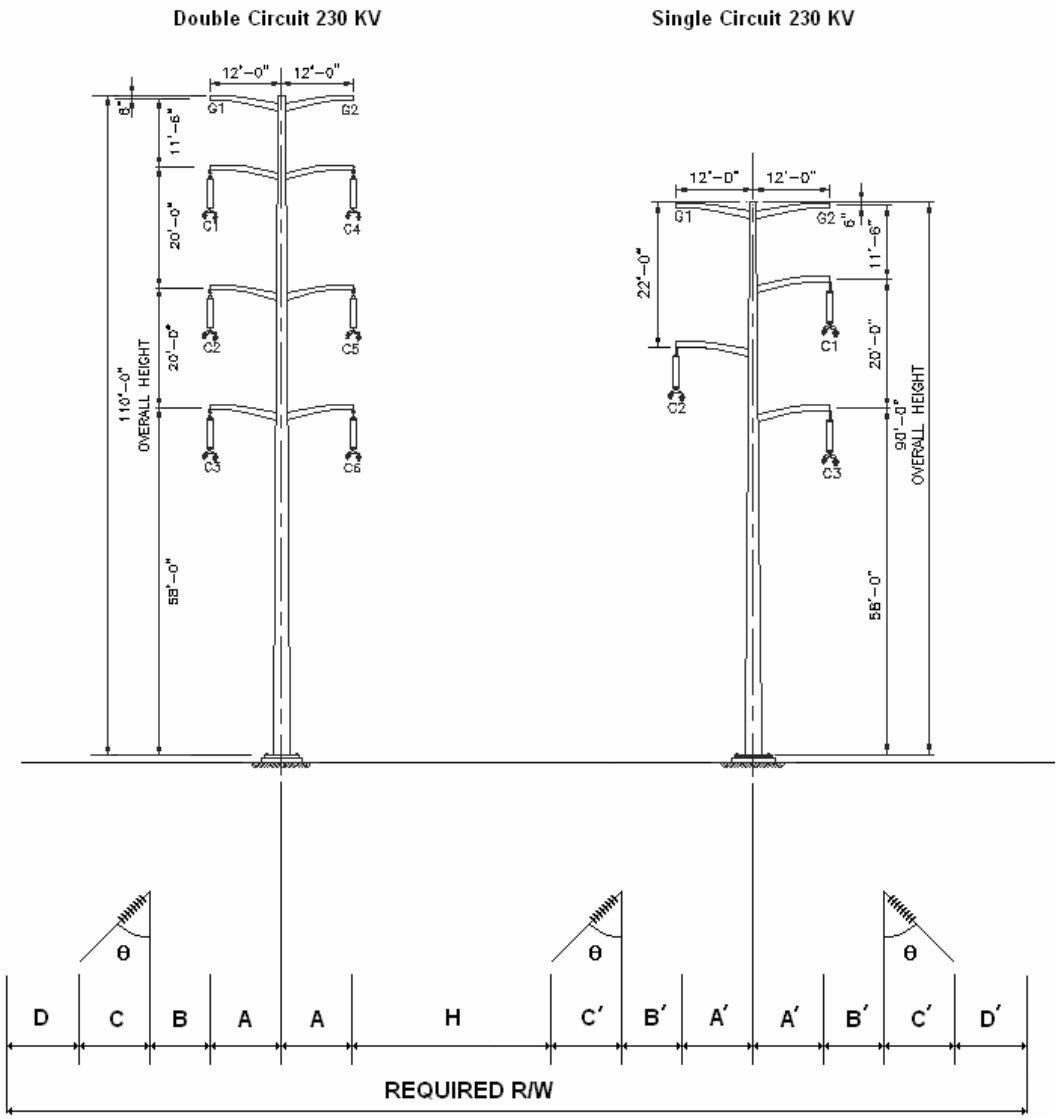
Figure 4.3-9 Plan B Phase I Preferred Route WRB-1 230kV Double Circuit HVTL Structure Summary

Mesaba Energy Project
Preliminary Corridor Structure Design for the West Range Site: Alternative 1 Route, Phase I
230kV Preliminary Structure Summary

	Structure Type											
												
Height	SUS1_UB	SUS2_UB	STR1_UB	STR2_UB	DED1_UB	DED2_UB	SUS1	SUS2	STR1	STR2	DED1	DED2
	0°- 2°	2°- 6°	6°- 15°	15°- 30°	30°- 60°	60°- 90°	0°- 2°	2°- 6°	6°- 15°	15°- 30°	30°- 60°	60°- 90°
107										3	6	
115							57					
122				1	0	3						
125							2				0	1
128	6											
143	1											
Total	7	0	0	1	0	3	59	0	0	3	6	1

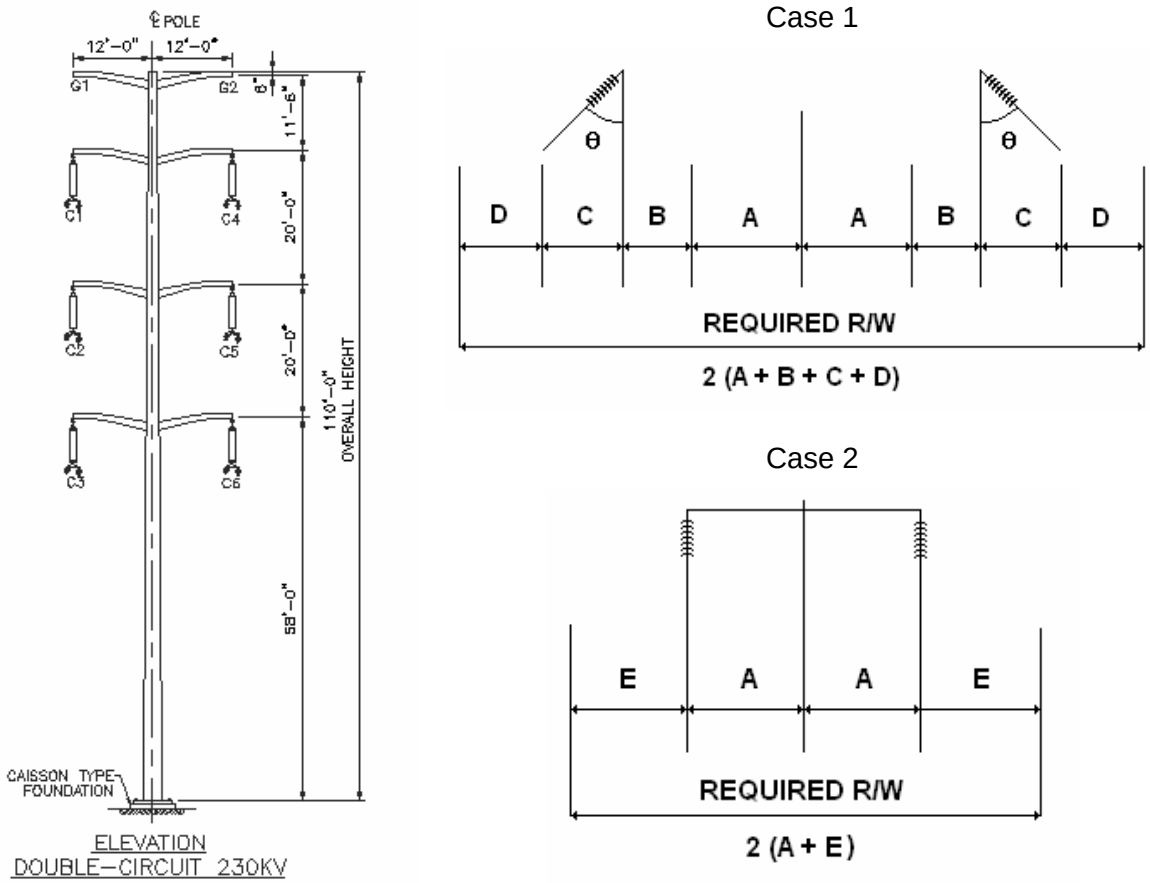
80 Structures

Figure 4.3-10 ROW Calculations for 230kV Double Circuit and 230kV Single Circuit HVTL



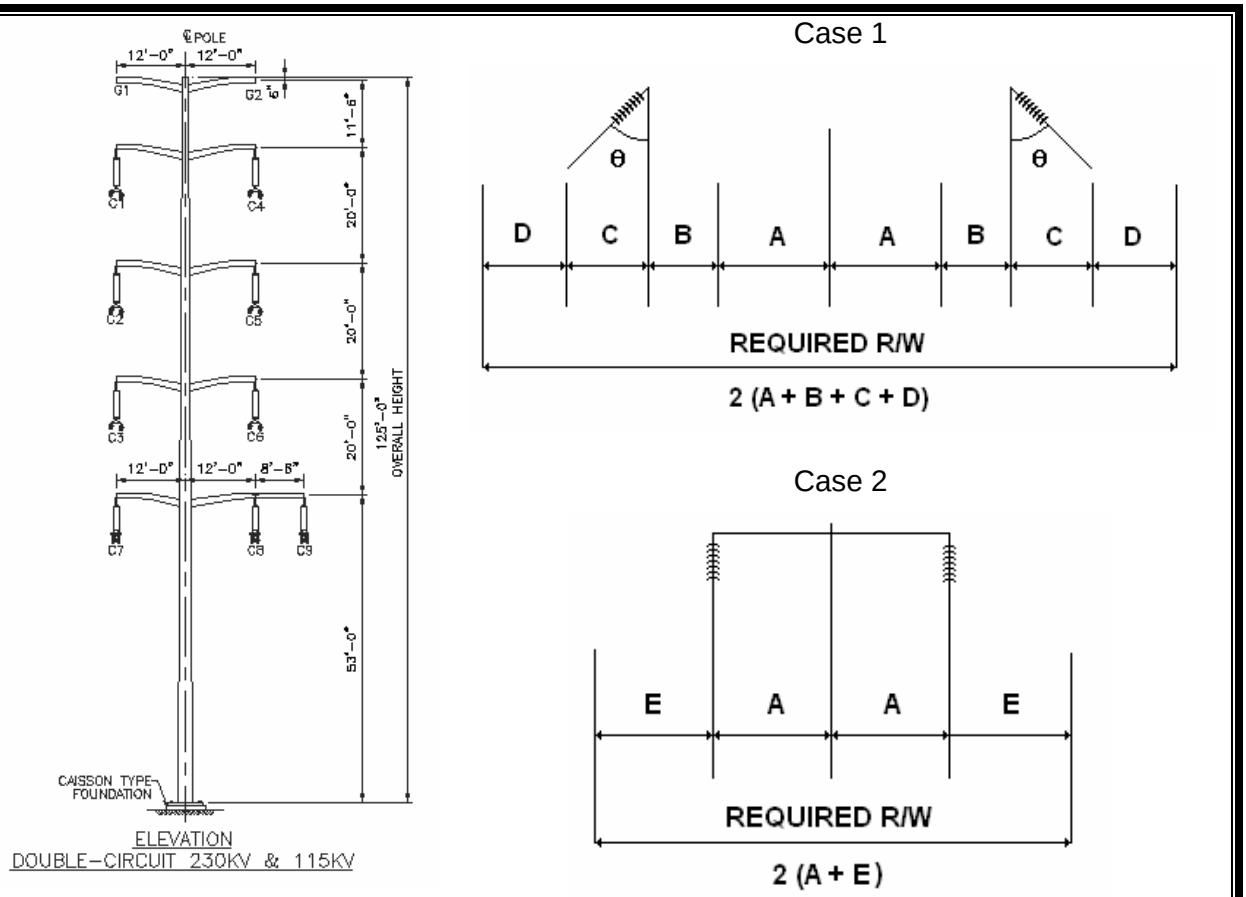
	Required Distance	Width (ft)
A	Distance between end of arm conductor attachment and center of structure	12
B	Structure attachment deviation due to deflection	4
C	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	8.25
H	Minimum horizontal working distance between arms to provide safe construction and maintenance between parallel lines	25
A'	Distance between end of arm conductor attachment and center of structure	12
B'	Structure attachment deviation due to deflection	4
C'	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D'	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	8.25
	ROW = 2A + B + C + D + H + 2 (A' + B' + C') + D'	**137.50**

Figure 4.3-11 ROW Calculation for 230kV Double Circuit HVTL



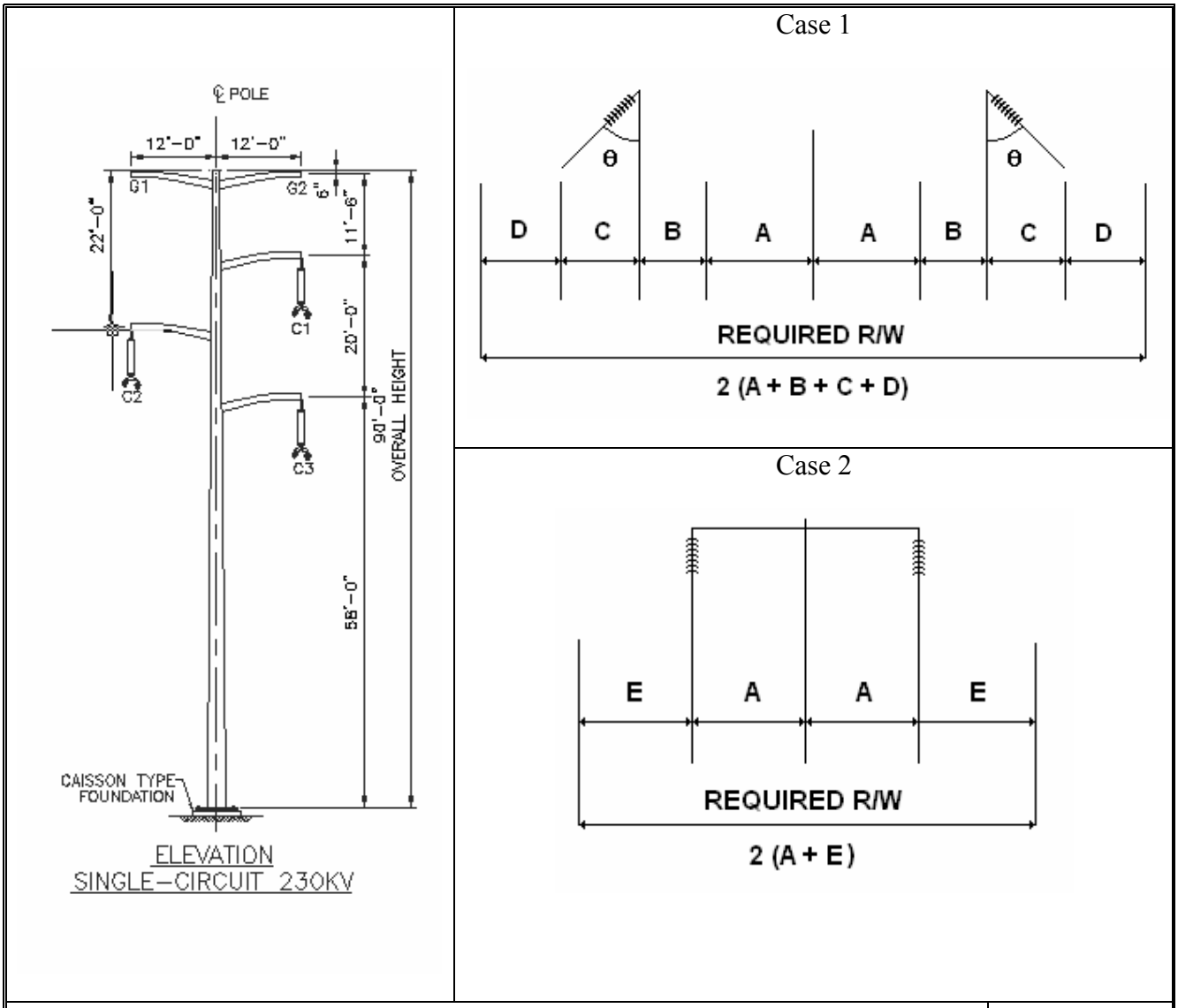
	Required Distance	Width (ft)
A	Distance between end of arm conductor attachment and center of structure	12
B	Structure attachment deviation due to deflection	4
C	Blowout. Obtained from PLS_CADD 3D model with Twin Cardinal conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	8.25
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	11
	Required Right of Way (The larger value between Case 1 and Case 2)	**72.5**

Figure 4.3-12 ROW Calculation for 230kV Double Circuit HVTL with 115kV Underbuild



	Required Distance	Width (ft)
A	Distance between end of arm conductor attachment and center of structure	20.5
B	Structure attachment deviation due to deflection	4
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115 Circuit	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2)	**86.2**

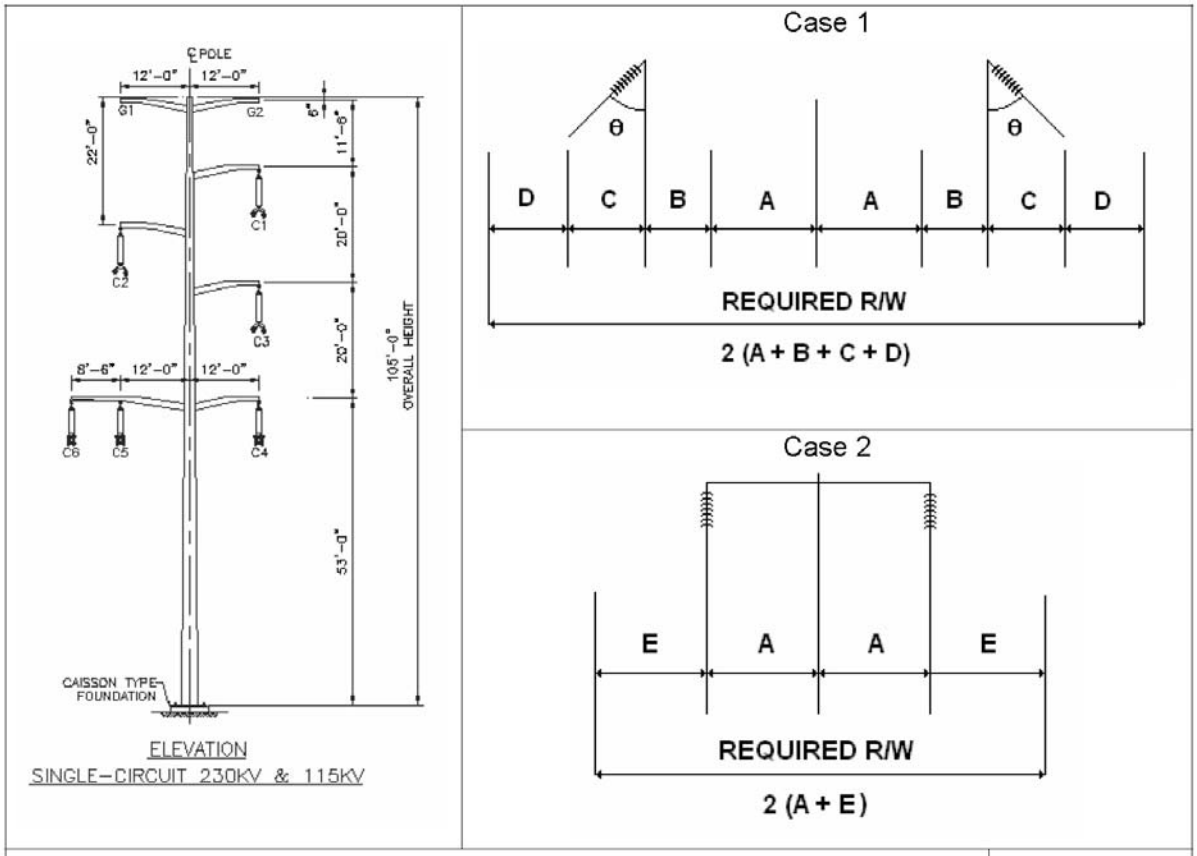
Figure 4.3-13 ROW Calculation for 230kV Single Circuit HVTL



Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	12
B	Structure attachment deviation due to deflection	4
C	Blowout. Obtained from PLS_CADD 3D model with Twin Cardinal conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	8.25
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	11
	Required Right of Way (The larger value between Case 1 and Case 2)	**72.5**

Figure 4.3-14 ROW Calculation for 230kV Single Circuit HVTL with Underbuild

Right of Way (ROW) for 230 KV - 1 CKT with 115 KV



Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	20.5
B	Structure attachment deviation due to deflection	4
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115 Circuit	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2)	**86.2**

Figure 4.3-15 345kV HVTL Single Circuit Delta Configuration Structures With 115kV Underbuild Along West Range Plan B Phase II Alternate Route (WRB-2A) See Table 4.2-2 for Option 2

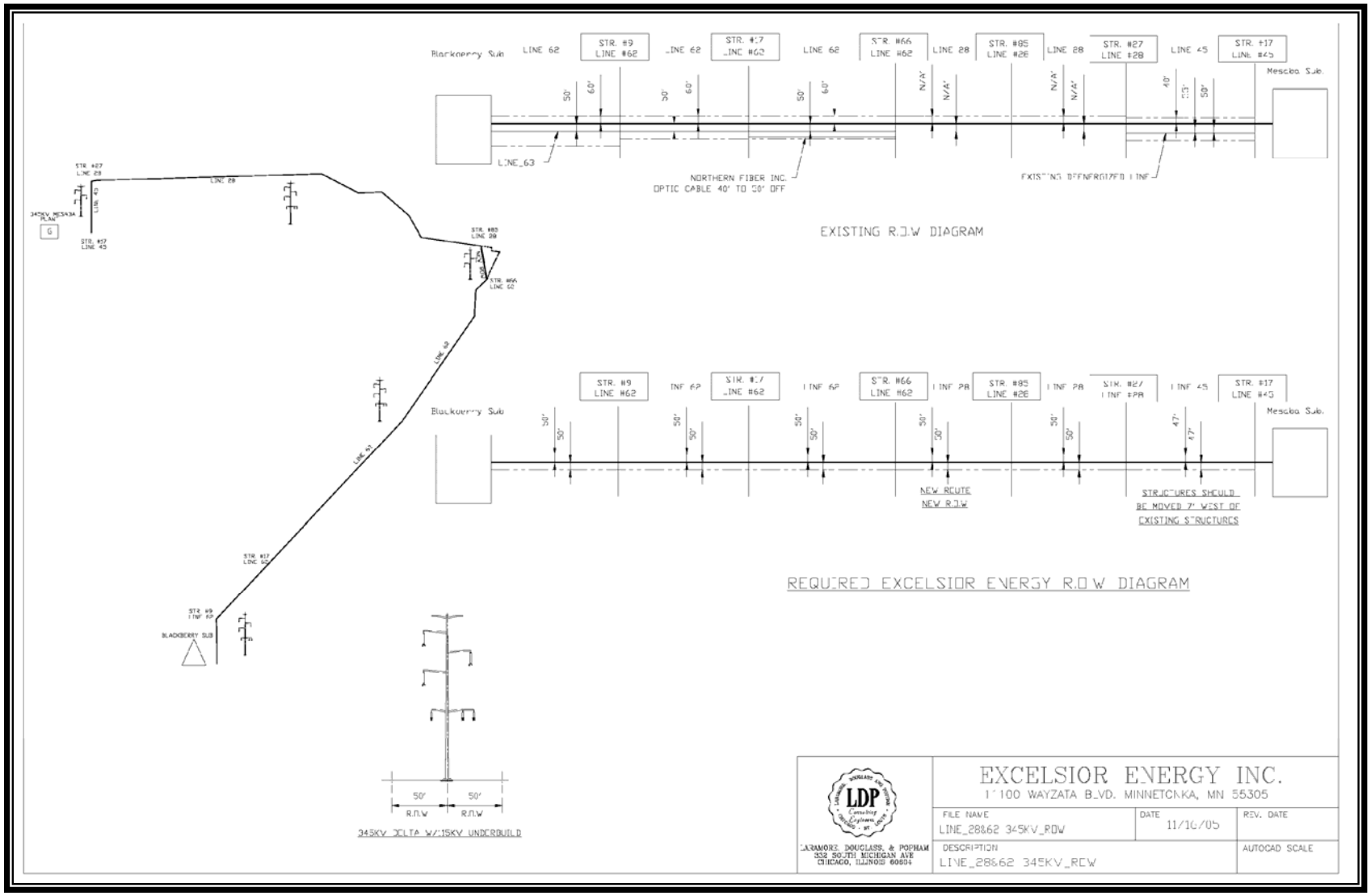
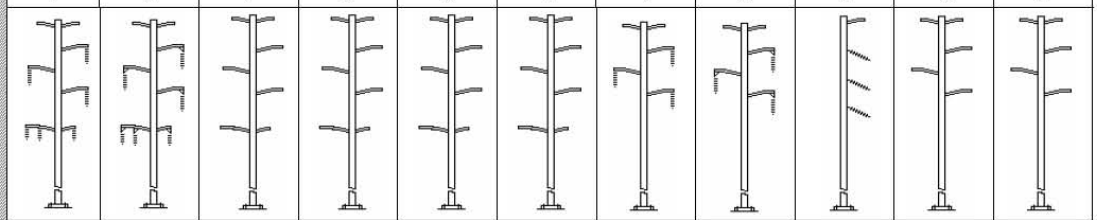


Figure 4.3-16 Plan B Phase II Alternate Route WRB-2A 345kV Double Circuit HVTL Structure Summary



Height	Structure Type										
	1	2	3	4	5	6	7	8	9	10	11
	SUS1_UB	SUS2_UB	STR1_UB	STR2_UB	DED1_UB	DED2_UB	SUS1	SUS2	RAN1	DED1	DED2
	0° - 2°	2°-6°	6°-15°	15°-30°	30°-60°	60°-90°	0° - 2°	2°-15°	15°-30°	30°-60°	60°-90°
107	1										1
108.5							1				
110.0							8				
113.0	1										
117.5	77						8				
119.0							1				
120.0			1								
122.0	18						1				
124.0					2	1					
124.5				3							
126.0			1								
126.5	11						1				
128.5											1
129.0					2						
131.0	1										
133.0											1
133.5					1						
135.5											
137.0									1		
137.5						1					
140.0	1										
144.5											
149.0											
Total	110	0	2	3	5	2	20	0	1	0	3

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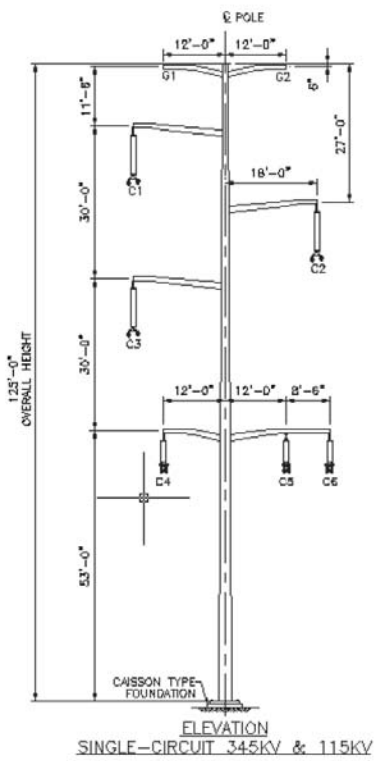
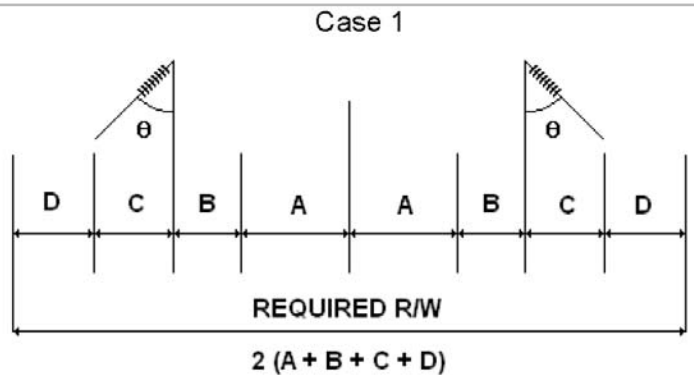
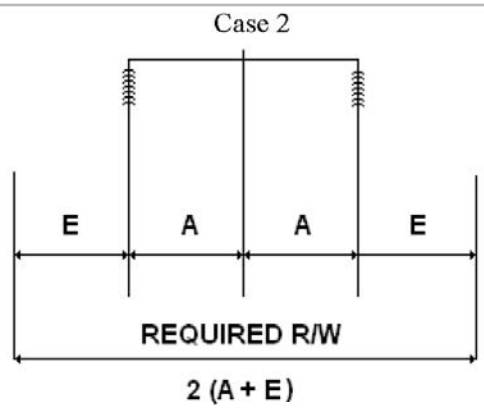
Figure 4.3-17 ROW Calculation for 345 kV Single Circuit Delta Configuration With 115 kV Underbuild (750 ft Span)

Right of Way (ROW) for 345 KV - 1 CKT with 115 KV

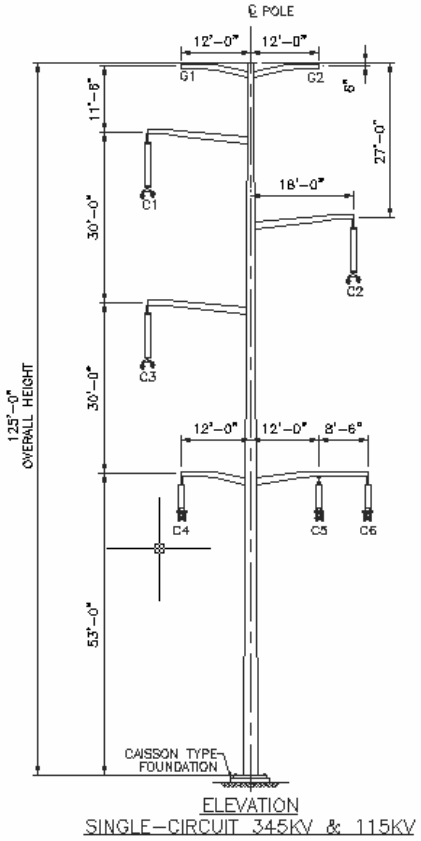




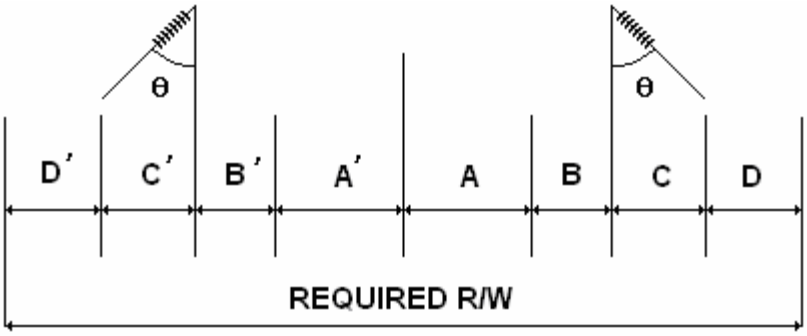


Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	20.5
B	Structure attachment deviation due to deflection	5
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115 KV circuit.	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2)	**88.2**

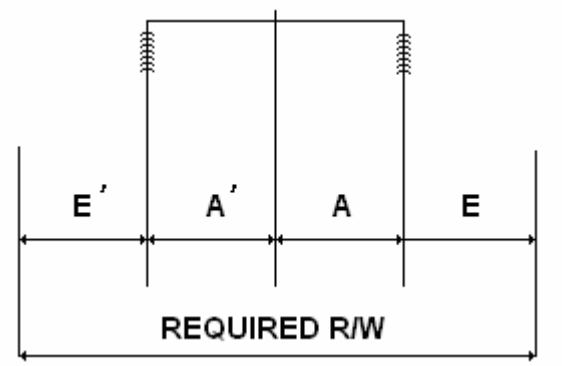
Figure 4.3-18a ROW Calculation for 345 kV Single Circuit Delta Configuration With 115 kV Underbuild (1100 ft Span Right Side)



Case 1

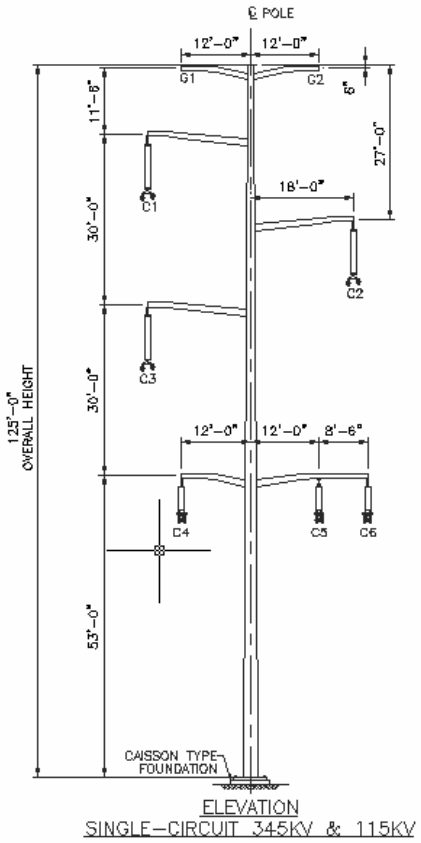


Case 2

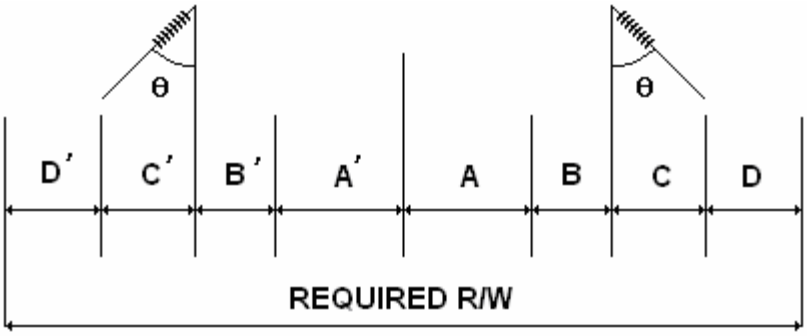


Required Distance (Right side of structure)		Width (ft)
A	Distance between end of arm conductor attachment and center of structure (115kV lower arm)	20.5
B	Structure attachment deviation due to deflection	5
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115kV circuit.	20.3
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2) **A + B + C + D**	**52.4**

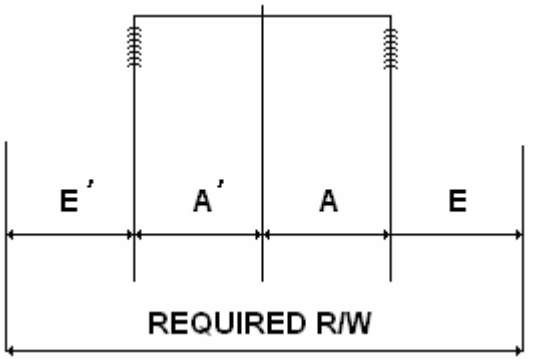
Figure 4.3-18b ROW Calculation for 345kV Single Circuit Delta Configuration With 115kV Underbuild (1100 ft Span Left Side)



Case 1



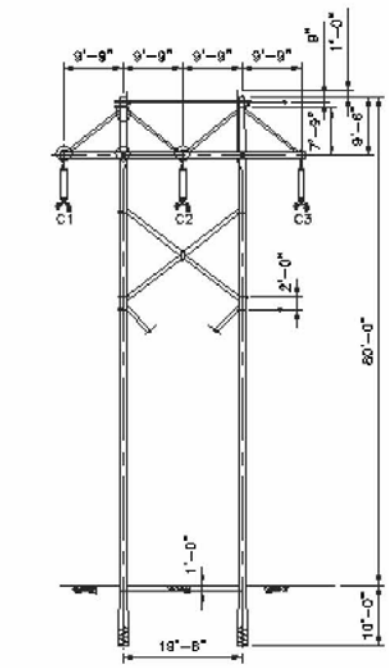
Case 2



Required Distance (Left Side of Structure)		Width (ft)
A'	Distance between end of arm conductor attachment and center of structure (345 KV)	18
B'	Structure attachment deviation due to deflection	6
C'	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	18.7
D'	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E'	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2). **A' + B' + C' + D'**	**53.5**
Total ROW	**52.4 + 53.5**	**105.9**

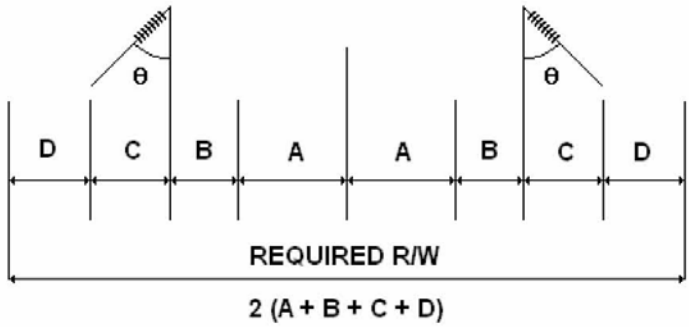
Figure 4.3-19 ROW Calculations for 230kV "H" Frame Structures for Special Uses

Right of Way (ROW) for 230 KV - H-FRAME

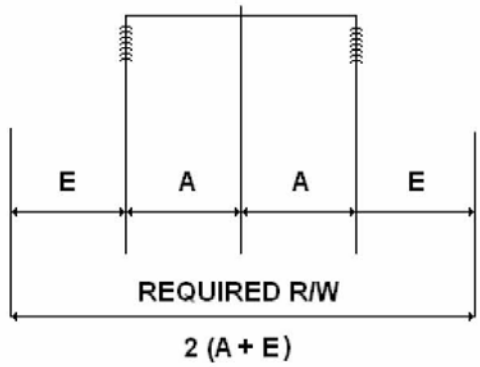


ELEVATION
SINGLE-CIRCUIT 230KV H-FRAME

Case 1



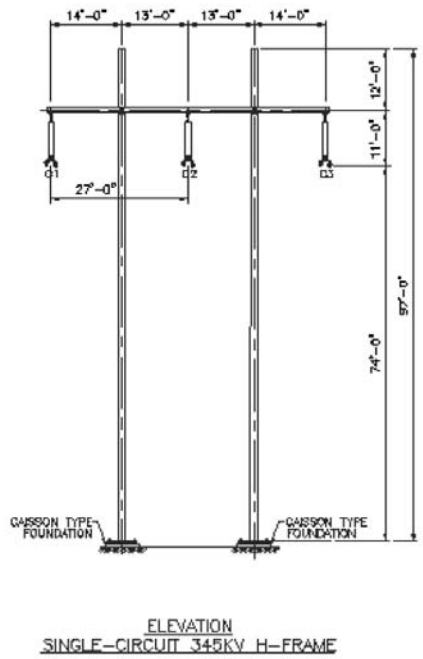
Case 2

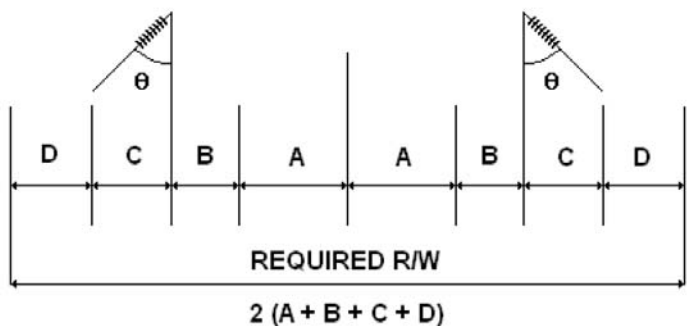


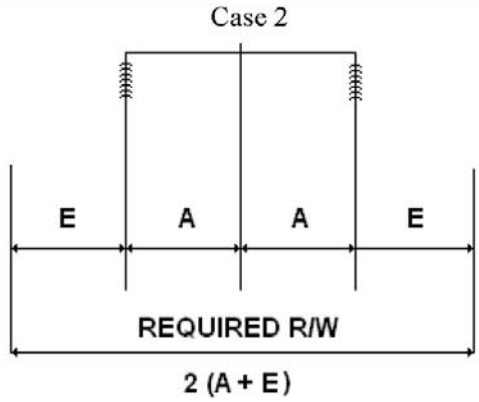
Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	17.5
B	Structure attachment deviation due to deflection	3
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2)	**78.2**

Figure 4.3-20 ROW Calculations for 345kV "H" Frame Structure for Special Uses

Right of Way (ROW) for 345 KV - H-FRAME







Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	26
B	Structure attachment deviation due to deflection	3
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak conductor at 6 psf for 115 KV circuit.	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2)	**103.6**

1.1.1.2 East Range

4.3.1.2.3 39L/37L Route: Preferred Configuration

Figure 4.3-21 shows the 345kV/115kV double circuit preferred 39L/37L Route line segments. A preliminary summary of the HVTL structure configurations and heights that would be used along the 345kV preferred 39L/37L Route are provided in Figure 4.3-22. A detailed analysis showing the ROW required for each of the structures is provided in Figure 4.3-23a and Figure 4.3-23b (the double circuit 345kV/115kV structure sufficient to span 750 feet); Figure 4.3-24a and Figure 4.3-24b show the double circuit 345kV/115kV structure sufficient to span 1,100 feet. The ROW calculations for the single circuit delta configuration 345kV structure are shown in Figure 4.3-25.

4.3.1.2.4 38L Route: Preferred Configuration

Figure 4.3-26 shows the 345kV single circuit (with 115kV underbuild) 38L Route line segments. The HVTL structures used in this route were shown previously in Figures 4.3-17, 4.3-18a, 4.3-18b, and 4.3-25. This route will not require additional ROW. The preliminary structure summarizes for the 38L route are provided in Figure 4.3-27.

4.3.1.2.5 Alternate Configuration

The alternate configuration would involve reversing the route from which the additional 30 feet of ROW is acquired. That is, the 30 feet of additional ROW would be taken from the 38L Route instead of the 39L/37L route.

Figure 4.3-21 East Range Preferred 39L/37L 345kV HVTL Route and Structure Configurations

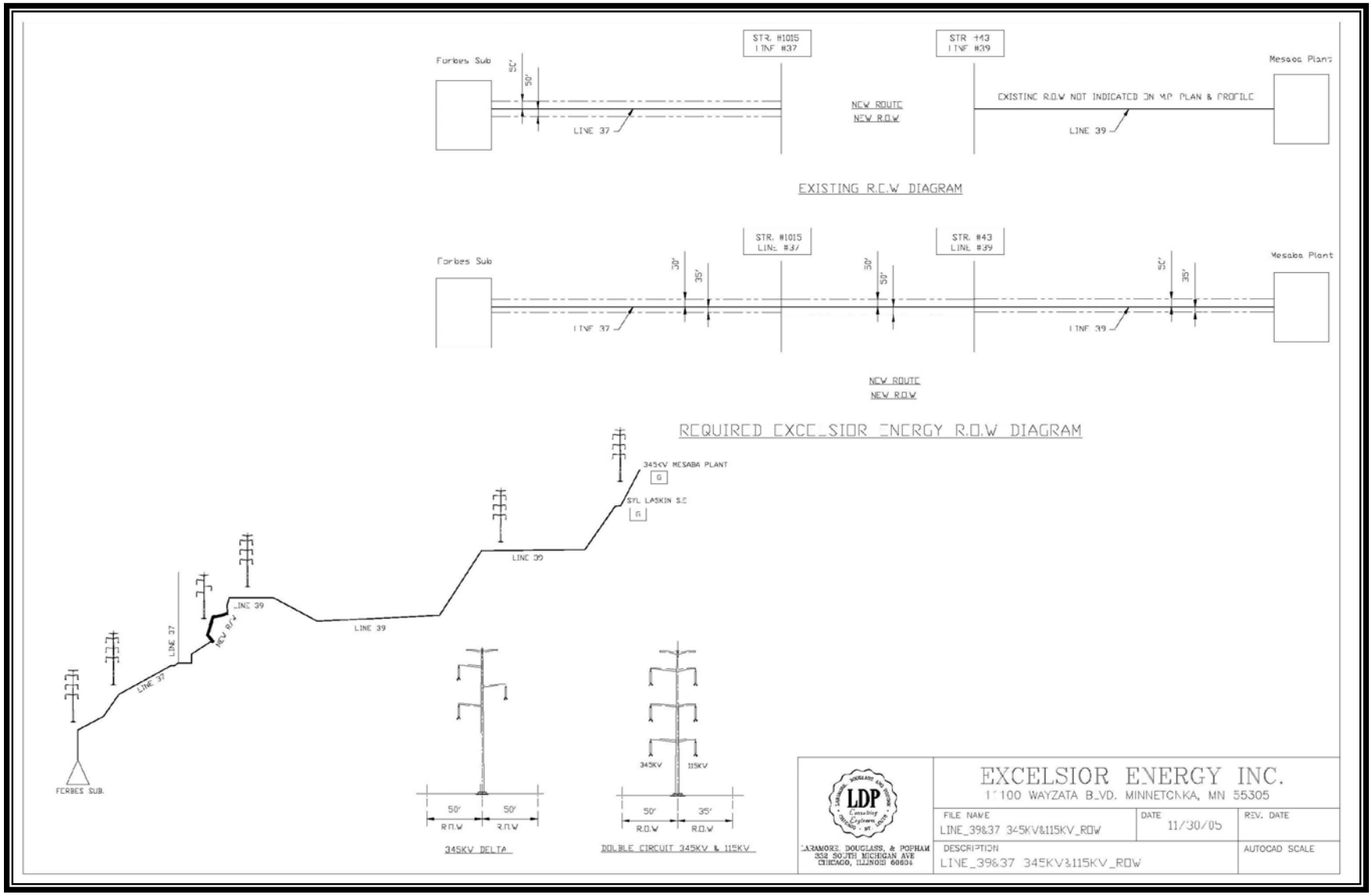
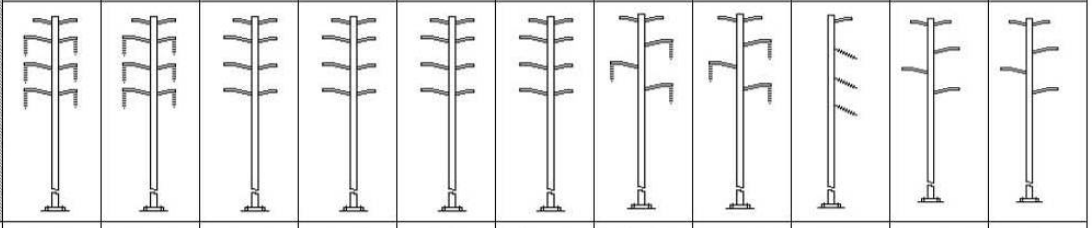


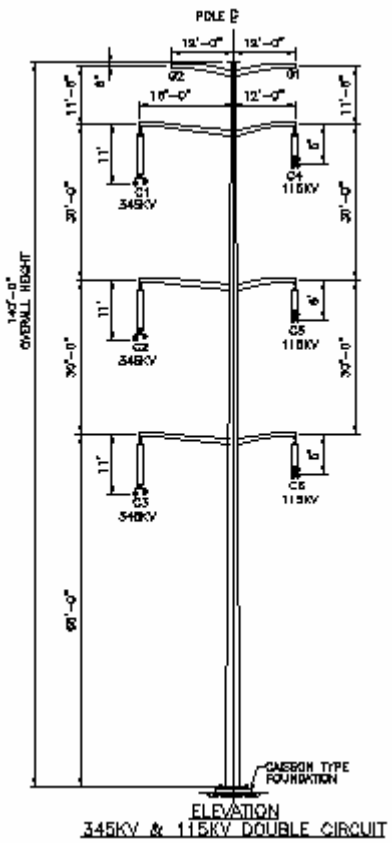
Figure 4.3-22 East Range 39L/37L Leg HVTL Structure Summary



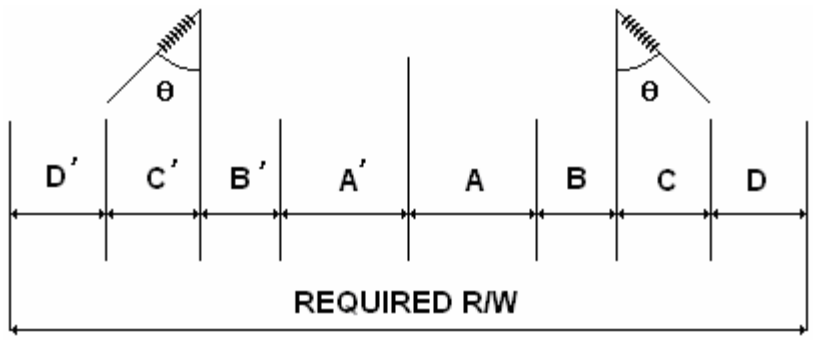
	1	2	3	4	5	6	7	8	9	10	10
Height	SUS1	SUS2	STR1	STR2	DED1	DED2	SUS1(DLT)	SUS2(DLT)	RAN1	DED1(DLT)	DED2(DLT)
	0° - 2°	2°-6°	6°-15°	15°-30°	30°-60°	60°-90°	0° - 2°	2°-15°	15°-30°	30°-60°	60°-90°
90								1	2	2	3
100							11		1		
105							1				
120	1									1	
124	139										
128	1		2	1	10						
129	54										
130						1					
132			1	1	7	2					
133	23						1				
134	1										
137	3		2		3	1					
138	16										
139	1										
141						2					
142	5				2						1
147	6				1					1	
151	1										
155							1				
156	1										
Total	252	0	5	2	23	6	14	1	3	4	4

314 Structures

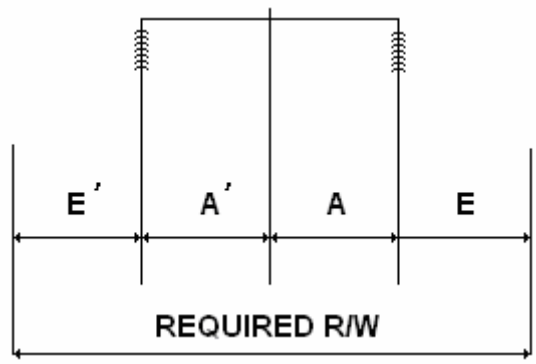
Figure 4.3- 23a East Range 39l/37L Leg HVTL ROW Calculation-345kV/115kV Double Circuit, 750 Foot Span, Right Side Structure



Case 1

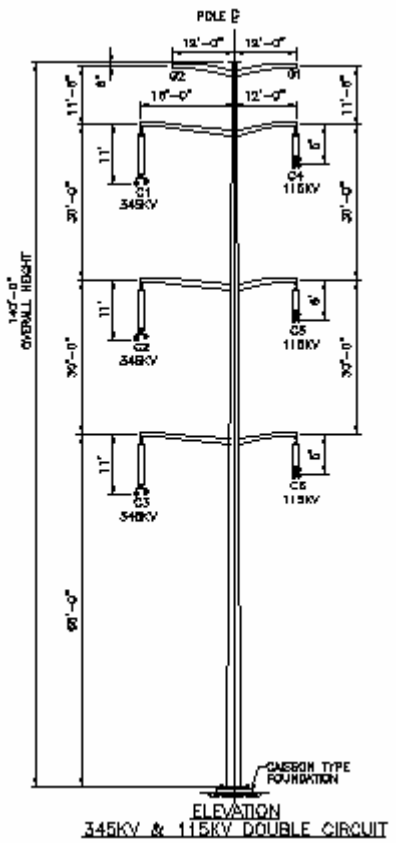


Case 2

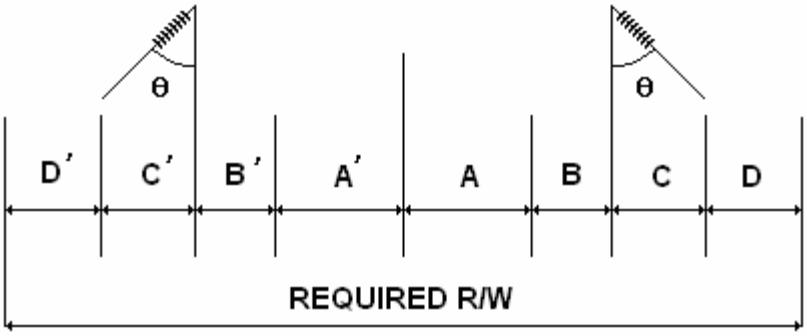


Required Distance (Right side of structure)		Width (ft)
A	Distance between end of arm conductor attachment and center of structure (115kV arm)	12
B	Structure attachment deviation due to deflection	6
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115kV circuit.	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2) **A + B + C + D**	**36.6**

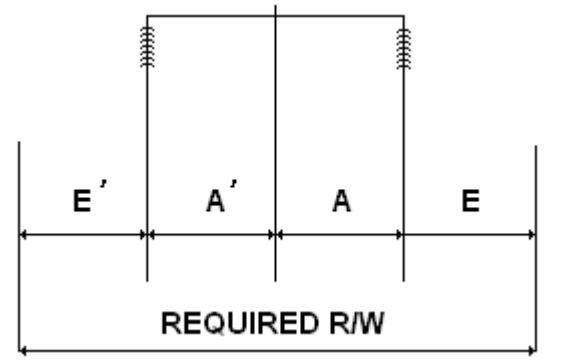
Figure 4.3-23b East Range 39l/37L Leg HVTL ROW Calculation-345kV/115kV Double Circuit, 750 Foot Span, Left Side Structure



Case 1

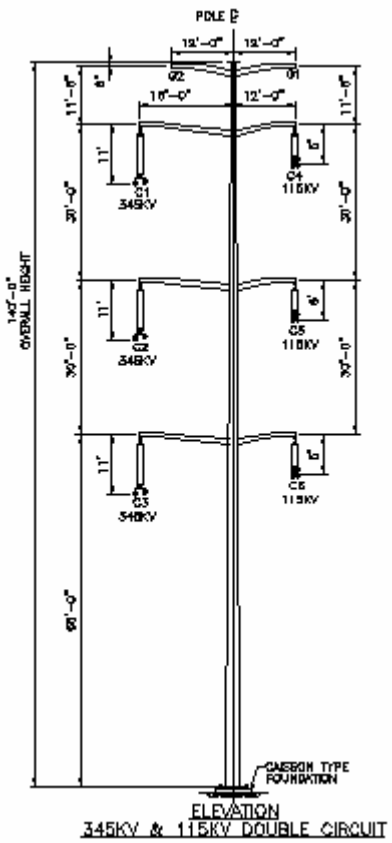


Case 2

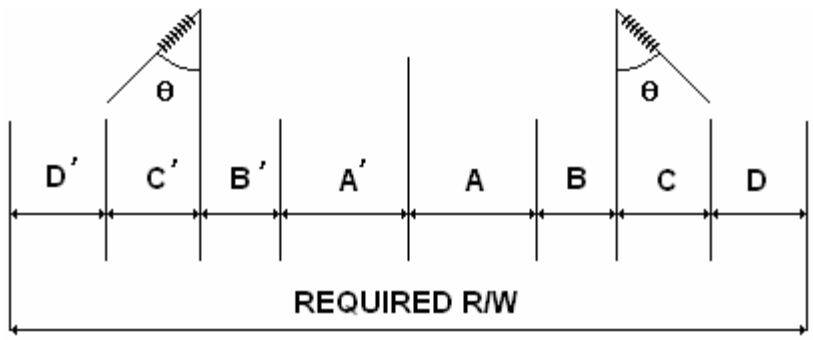


Required Distance (Left Side of Structure)		Width (ft)
A'	Distance between end of arm conductor attachment and center of structure (345kV arm)	18
B'	Structure attachment deviation due to deflection	6
C'	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D'	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E'	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2). **A' + B' + C' + D'**	**46.8**
Total ROW	**36.6 + 46.81**	**83.4**

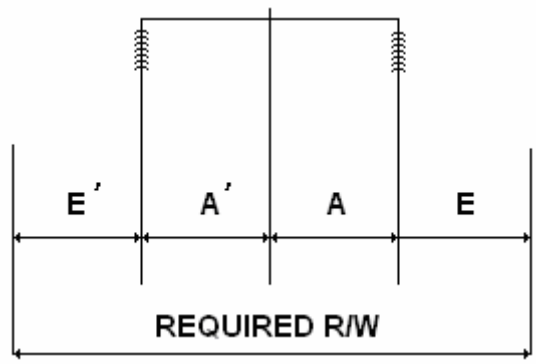
Figure 4.3-24a East Range 39l/37L Leg HVTL ROW Calculation-345kV/115kV Double Circuit, 1100 Foot Span, Right Side Structure



Case 1

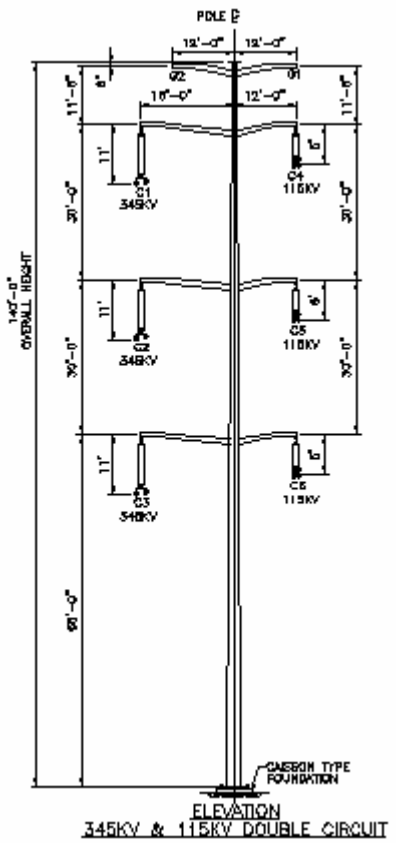


Case 2

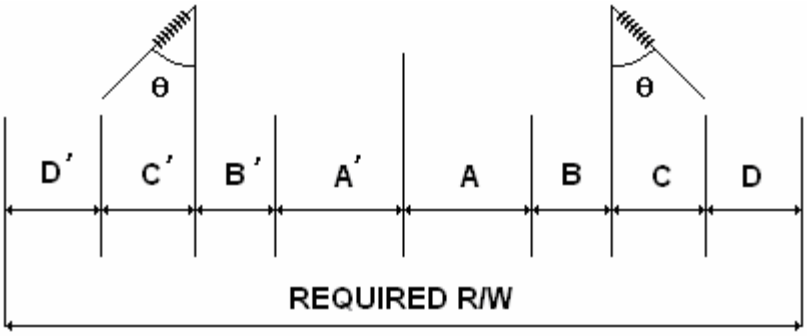


Required Distance (Right side of structure)		Width (ft)
A	Distance between end of arm conductor attachment and center of structure (115kV arm)	12
B	Structure attachment deviation due to deflection	6
C	Blowout. Obtained from PLS_CADD 3D model with Grosbeak (636 MCM) conductor at 6 psf for 115kV circuit.	20.3
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	6.6
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	9.6
	Required ROW (The larger value between Case 1 and Case 2) **A + B + C + D**	**44.9**

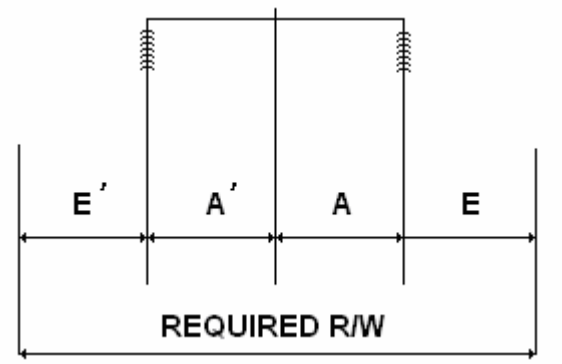
Figure 4.3-24b East Range 39l/37L Leg HVTL ROW Calculation-345kV/115kV Double Circuit, 1100 Foot Span, Left Side Structure



Case 1

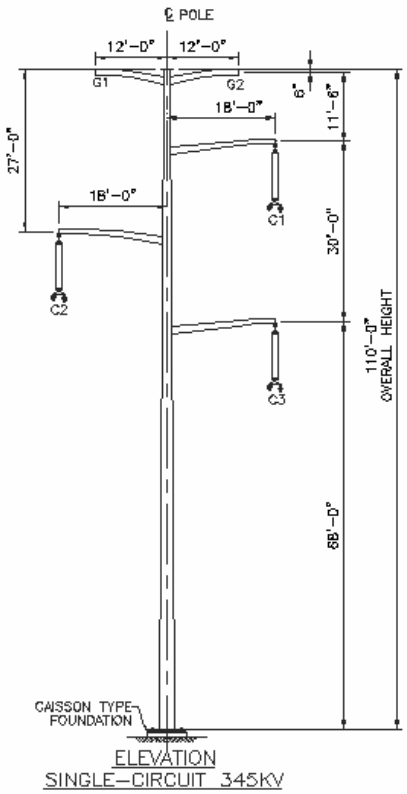


Case 2

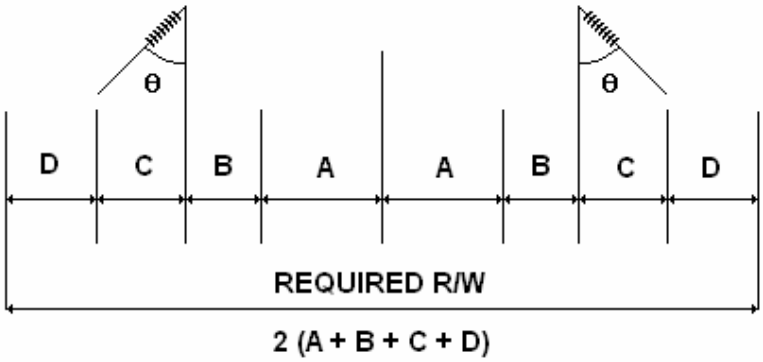


Required Distance (Left Side of Structure)		Width (ft)
A'	Distance between end of arm conductor attachment and center of structure (345kV arm)	18
B'	Structure attachment deviation due to deflection	6
C'	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	18.7
D'	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E'	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required ROW (The larger value between Case 1 and Case 2). **A' + B' + C' + D'**	**53.5**
Total ROW	**44.9 + 53.5**	**98.4**

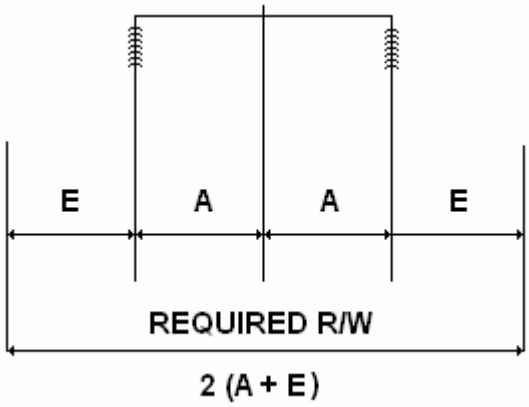
Figure 4.3-25 East Range 39L/37L Leg HVTL ROW Calculation-345kV Single Circuit Structure



Case 1



Case 2



Required Distance		Width (ft)
A	Distance between end of arm conductor attachment and center of structure	18
B	Structure attachment deviation due to deflection	5
C	Blowout. Obtained from PLS_CADD 3D model with Twin Pheasant conductor at 6 psf	12
D	Clearance requirement to building or objects with conductor displaced by wind per NESC Rule 234	10.8
E	Clearance requirement to building or objects with conductor at rest per NESC Rule 234	13.8
	Required Right of Way (The larger value between Case 1 and Case 2)	**91.6**

Figure 4.3-26 East Range Alternate 38L 345kV HVTL Route and Structure Configurations

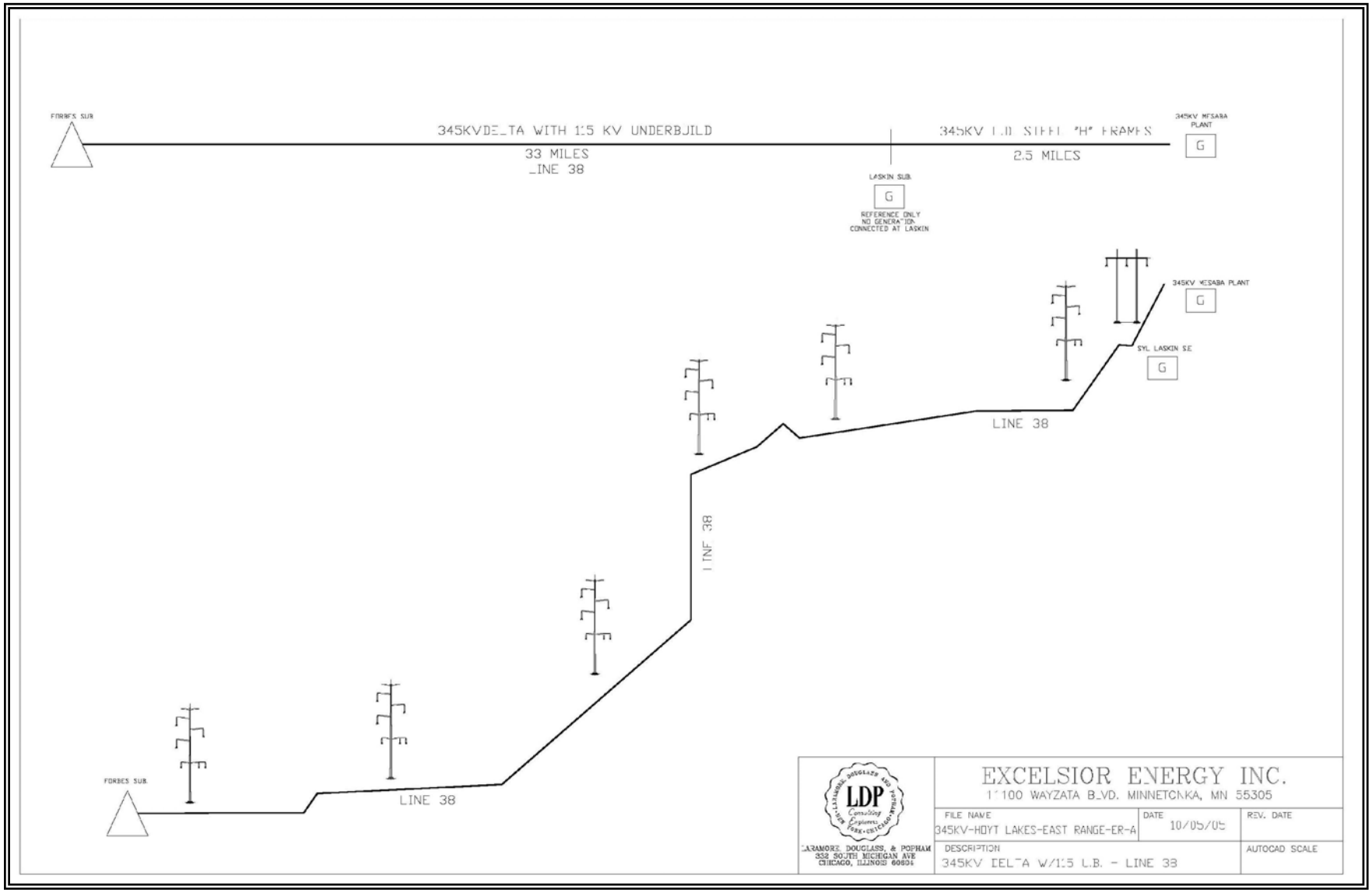
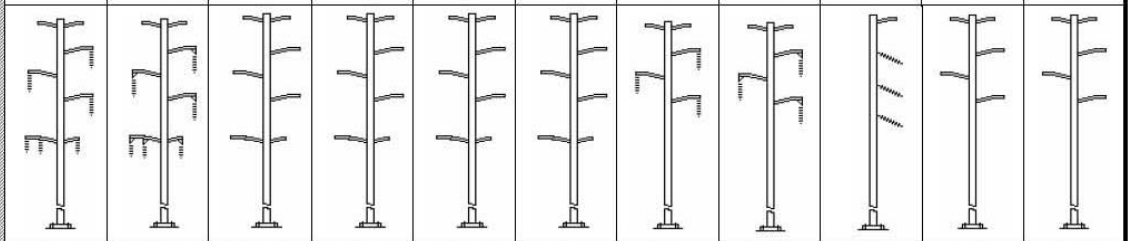


Figure 4.3-27 East Range 38L Leg HVTL Structure Summary

Mesaba Energy Project
Preliminary Corridor Structure Design for the East Route
Preliminary Structure Summary Line 38 and 43



	1	2	3	4	5	6	7	8	9	10	11
Height	SUS1_UB	SUS2_UB	STR1_UB	STR2_UB	DED1_UB	DED2_UB	SUS1	SUS2	RAN1	DED1	DED2
	0° - 2°	2°-6°	6°-15°	15°-30°	30°-60°	60°-90°	0° - 2°	2°-15°	15°-30°	30°-60°	60°-90°
115	1										
120	13										
124	149	1	1		6	3					
129	46				1						
132					1						
133.0	25		1			1	1				
134.0	1										
137.0						1					
138.0	6										
139.0	1										
142.0	5				3					1	
147.0											1
Total	247	1	2	0	11	5	1	0	0	1	1

269 Structures

4.3.2 Conductors

Two different size conductors for each transmission line segment to be operated at a specific voltage were evaluated. The proposed conductor, listed for each line segment, was selected based on an economic analysis that estimated the lowest cost considering initial construction cost, power losses due to line characteristics and construction sequencing to account for the time value of funds. The characteristics of each conductor type operating at 230 kV are included in Table 4.3-1. Characteristics of various conductor types operating at 345kV are included in Table 4.3-2. The line impedances and power flow data for the alternative conductors considered for use are presented in this table. The rating for each conductor is presented in Table 4.3-2.

Table 4.3-1 Conductor Impedances and Power Flow Data: 230kV

	230KV ER-A/ER-B 795KCMIL Bundle	230KV ER-C 795KCMIL Bundle	230KV ER-A/ER-B 1590KCMIL	230KV ER-C 1590KCMIL	230KV WR-A 795KCMIL Bundle	230KV WR-B 795KCMIL Bundle	230KV WR-A 1590KCMIL	230KV WR-B 1590KCMIL
Pr (MW)	583.710408	582.388675	583.059919	581.651236	594.9268	591.474692	594.71364	591.148182
Vr (kV)	230	230	230	230	230	230	230	230
Ir (AMP)	1475.03605	1468.93385	1465.12214	1460.42143	1544.385	1519.8395	1535.88	1508.43805
P.F.r	0.99338839	0.99525635	0.99899573	0.99978988	0.967013	0.97692836	0.9720193	0.98376905
Sine(PFr Angle)	0.11480204	0.09728716	0.04480541	0.02049887	0.254727	0.21356727	0.2349008	0.17943929
L (mile)	35.5	38.7	35.5	38.7	10	17.5	10	17.5
R+ (Ohm)/mile	0.0703	0.0703	0.0741	0.0741	0.0709	0.0703	0.0747	0.0741
R0 (Ohm)/mile	0.6592	0.6592	0.6626	0.6626	0.629	0.6592	0.6328	0.6626
X+ (Ohm)/mile	0.56	0.56	0.7483	0.7483	0.566	0.56	0.7559	0.7483
X0 (Ohm)/mile	1.8892	1.8892	2.077	2.077	1.926	1.8892	2.116	2.077
Xc+ (M Ohm)/mile	0.1322	0.1322	0.1646	0.1646	0.1322	0.1322	0.1747	0.1646
Xc0 (M Ohm)/mile	0.2414	0.2414	0.2838	0.2838	0.2515	0.2414	0.294	0.2838
Ps (MW)	600	600	600	600	600	600	600	600
Delta(Es,Vr) DEG	11.5979972	12.6068233	15.6205642	17.0134434	3.436089	5.86102724	4.6072413	7.85460924
P loss (MW)	16.2895918*	17.6113247**	16.9400808*	18.3487643**	5.073159*	8.52530805**	5.2863559*	8.8518179**
V drop (Kv)	22.2553512	24.1610981	29.4521444	32.0039732	6.63396	11.3041845	8.7852074	14.9479028
Es (KV)	247.215918	248.242862	248.888716	249.689789	236.1152	239.928406	237.42271	241.741884
%Regulation	7.48518186	7.93167913	8.21248505	8.56077771	2.658804	4.31669839	3.2272662	5.10516678
P.F.s	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

* When only unit 1 is in service, the two lines will operate in parallel resulting in 25% of losses shown.
** When both units are in operation, the three lines will operate in parallel resulting in reduced losses from those shown in the table.

Table 4.3-2 Conductor Impedances and Power Flow Data: 345kV

345 KV LINE IMPEDANCES AND POWER FLOW DATA (REV1)
(600 MW Generation at 0.95 Power Factor)

	345KV ER-A/ER-B 954KCMIL BUNDLE	345KV ER-A/ER-B 1272KCMIL BUNDLE	345KV WR-1A 954KCMIL BUNDLE	345KV WR-2A 954KCMIL BUNDLE	345KV WR-1B 954KCMIL BUNDLE	345KV WR-1A 1272KCMIL BUNDLE	345KV WR-2A 1272KCMIL BUNDLE	345KV WR-1B 1272KCMIL BUNDLE
Pr (MW)	593.273698	594.8309783	598.002447	598.01863	596.5632363	598.4706794	598.4315168	597.3657458
Vr (kV)	345	345	345	345	345	345	345	345
Ir (AMP)	1016.699879	1019.461745	1043.921686	1043.964	1035.081572	1044.792888	1044.748021	1036.551184
P.F.r	0.976551925	0.976462708	0.95866762	0.9586547	0.964528194	0.958618238	0.958596675	0.964456359
Sine(PFr Angle)	0.215281997	0.215686302	0.284528372	0.2845719	0.263979855	0.284694702	0.2847673	0.264242185
L (mile)	35.5	35.5	10	10	17.5	10	10	17.5
R+ (Ohm)/mile	0.0611	0.0467	0.0611	0.0606	0.0611	0.0467	0.0479	0.0467
R0 (Ohm)/mile	0.6206	0.6062	0.6206	0.6218	0.6206	0.6062	0.6074	0.6062
X+ (Ohm)/mile	0.6034	0.5947	0.6034	0.6023	0.6034	0.5947	0.5936	0.5947
X0 (Ohm)/mile	1.8334	1.8247	1.8334	1.8367	1.8334	1.8247	1.828	1.8247
Xc+ (M Ohm)/mile	0.1423	0.1402	0.1423	0.1414	0.1423	0.1402	0.1392	0.1402
Xc0 (M Ohm)/mile	0.2355	0.2333	0.2355	0.2304	0.2355	0.2333	0.2283	0.2333
Ps (MW)	600	600	600	600	600	600	600	600
Delta(Es,Vr) DEG	5.7604818	5.736769081	1.66354358	1.6609418	2.887365764	1.653606465	1.649268995	2.871788264
P loss (MW)	6.726301985*	5.169021705*	1.997552968**	1.9813671**	3.436763654**	1.529320644**	1.568483239**	2.634254243**
V drop (Kv)	10.98930946	10.83829436	3.178463278	3.172593	5.5152081	3.128901295	3.123515171	5.432383933
Es (KV)	358.6631018	357.6914871	349.3105906	349.29643	352.2938282	349.0193334	349.034321	351.7943769
%Regulation	3.960319355	3.6786919	1.249446557	1.2453411	2.114153108	1.165024163	1.169368412	1.969384615
P.F.s	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

* When only unit 1 is in service, the two lines will operate in parallel resulting in 25% of losses shown.
** When only unit 1 is in service, lines 1A and 1B or 2A and 1B will be operating in parallel resulting in reduced losses from those shown in the table.

Table 4.3-3 Conductor Rating Data

EXCELSIOR ENERGY INC.

Conductor Selection	
Rating Ampacity Criteria	
Temp	30 C / 86 F
Wind Speed	2.0 ft/s
Angle b/w wind and Cond.	90 deg
Cond. Elev	1400 ft
Sun Time	12 hrs
Cond. Lat	47 deg
Atmosphere	Clear
Day of Yr.	June 30
230 kV System	
1-Generator 600MW - 1585 A (.95 PF)	
Conductor Type	100C/212F
1-1590 kcm ACSR "Lapwing	1601 A
2-795 kcm ACSR " Drake"	2128 A
345 kV System	
2-Generator 1200MW - 2113 A (.95 PF)	
Conductor Type	100C/212F
2-954 kcm ACSR "Cardinal"	2328 A
2-1272 kcm ACSR "Pheasant"	2785 A
115 kV System	
Conductor Emergency Rating	
Conductor Type	135C/275F
1-954 kcm ACSR "Cardinal"	1411 A

4.3.3 Other Transmission Network Reinforcements

In addition to the necessary generator outlet HVTLs identified above, the Applicant anticipates that network reinforcements[16] will be required within other existing HVTL corridors leading to load centers and/or at substations down-network of the Blackberry and Forbes Substations. MISO is the organization with responsibility to coordinate the objective review of, and ultimately approve, all transmission-related additions and alterations. MISO's Large Generator Interconnection Agreement Procedure ("LGIP") is the process established to facilitate such review and approval.

At Excelsior's request (formally logged as MISO Queue No. 38491-01), the LGIP has been initiated and designated as Project G519. Work to-date has verified that the Blackberry 230kV Substation is an acceptable POI and that some additional network upgrades/reinforcements will likely be required to deliver the output from Mesaba One to the Xcel Energy control area.

4.3.3.1 West Range Site

4.3.3.1.1 Mesaba One Reinforcements

Excelsior has conducted preliminary power flow studies to identify potential HVTL Phase I reinforcements needed to avoid constructing new HVTLs outside existing corridors. Such reinforcements will include the following types of improvements to existing transmission lines:

- Replacing conductors (wires) to increase capacity
- Installing new towers or replacing aging towers
- Replacing insulators on existing towers so that existing lines can be used for higher kV transmission

The studies suggest that 230kV or 345kV reinforcements between MP's Clay Boswell Station (or the Blackberry Substation) and the Riverton Substation will be identified through the LGIP as part of the Phase I developments. Currently, the lines around the Blackberry Substation are heavily loaded as most of the output of Clay Boswell Units 3 and 4 (nearly 900 MW) flows through this substation.

As noted above, MISO has performed preliminary powerflow studies of Mesaba One's injection into the existing electrical grid. The results have been analyzed and prompted additional work. MP has also completed and forwarded its requested short circuit studies to MISO. The remaining powerflow and stability studies will be done immediately following, and perhaps concurrent with, the G477 studies (Queue No. 38280-01) associated with the East Range Site. The System Impact Study report is expected to be completed in April/May of 2006.

[16] Network reinforcements are defined as upgrades to the existing transmission system designed to eliminate new constraints on existing generating resources that would otherwise interfere with the existing generator's capability to place into commerce the amount of energy it provided to existing load centers prior to introducing new generating capacity at a point intermediate to such pre-existing load centers.

4.3.3.1.2 Mesaba Two Reinforcements

Existing 230kV lines from Blackberry Substation to the Arrowhead Substation (near Duluth) and to the Riverton Substation (near Brainerd) are likely candidates for upgrading and/or double circuiting to increase transfer capabilities to the south commensurate with the addition of Mesaba Two.

Existing 230kV HVTL corridors connect the Blackberry and Arrowhead 230/115kV Substations (65 miles in length) and the Blackberry and Riverton 230/115kV Substations (80 miles in length). In the powerflow studies performed by Excelsior, the circuits on these corridors were upgraded to 345kV as part of a combined generator outlet/network reinforcement delivery concept for the Phase II Development. The studies also indicated that additional 345kV reinforcements would likely be needed beyond the Riverton substation to Great River Energy's Benton County Substation to accommodate Mesaba Two. Excelsior has recently submitted to MISO an LGIP request for Mesaba Two to confirm the required network reinforcements for the Phase II Development.

4.3.3.2 East Range Site

4.3.3.2.1 Mesaba One Reinforcements

In addition to the East Range IGCC Power Station's GO HVTLs identified above, Excelsior anticipates that network reinforcements would be required within other existing HVTL corridors leading to load centers and/or at substations down-network of the Forbes Substation. Based upon preliminary system studies, interconnecting the IGCC Power Station directly to the Forbes Substation results in minimal impacts on the underlying MP system, including the already congested "North Shore Loop". The studies also show that network upgrades will be necessary from the Forbes Substation south at least to Duluth, and possibly to the Twin Cities, to minimize potential impacts on the existing Winnipeg-Forbes-Twin Cities 500kV Intertie.

The MISO large generator interconnection process has been initiated to evaluate the Forbes Substation as the POI and to determine what network upgrades are necessary to deliver the output of Mesaba One to the Xcel Energy control area (Twin Cities).

4.3.3.2.2 Mesaba Two Reinforcements

Based upon Excelsior's preliminary system powerflow studies, the addition of two new 345kV circuits in existing corridors between the Forbes Substation and the Arrowhead Substation (located in Proctor, MN near Duluth) and then continuing on from the Arrowhead Substation into the Twin Cities 345kV system via existing routes appears to provide a robust reinforcement plan sufficient for both Mesaba One and Mesaba Two. It may be sufficient to upgrade existing 230kV circuits between these locations to 345kV for one of these circuit paths. Such upgrades would involve replacing existing HVTL towers with double circuit structures similar to what has been proposed for the 39L/37L and 38L GO HVTLs. This would minimize, if not eliminate, the need to acquire new ROWs.

4.4 TRANSMISSION LINE CONSTRUCTION

Areas that are stable and dry can be worked on during summer months, with difficult swampy areas reserved for winter construction. In areas where the frozen ground will not support weight, cribbing or matting is layed on the ground, to spread the weight. Most vehicle traffic will use the ROW for construction, with possible placement of a few access roads to the ROW. In some areas additional temporary ROW will be required for access. Erosion control measures will be implemented to minimize erosion during construction.

The steel structures will be supported by a drilled concrete pier foundation that will require an excavation 15 to 55 feet deep and 7 to 12 feet in diameter. Concrete piers can easily be drilled in frozen soils, with curing agents added to the concrete mix while pouring. In peat, special foundation structures will be required as shown in Figure . Once the concrete has cured, towers are assembled and erected. Poles will be delivered to structure locations and placed on the right-of-way and out of the clear zone of any adjacent roadways or designated pathways. Insulators and other hardware will be attached while the pole is on the ground, and the pole will then be lifted, placed, and secured on the foundation by a crane or similar heavy equipment.

Once the structures have been erected, conductors will be installed by establishing a stringing setup area on a portion of the right-of-way. The conductors are added after the towers are in place and dressed out. Pulleys placed on the insulators allow the cable to be pulled along the route with pulling and tensioning equipment, thereby allowing the wire to be pulled over the swampy areas. Conductor stringing operations will also require brief access to each structure to secure the conductor cable to the insulators or to install shield wire clamps once final tensioning is completed. Temporary guard or clearance poles will be installed as needed over existing distribution or communication lines, streets, roads, highways, railways or other obstructions after any necessary notifications are made and permits obtained. This ensures that conductors will not obstruct traffic or contact existing energized conductors or other cables.

Construction crews will comply with local, state, National Electric Safety Code (NESC) and other applicable standards regarding clearance to ground, clearance to crossing utilities, clearance to buildings, right-of-way widths, erection of power poles and stringing of transmission line conductors. During construction, crews will attempt to limit ground disturbance wherever possible. Disturbed areas will be restored to their original condition to the extent practicable and as negotiated with landowners. Post-construction reclamation activities include removing and disposing of debris, dismantling all temporary facilities (including staging and lay down areas), leveling or filling tire ruts, employing appropriate erosion control measures, and reseeding areas disturbed by construction activities with vegetation similar to that which was removed.

Construction for the East Range is expected to be spread over two years, with the West Range preferred transmission plan likely being completed in one winter season.

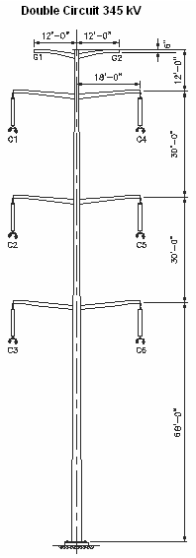
4.5 TRANSMISSION LINE OPERATION AND MAINTENANCE

The owners will periodically perform inspections, maintain equipment and make repairs over the life of the line. As well, the owners will also conduct routine maintenance approximately every five years to remove undesired vegetation that may interfere with the safe and reliable operation of the HVTL.

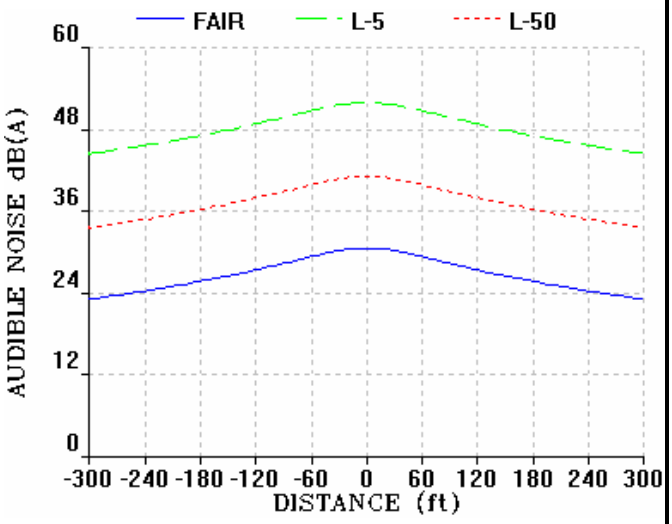
4.6 ELECTRIC AND MAGNETIC FIELDS AND NOISE

The electric and magnetic fields (EMF) and noise levels that are modeled to be generated by the proposed transmission lines are shown in Figures 4.6-1 through 4.6-12. As designed, all such levels will be in compliance with applicable State and Federal standards.

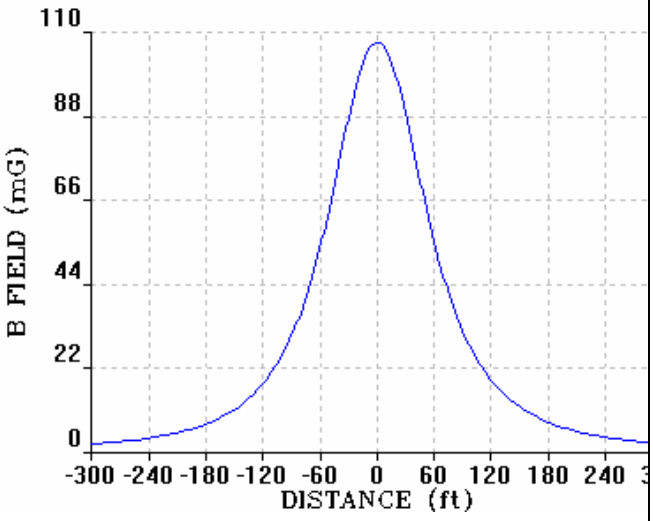
Figure 4.6-1 EMF Calculations for Plan A 345kV Preferred and Alternate Route Vertically Configured Double Circuit Structure



Audio Noise



Magnetic Field



Electric Field

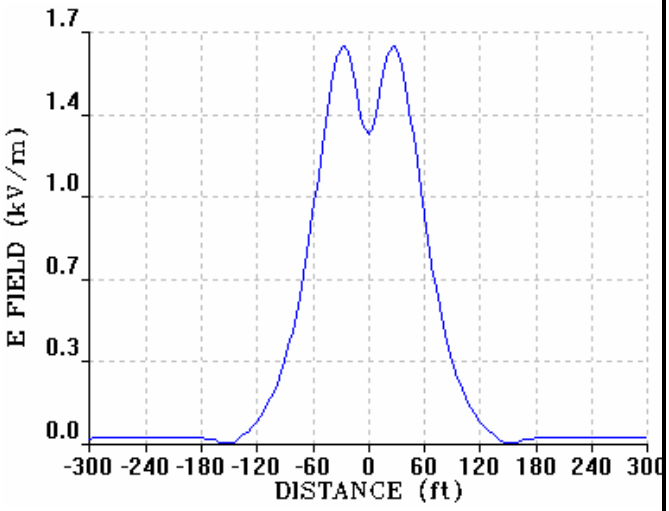
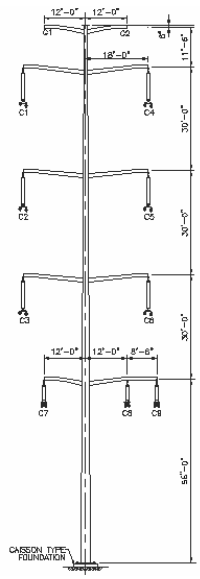
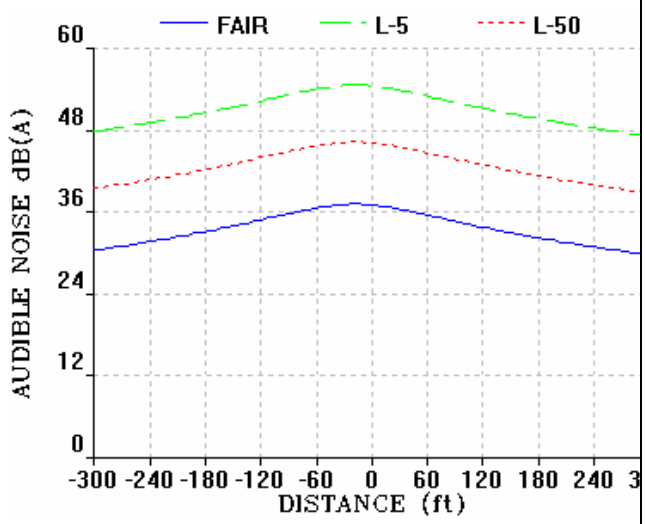
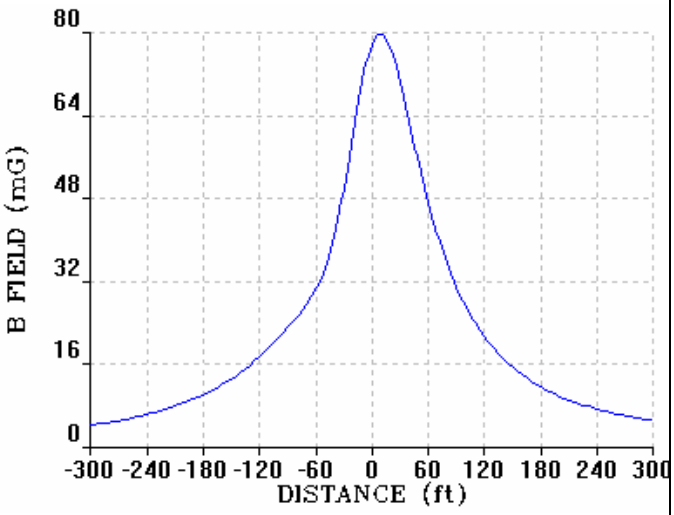


Figure 4.6-2 EMF Calculations for Plan A 345kV Preferred and Alternate Route Vertically Configured Double Circuit Structures With 115kV Underbuild







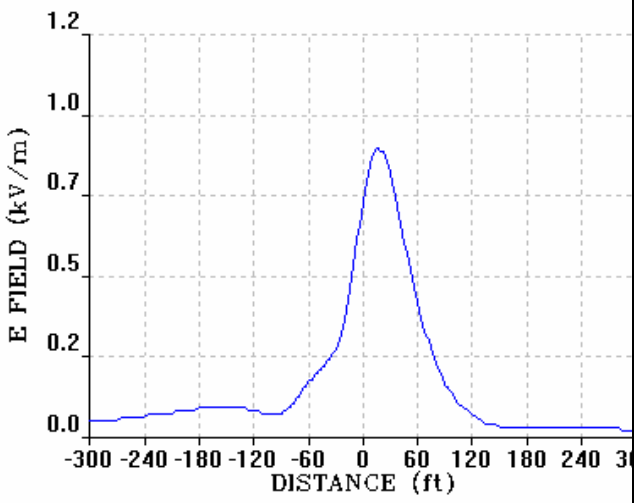
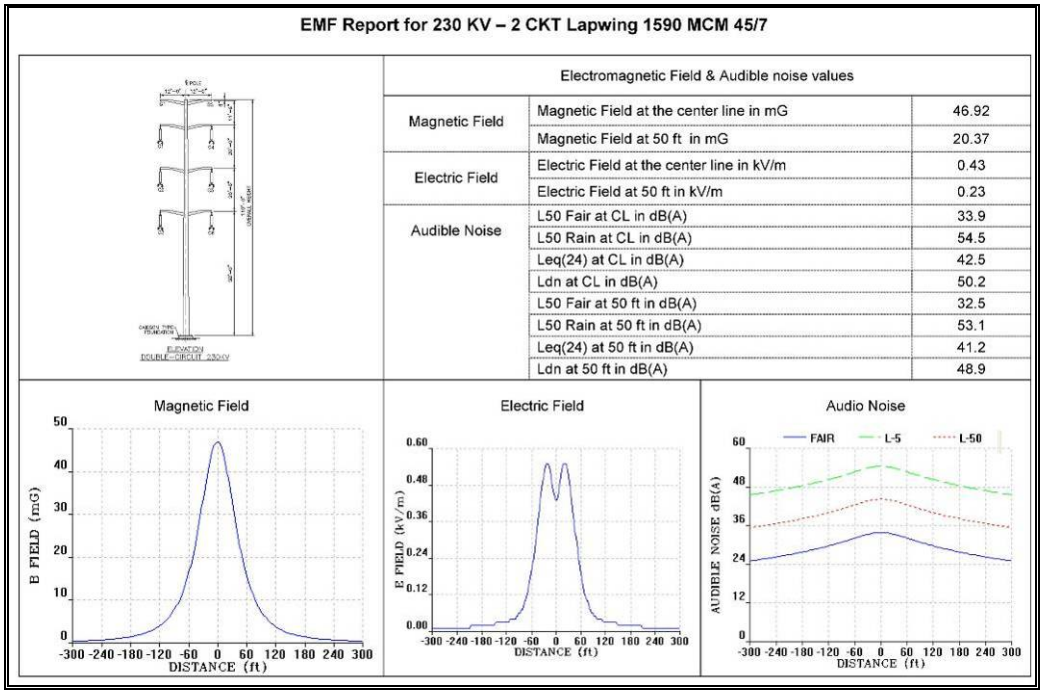
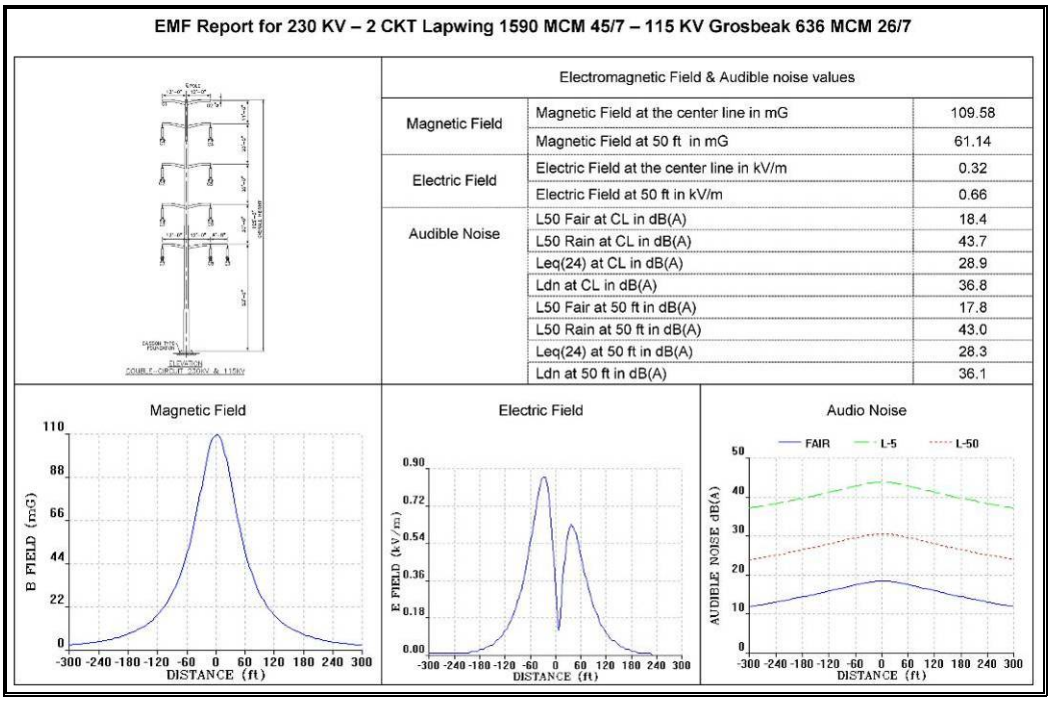


Figure 4.6-3 Electric and Magnetic Field and Noise Values-230kV Double Circuit HVTL



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	46.92
	Magnetic Field at 50 ft in mG	20.37
Electric Field	Electric Field at the center line in kV/m	0.43
	Electric Field at 50 ft in kV/m	0.23
Audible Noise	L50 Fair at CL in dB(A)	33.9
	L50 Rain at CL in dB(A)	54.5
	Leq(24) at CL in dB(A)	42.5
	Ldn at CL in dB(A)	50.2
	L50 Fair at 50 ft in dB(A)	32.5
	L50 Rain at 50 ft in dB(A)	53.1
	Leq(24) at 50 ft in dB(A)	41.2
	Ldn at 50 ft in dB(A)	48.9

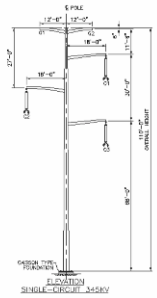
Figure 4.6-4 Electric and Magnetic Field and Noise Values-230kV Double Circuit HVTL with 115kV Underbuild



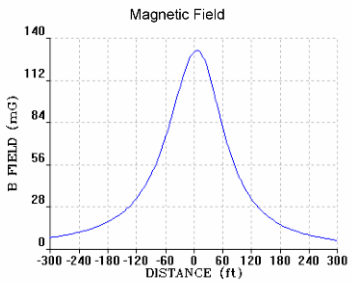
Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	109.58
	Magnetic Field at 50 ft in mG	61.14
Electric Field	Electric Field at the center line in kV/m	0.32
	Electric Field at 50 ft in kV/m	0.66
Audible Noise	L50 Fair at CL in dB(A)	18.4
	L50 Rain at CL in dB(A)	43.7
	Leq(24) at CL in dB(A)	28.9
	Ldn at CL in dB(A)	36.8
	L50 Fair at 50 ft in dB(A)	17.8
	L50 Rain at 50 ft in dB(A)	43.0
	Leq(24) at 50 ft in dB(A)	28.3
	Ldn at 50 ft in dB(A)	36.1

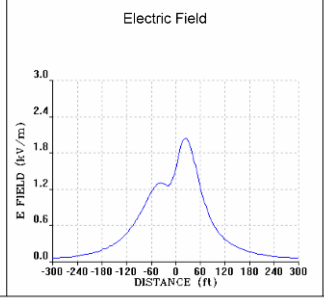
Figure 4.6-5 Electric and Magnetic Field and Noise Values-345kV Delta Tower HVTL

Electromagnetic Field Report for 345 KV – 1 CKT Delta Bundle (• •) Pheasant 1272 MCM 54/19



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	130.82
	Magnetic Field at 50 ft in mG	93.58
Electric Field	Electric Field at the center line in kV/m	1.54
	Electric Field at 50 ft in kV/m	1.53
Audible Noise	L50 Fair at CL in dB(A)	25.4
	L50 Rain at CL in dB(A)	47.8
	Leq(24) at CL in dB(A)	34.6
	Ldn at CL in dB(A)	42.4
	L50 Fair at 50 ft in dB(A)	24.9
	L50 Rain at 50 ft in dB(A)	47.2
	Leq(24) at 50 ft in dB(A)	34.1
	Ldn at 50 ft in dB(A)	41.9





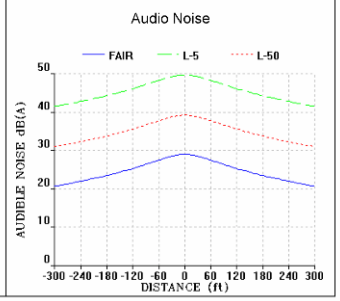
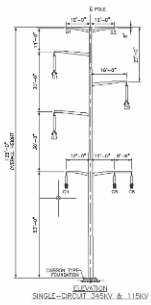
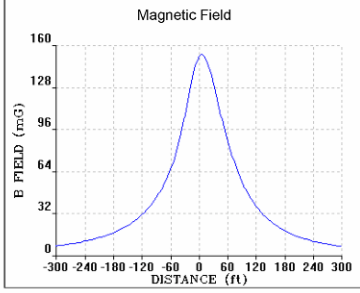


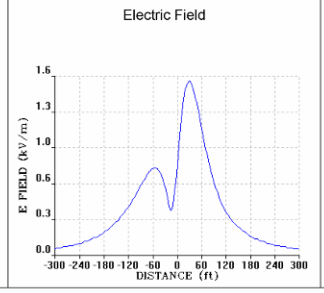
Figure 4.6-6 Electric and Magnetic Field and Noise Values-345kV Delta Tower HVTL with 115kV Underbuild

EMF Report for 345 KV – 1 CKT Delta Bundle (• •) Pheasant 1272 MCM 54/19 – 115 KV Grosbeak 636 MCM 26/7



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	151.60
	Magnetic Field at 50 ft in mG	101.05
Electric Field	Electric Field at the center line in kV/m	0.806
	Electric Field at 50 ft in kV/m	1.32
Audible Noise	L50 Fair at CL in dB(A)	24.0
	L50 Rain at CL in dB(A)	46.6
	Leq(24) at CL in dB(A)	33.2
	Ldn at CL in dB(A)	41.0
	L50 Fair at 50 ft in dB(A)	23.6
	L50 Rain at 50 ft in dB(A)	46.1
	Leq(24) at 50 ft in dB(A)	33.8
	Ldn at 50 ft in dB(A)	40.6





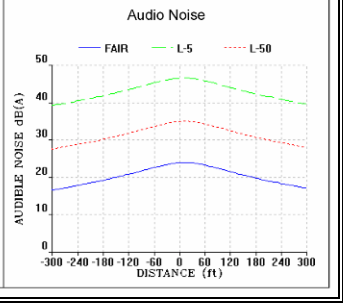
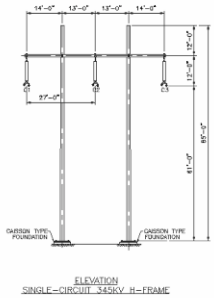
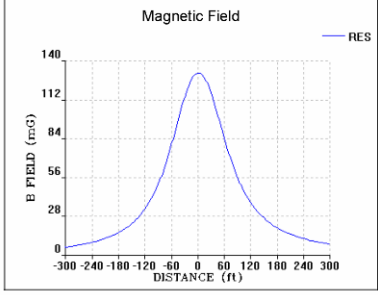


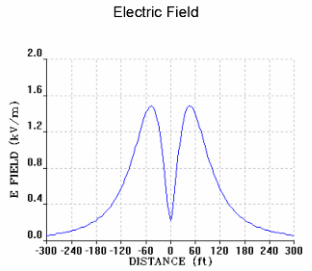
Figure 4.6-7 Electric and Magnetic Field and Noise Values-345kV H-Frame HVTL

Electromagnetic Field Report for 345 KV – 1 CKT H-Frame Bundle (• •) Pheasant 1272 MCM 54/19



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	184.86
	Magnetic Field at 50 ft in mG	122.08
Electric Field	Electric Field at the center line in kV/m	0.6
	Electric Field at 50 ft in kV/m	2.0
Electric Audible Noise	L50 Fair at CL in dB(A)	29.2
	L50 Rain at CL in dB(A)	50.2
	Leq(24) at CL in dB(A)	37.8
	Ldn at CL in dB(A)	45.6
	L50 Fair at 50 ft in dB(A)	27.8
	L50 Rain at 50 ft in dB(A)	48.9
	Leq(24) at 50 ft in dB(A)	36.5
	Ldn at 50 ft in dB(A)	44.2





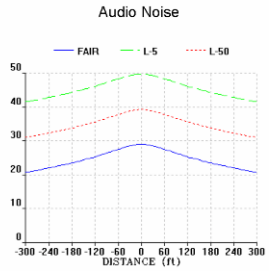
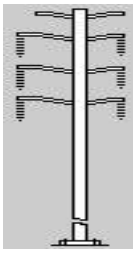
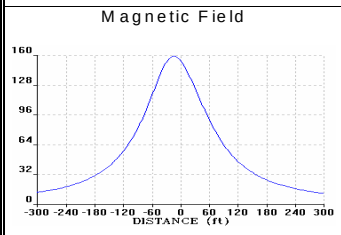
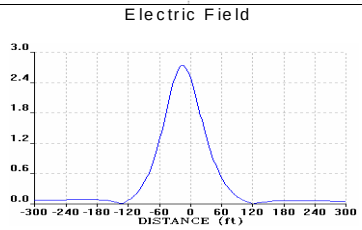


Figure 4.6-8 Electric and Magnetic Field and Noise Values-345kV/115kV Double Circuit Delta Tower HVTL



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	153.8
	Magnetic Field at 50 ft in mG	101.3
Electric Field	Electric Field at the center line in kV/m	2.49
	Electric Field at 50 ft in kV/m	.74
Audible Noise	L50 Fair at CL in dB(A)	24.4
	L50 Rain at CL in dB(A)	46.8
	Leq(24) at CL in dB(A)	35.3
	Ldn at CL in dB(A)	40.5
	L50 Fair at 50 ft in dB(A)	23.1
	L50 Rain at 50 ft in dB(A)	45.4
	Leq(24) at 50 ft in dB(A)	33.9
	Ldn at 50 ft in dB(A)	39.1





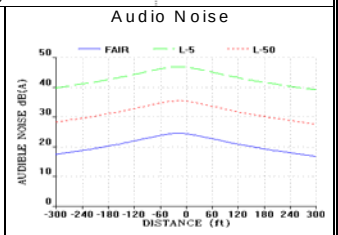
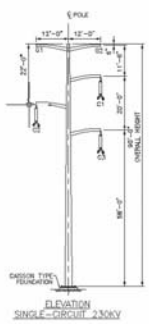
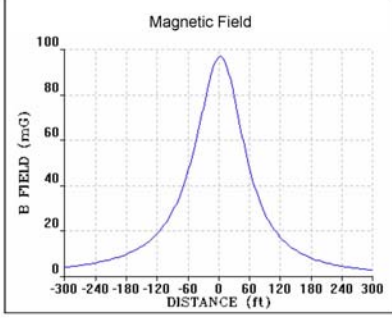


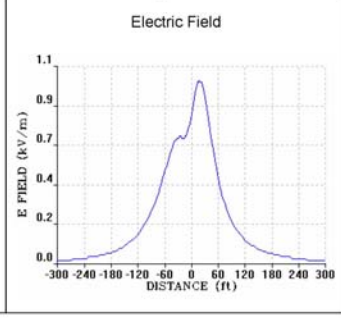
Figure 4.6-9 Electric and Magnetic Field and Noise Values-230kV Delta HVTL (Lapwing)

EMF Report for 230 KV – 1 CKT Delta Lapwing 1590 MCM 45/7



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	96.59
	Magnetic Field at 50 ft in mG	57.38
Electric Field	Electric Field at the center line in kV/m	0.83
	Electric Field at 50 ft in kV/m	0.61
Audible Noise	L50 Fair at CL in dB(A)	19.4
	L50 Rain at CL in dB(A)	44.3
	Leq(24) at CL in dB(A)	29.7
	Ldn at CL in dB(A)	37.6
	L50 Fair at 50 ft in dB(A)	18.3
	L50 Rain at 50 ft in dB(A)	43.2
	Leq(24) at 50 ft in dB(A)	28.7
	Ldn at 50 ft in dB(A)	36.5





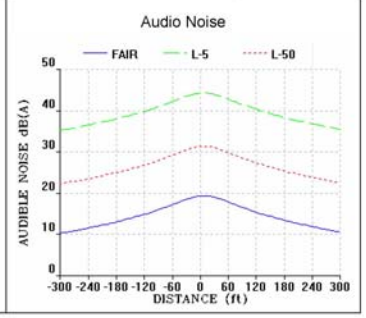
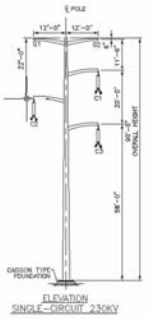
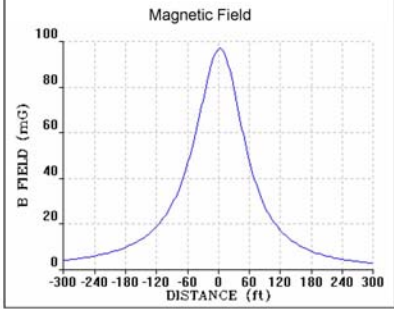


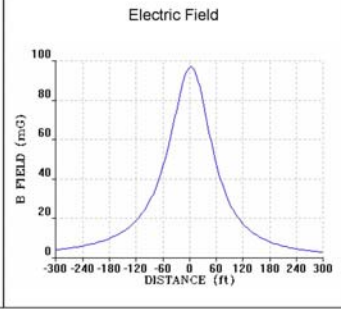
Figure 4.6-10 Electric and Magnetic Field and Noise Values-230kV Delta HVTL (Drake)

EMF Report for 230 KV – 1 CKT Delta Bundle (• •) Drake 795 MCM 26/7



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	96.59
	Magnetic Field at 50 ft in mG	57.38
Electric Field	Electric Field at the center line in kV/m	1.11
	Electric Field at 50 ft in kV/m	0.80
Audible Noise	L50 Fair at CL in dB(A)	8.8
	L50 Rain at CL in dB(A)	36.9
	Leq(24) at CL in dB(A)	20.1
	Ldn at CL in dB(A)	28.0
	L50 Fair at 50 ft in dB(A)	7.8
	L50 Rain at 50 ft in dB(A)	35.9
	Leq(24) at 50 ft in dB(A)	19.1
	Ldn at 50 ft in dB(A)	26.9





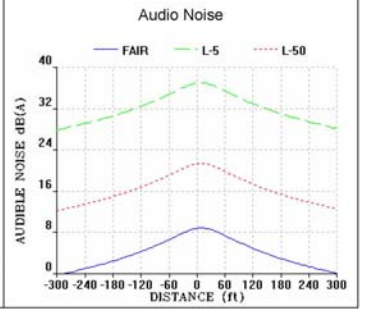
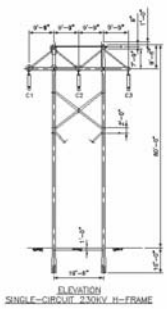


Figure 4.6-11 Electric and Magnetic Field and Noise Values-230kV H-Frame HVTL (Lapwing)

EMF Report for 230 KV – 1 CKT H-Frame Lapwing 1590 MCM 45/7



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	129.88
	Magnetic Field at 50 ft in mG	74.27
Electric Field	Electric Field at the center line in kV/m	0.18
	Electric Field at 50 ft in kV/m	0.89
Audible Noise	L50 Fair at CL in dB(A)	21.0
	L50 Rain at CL in dB(A)	45.3
	Leq(24) at CL in dB(A)	31.1
	Ldn at CL in dB(A)	38.9
	L50 Fair at 50 ft in dB(A)	19.4
	L50 Rain at 50 ft in dB(A)	43.7
	Leq(24) at 50 ft in dB(A)	29.5
	Ldn at 50 ft in dB(A)	37.3

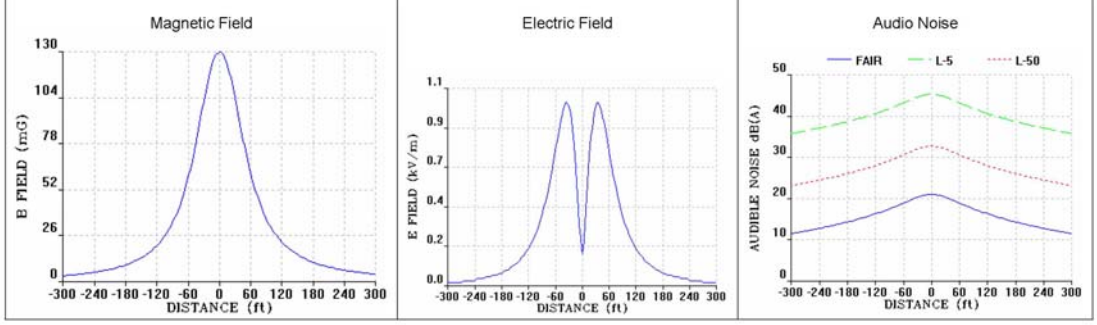
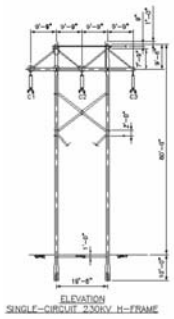
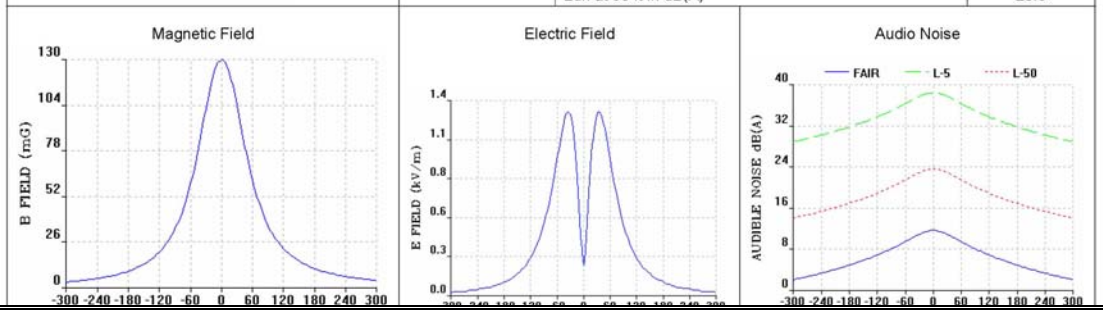


Figure 4.6-12 Electric and Magnetic Field and Noise Values-230kV H-Frame HVTL (Drake)

EMF Report for 230 KV – 1 CKT H-Frame Bundle (• •) Drake 795 MCM 26/7



Electromagnetic Field & Audible noise values		
Magnetic Field	Magnetic Field at the center line in mG	129.88
	Magnetic Field at 50 ft in mG	74.27
Electric Field	Electric Field at the center line in kV/m	0.21
	Electric Field at 50 ft in kV/m	1.16
Audible Noise	L50 Fair at CL in dB(A)	11.7
	L50 Rain at CL in dB(A)	38.4
	Leq(24) at CL in dB(A)	22.3
	Ldn at CL in dB(A)	30.2
	L50 Fair at 50 ft in dB(A)	10.0
	L50 Rain at 50 ft in dB(A)	36.8
	Leq(24) at 50 ft in dB(A)	20.6
	Ldn at 50 ft in dB(A)	28.5



4.7 TRANSMISSION LINE COST ESTIMATES

The estimated construction cost of the proposed transmission lines are presented in Table 2.8. These costs include material, labor and equipment, engineering, taxes, inspection and miscellaneous items. Presumed ROW acquisition costs are included. Costs associated with necessary system upgrades identified in the MISO process are included in the analysis.