APPENDIX C

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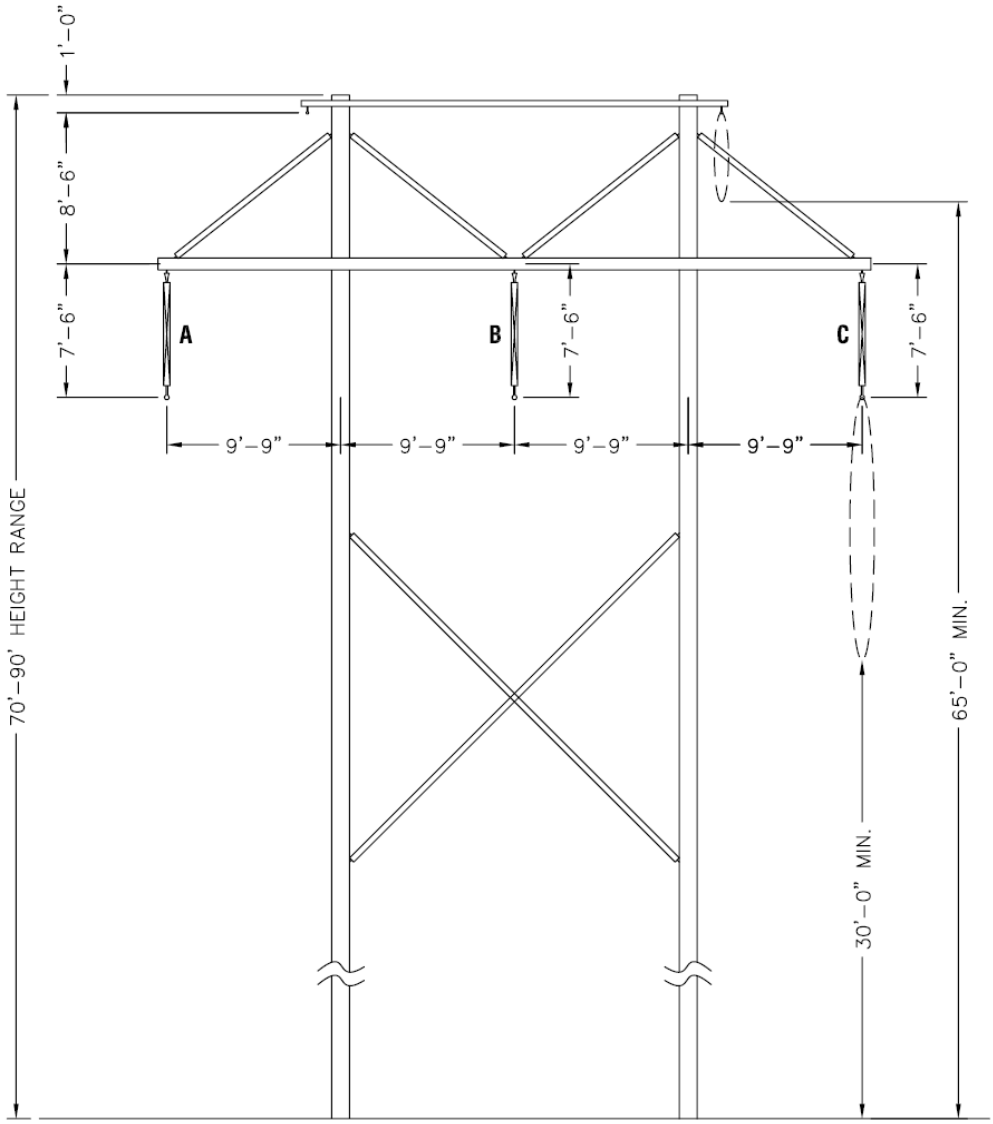
Potential Structure Types and Configurations for the Bemidji-Grand Rapids Line

The following pages are illustrations of the structure types and configurations currently being considered for the Bemidji-Grand Rapids Line.

230kV H–Frame

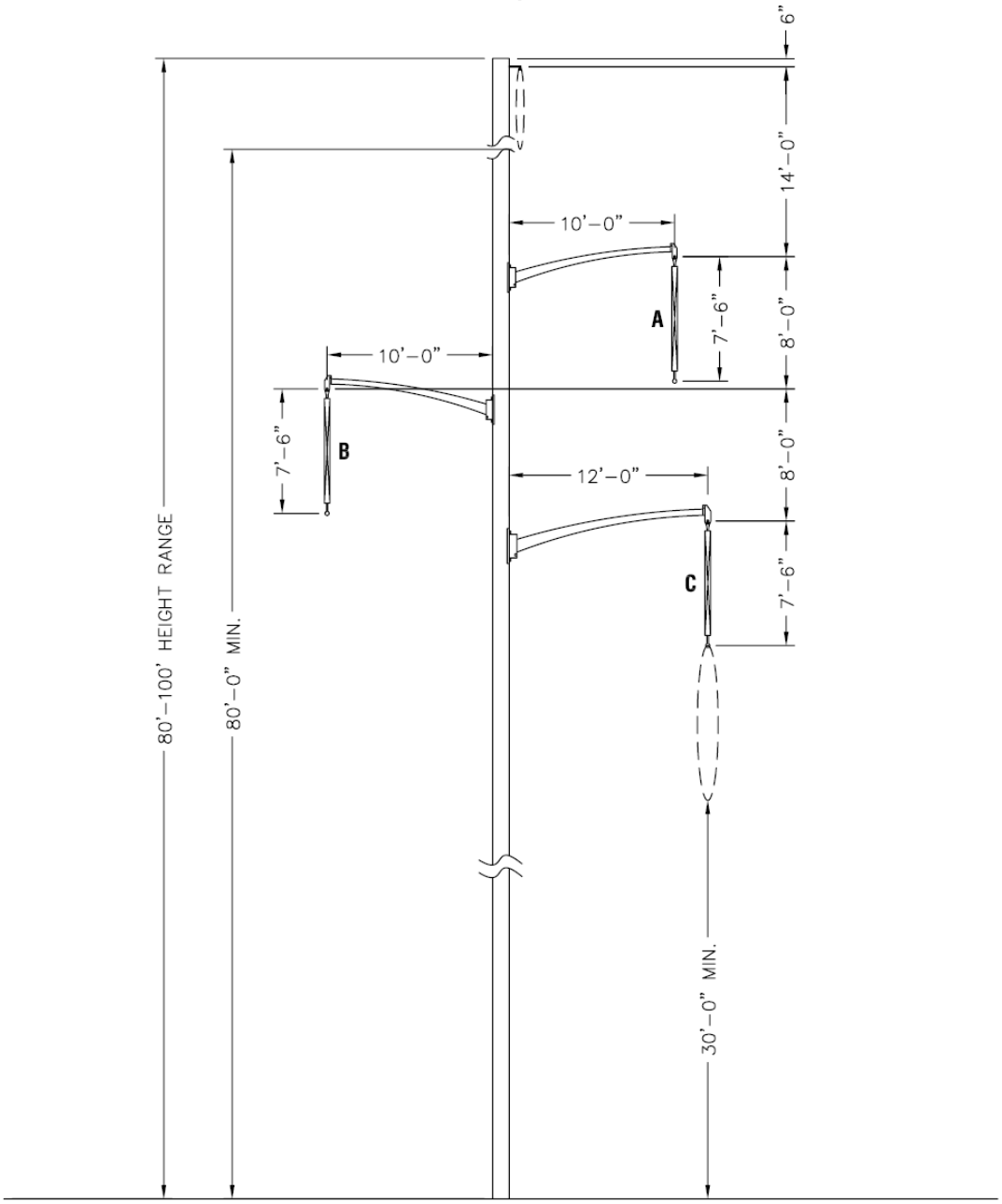


At Conductor Thermal Limit

Current (amps) = 1180
Conductor = 954 ACSR

BEMIDJI–BOSWELL
230KV H–FRAME

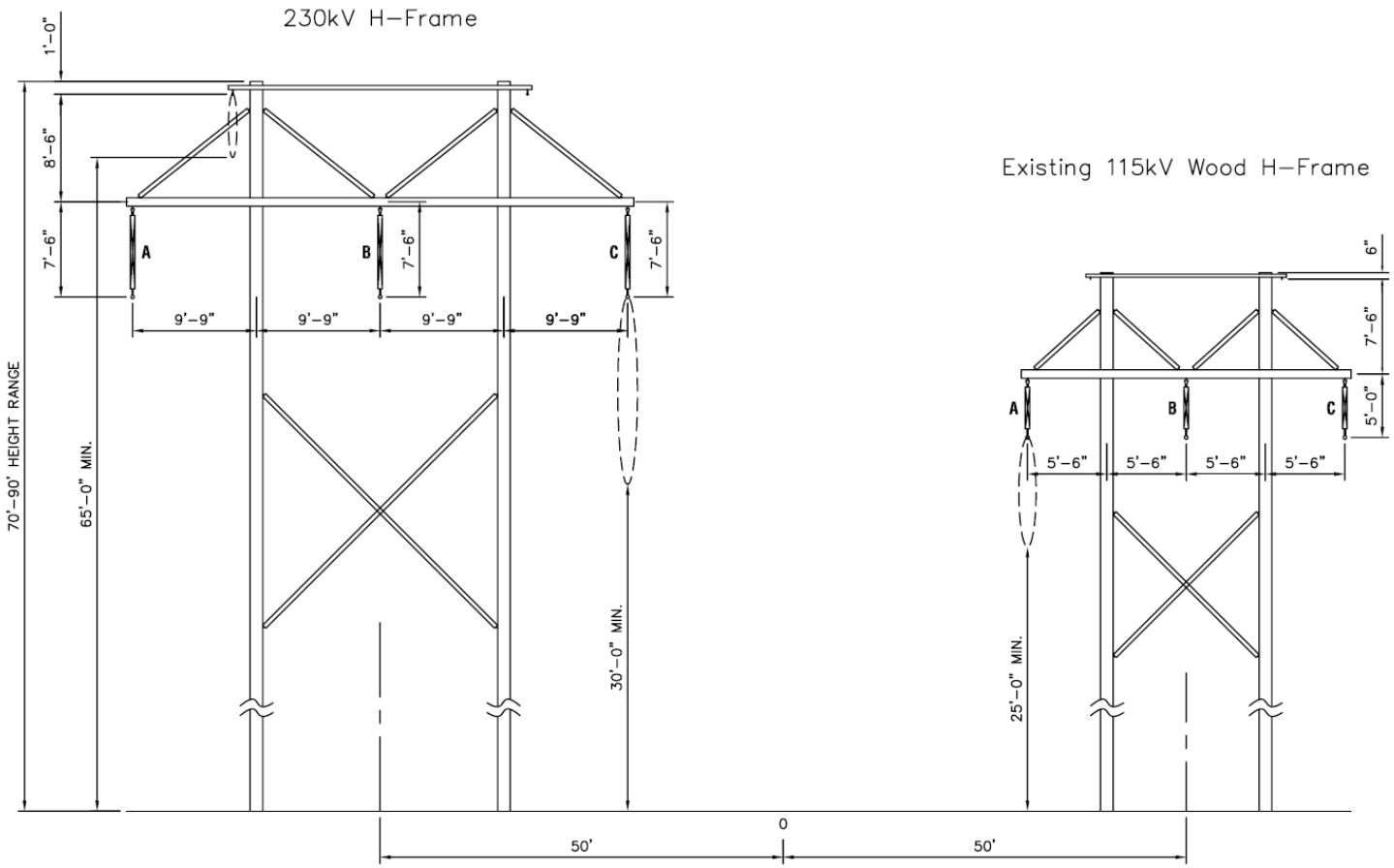
230kV Single Pole



At Conductor Thermal Limit

Current (amps) = 1080
Conductor = 954 ACSR

BEMIDJI-BOSWELL
230KV SINGLE POLE



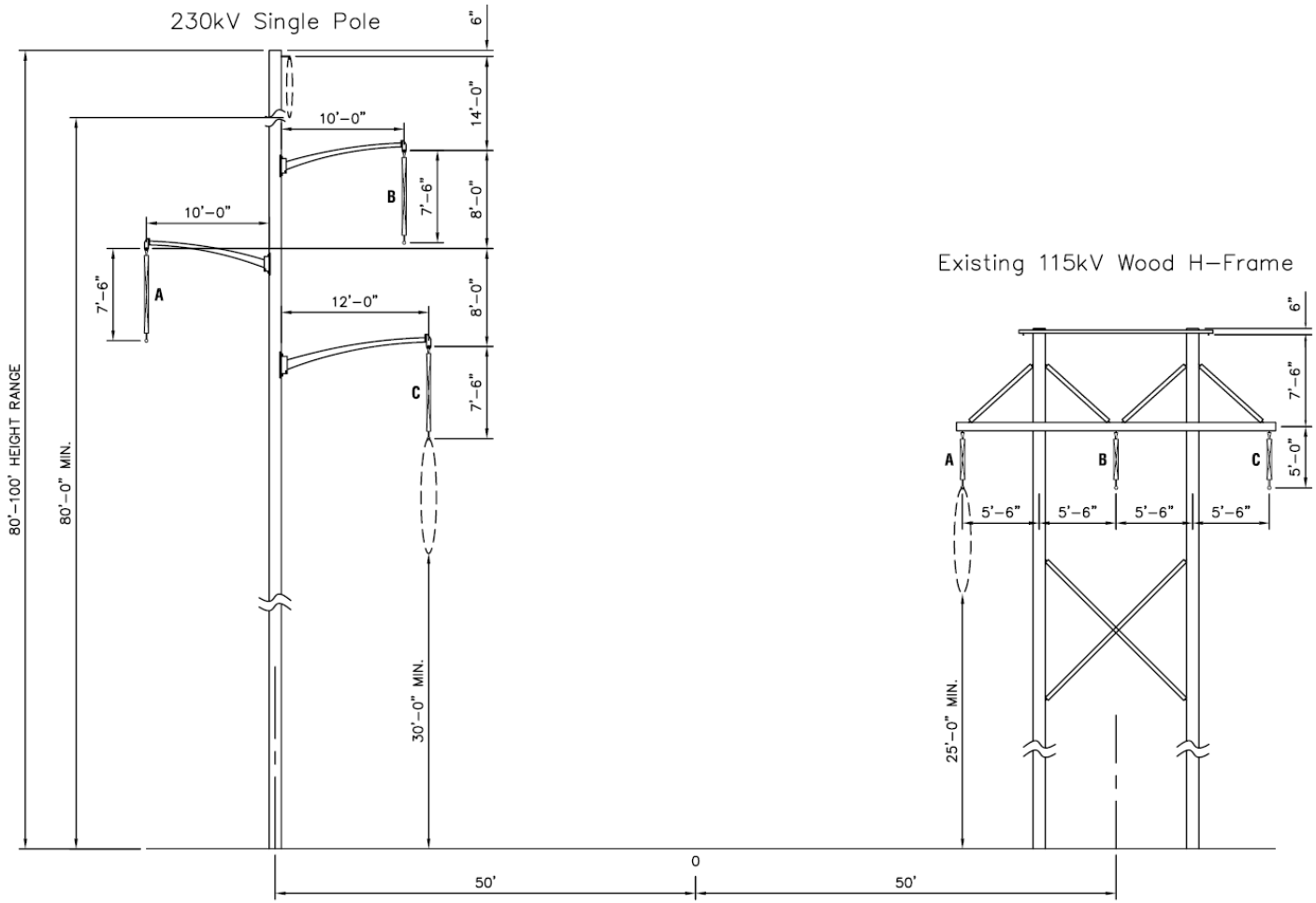
230kV At Conductor Thermal Limit

Current (amps) = 1080
Conductor = 954 ACSR

115kV At Conductor Thermal Limit

Current (amps) = 614
Conductor = 336 ACSR

BEMIDJI-BOSWELL
230KV AND 115KV H-FRAME



230kV At Conductor Thermal Limit

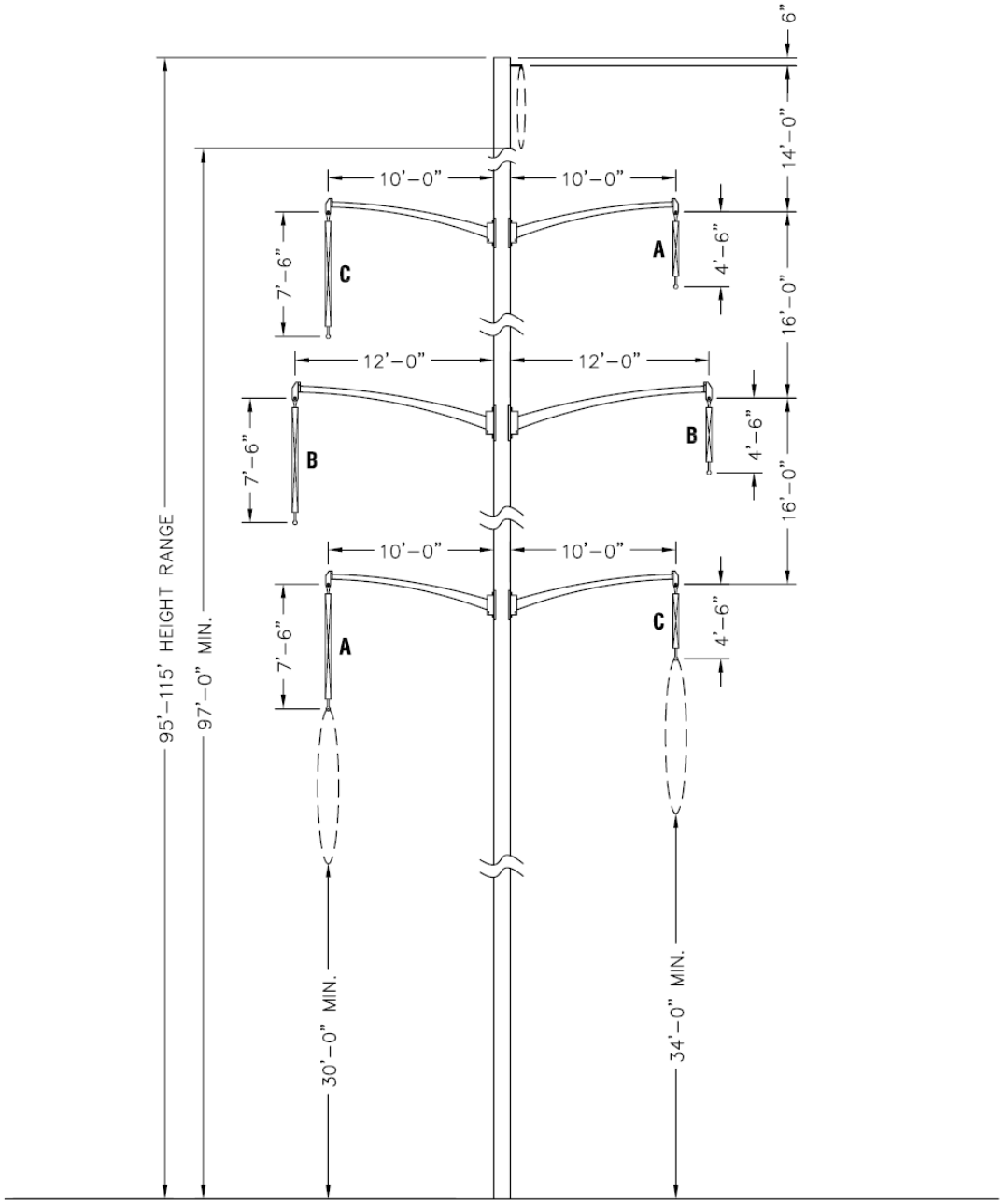
Current (amps) = 1080
Conductor = 954 ACSR

115kV At Conductor Thermal Limit

Current (amps) = 614
Conductor = 336 ACSR

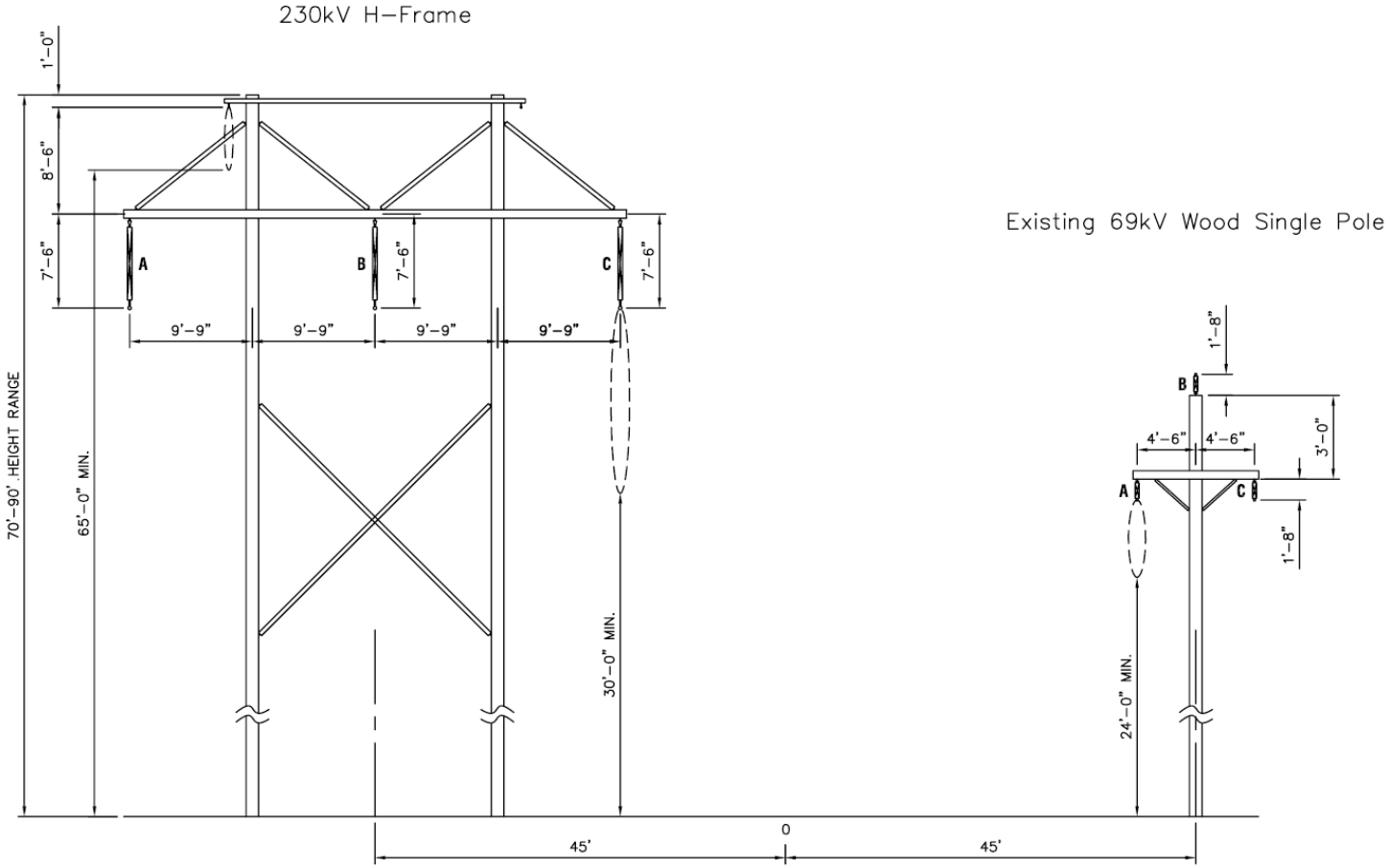
BEMIDJI–BOSWELL
230KV SINGLE POLE AND 115KV H–FRAME

230/115kV Single Pole Double Circuit



230kV At Conductor Thermal Limit	115kV At Conductor Thermal Limit
Current (amps) = 1080	Current (amps) = 915
Conductor = 954 ACSR	Conductor = 636 ACSR

BEMIDJI–BOSWELL
230/115KV SINGLE POLE DOUBLE CIRCUIT



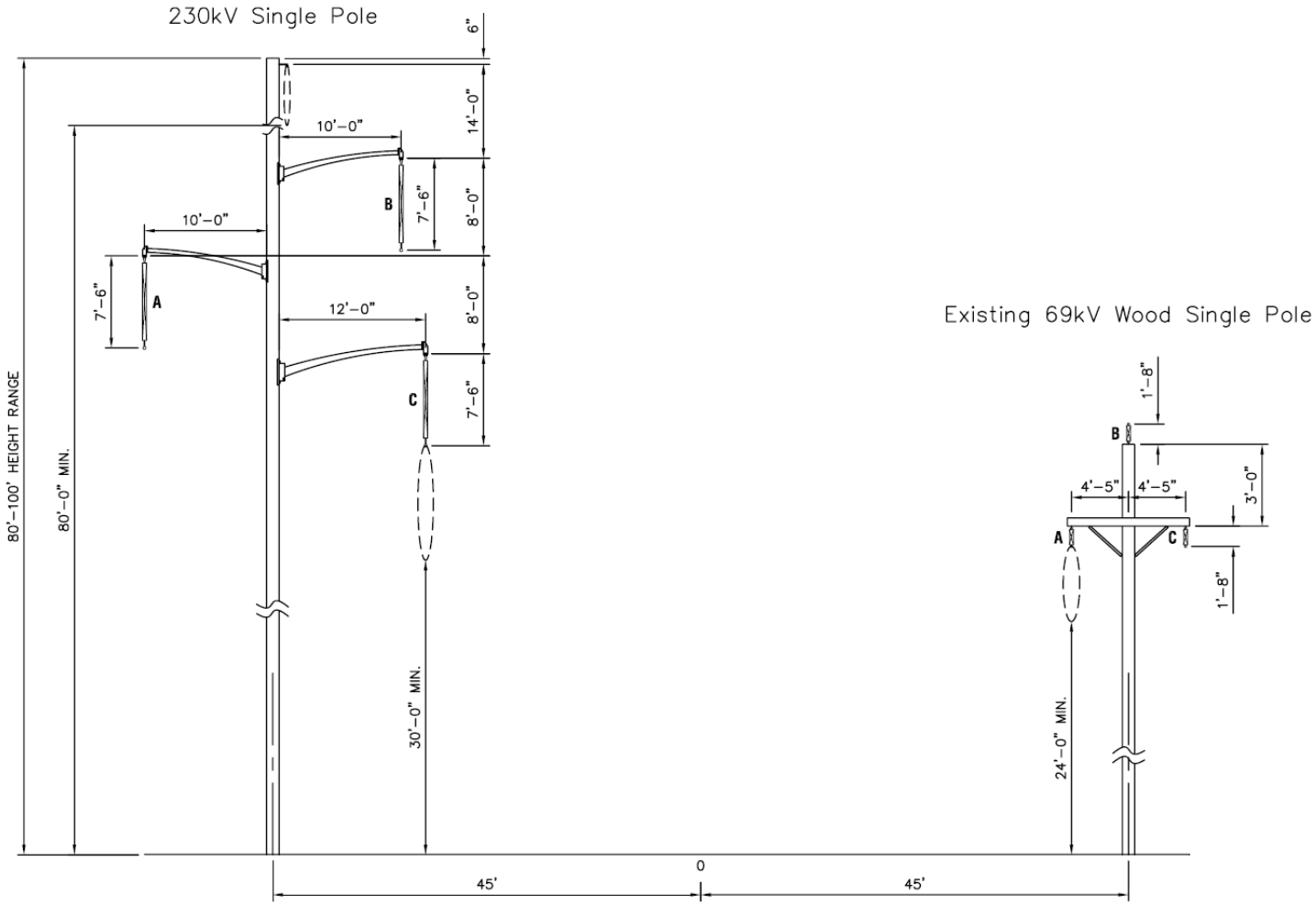
230kV At Conductor Thermal Limit

Current (amps) = 1080
Conductor = 954 ACSR

69kV At Conductor Thermal Limit

Current (amps) = 232
Conductor = 2/0 ACSR

BEMIDJI-BOSWELL
230KV H-FRAME/69KV SINGLE POLE



230kV At Conductor Thermal Limit

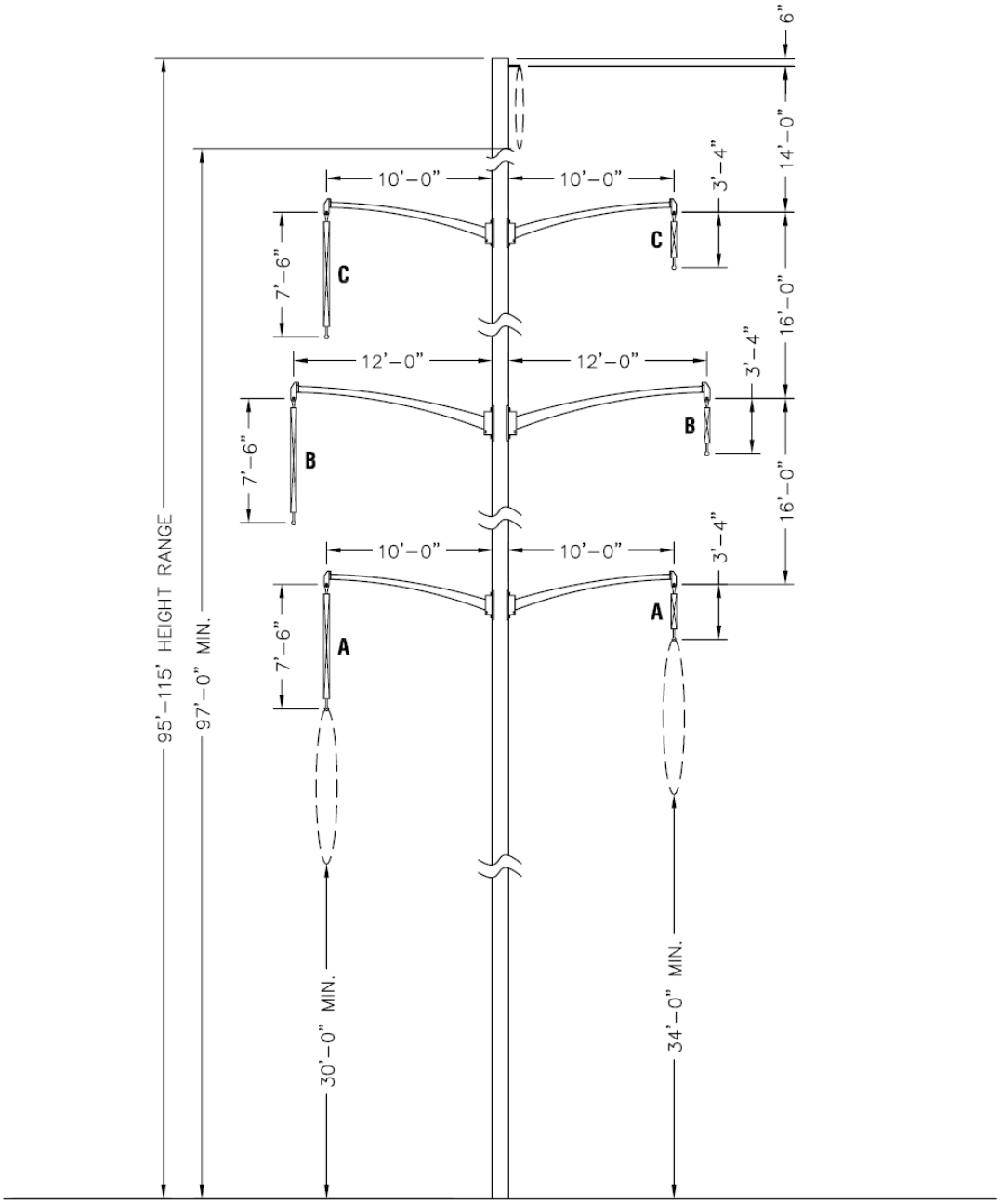
Current (amps) = 1080
Conductor = 954 ACSR

BEMIDJI–BOSWELL
230KV SINGLE POLE/69KV SINGLE POLE

69kV At Conductor Thermal Limit

Current (amps) = 232
Conductor = 2/0 ACSR

230/69kV Single Pole Double Circuit



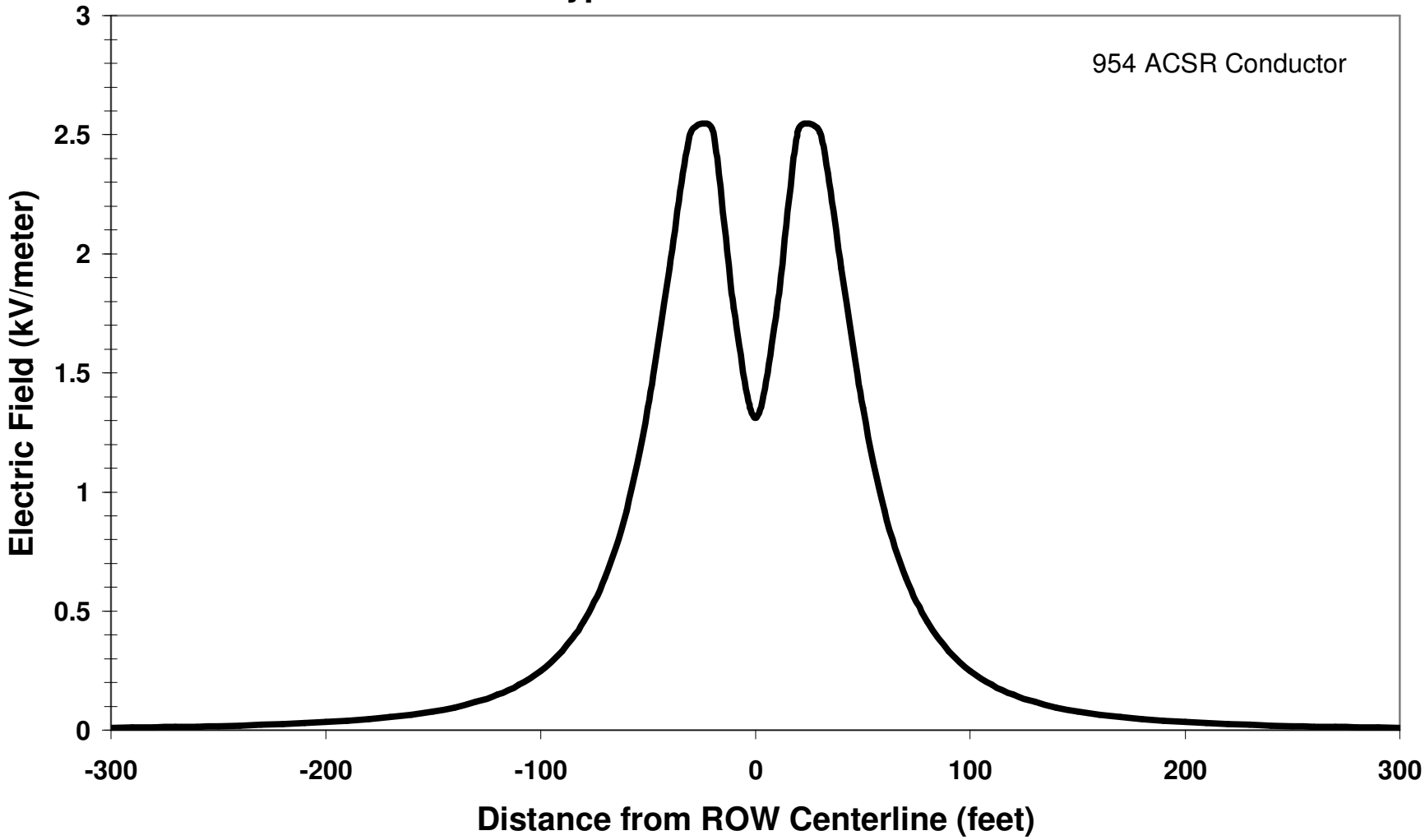
230kV At Conductor Thermal Limit	69kV At Conductor Thermal Limit
Current (amps) = 1080	Current (amps) = 614
Conductor = 954 ACSR	Conductor = 336 ACSR

BEMIDJI–BOSWELL
230/69KV SINGLE POLE DOUBLE CIRCUIT

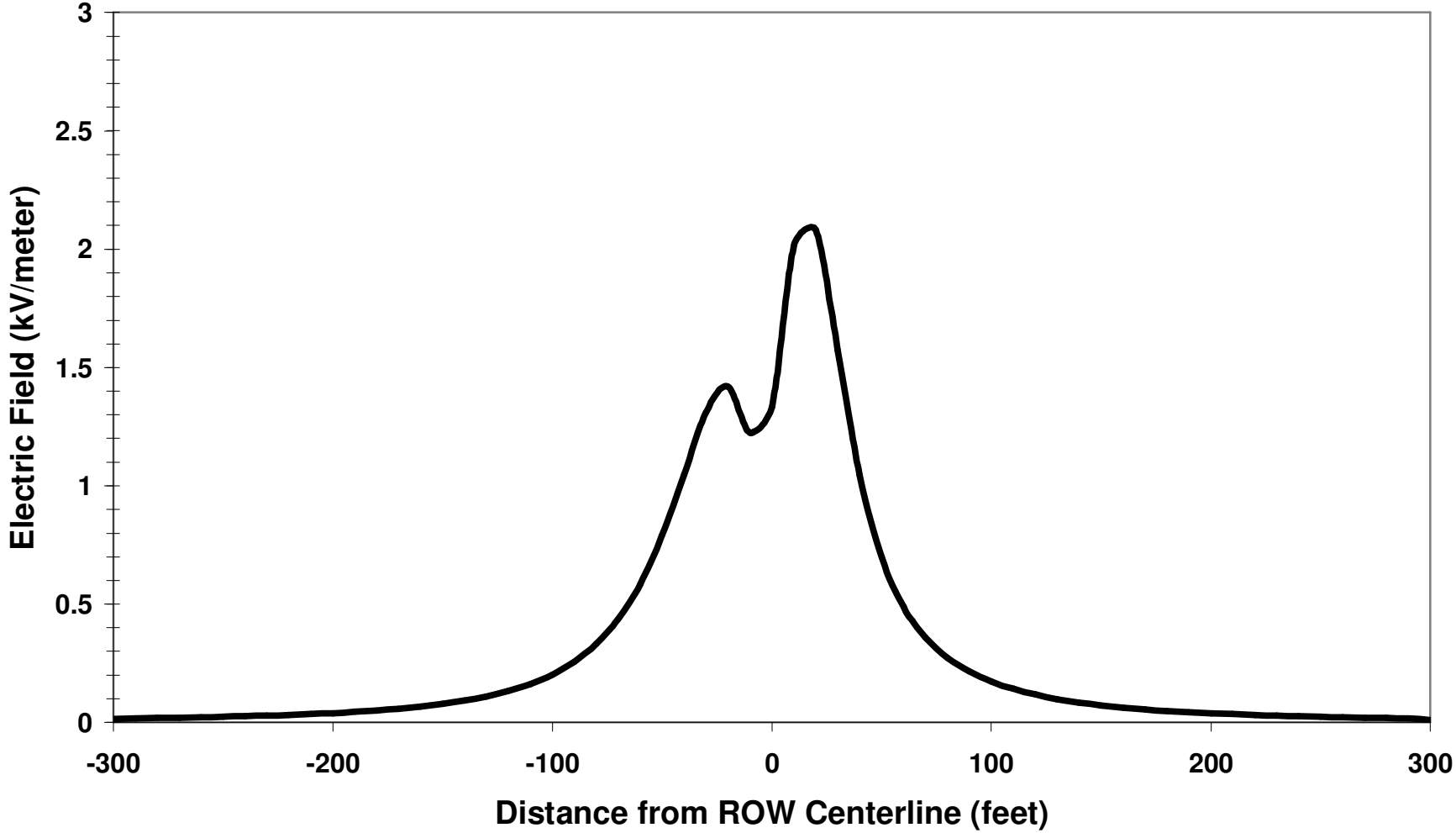
Electric Fields of Potential Structure Types and Configurations

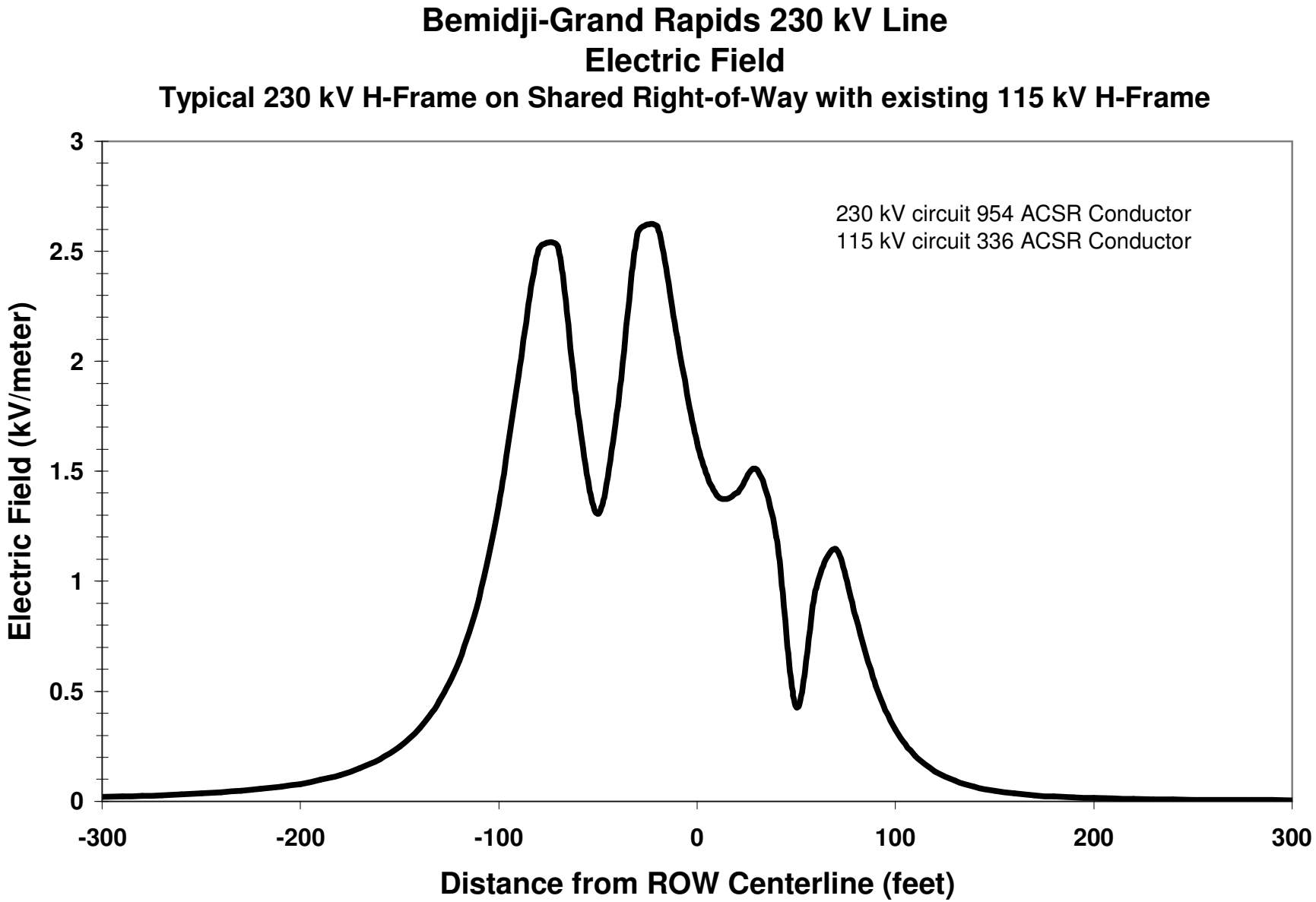
The electric fields associated with the structure types and configurations currently being considered for the Bemidji-Grand Rapids Line are shown in the following graphs. Illustrations of the structure types and configurations showing the phase arrangement and nominal operating voltage are in Appendix C1 As the graphs show, the maximum electric field for all structure types is well below the 8 kV/m limit that the EQB has imposed as an operating condition in permits for other high voltage transmission lines.

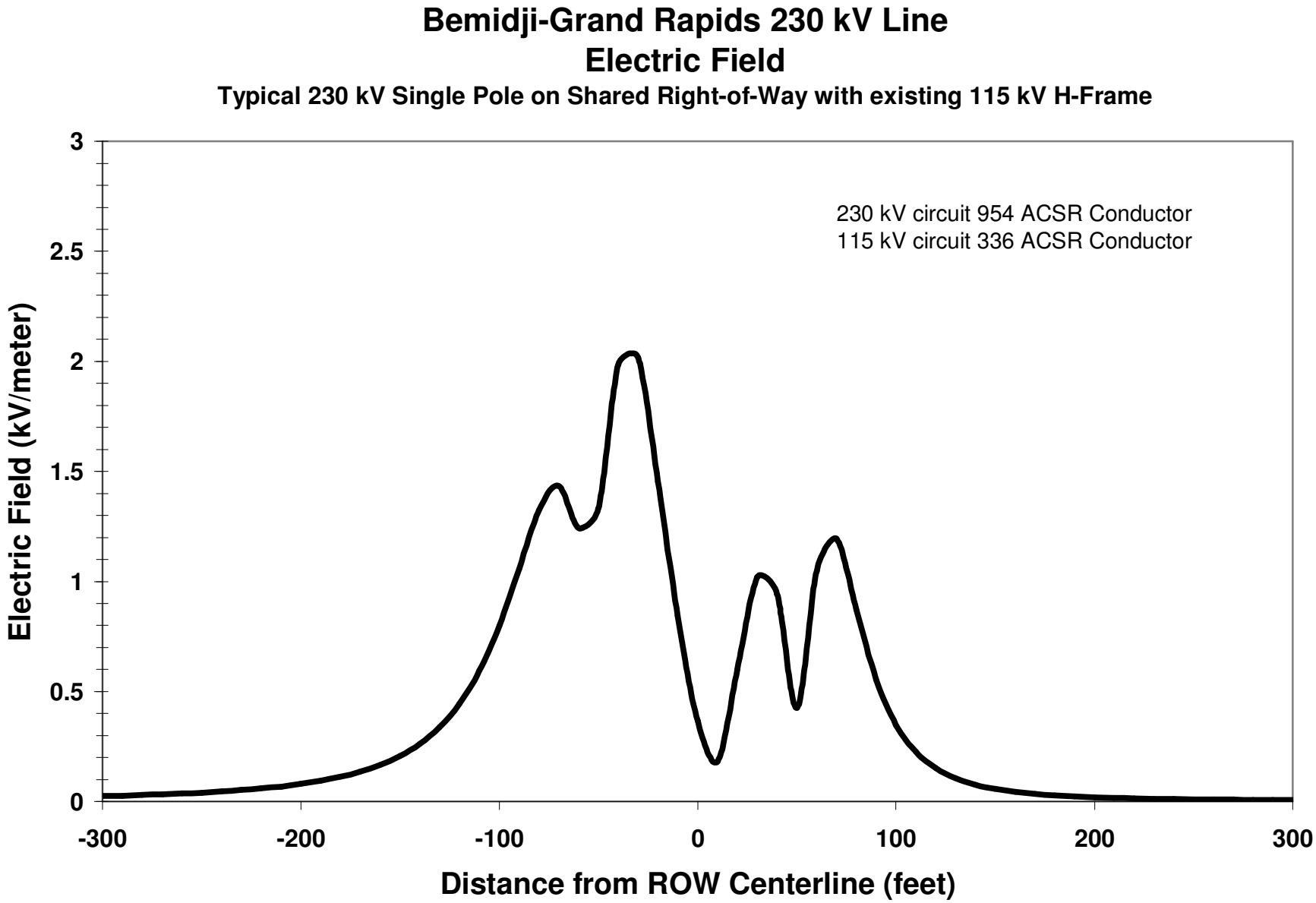
Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV H-Frame



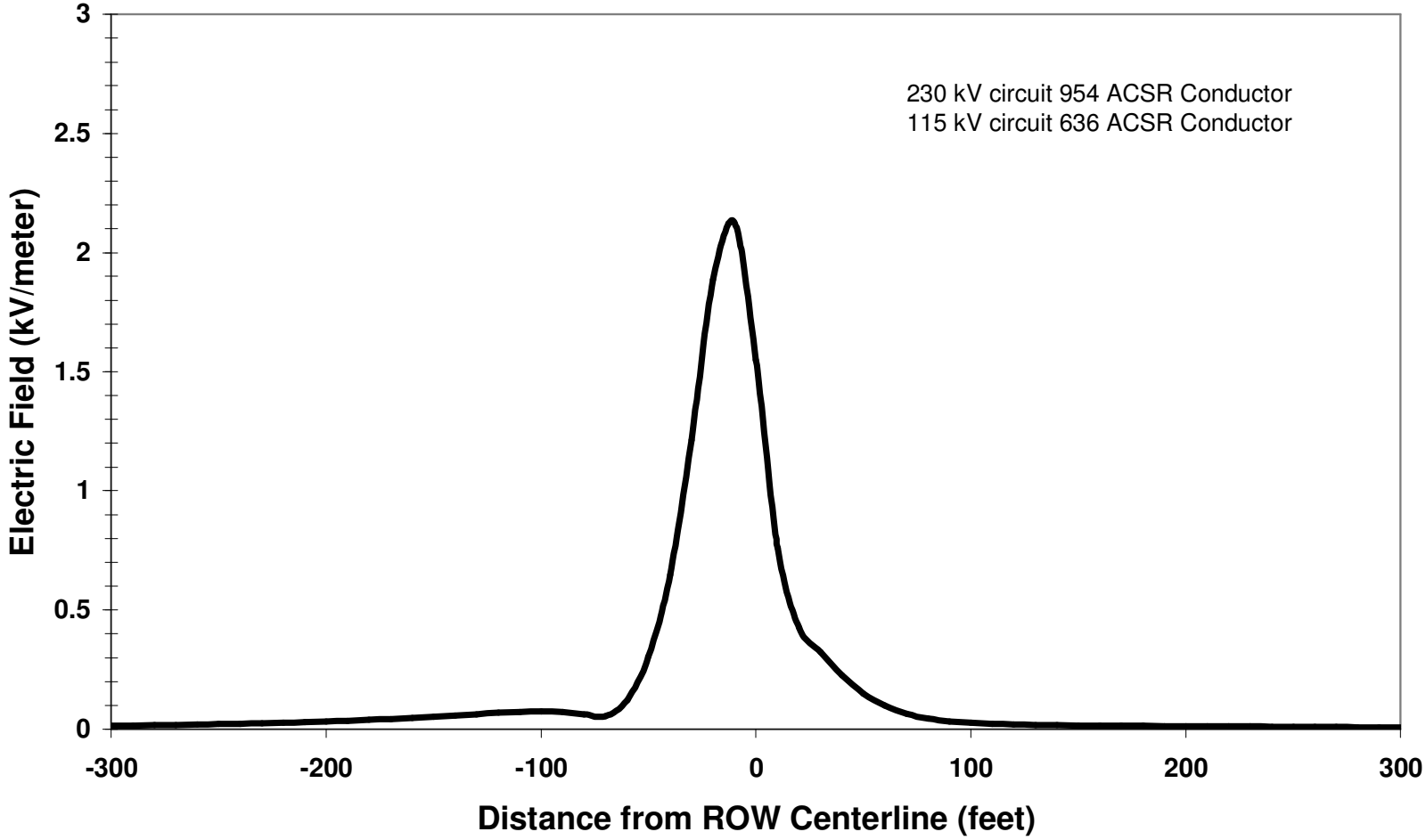
Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV Single Pole

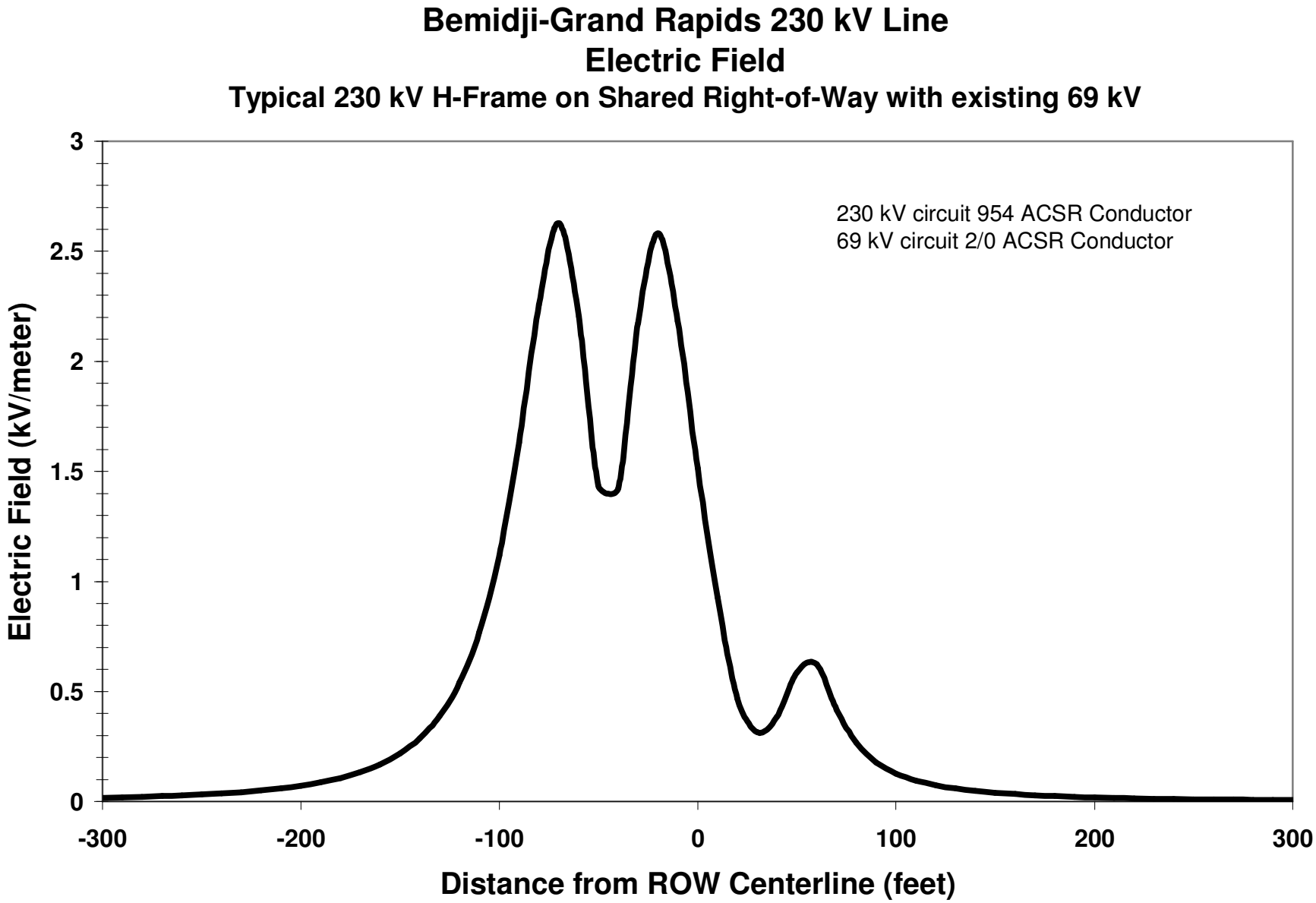


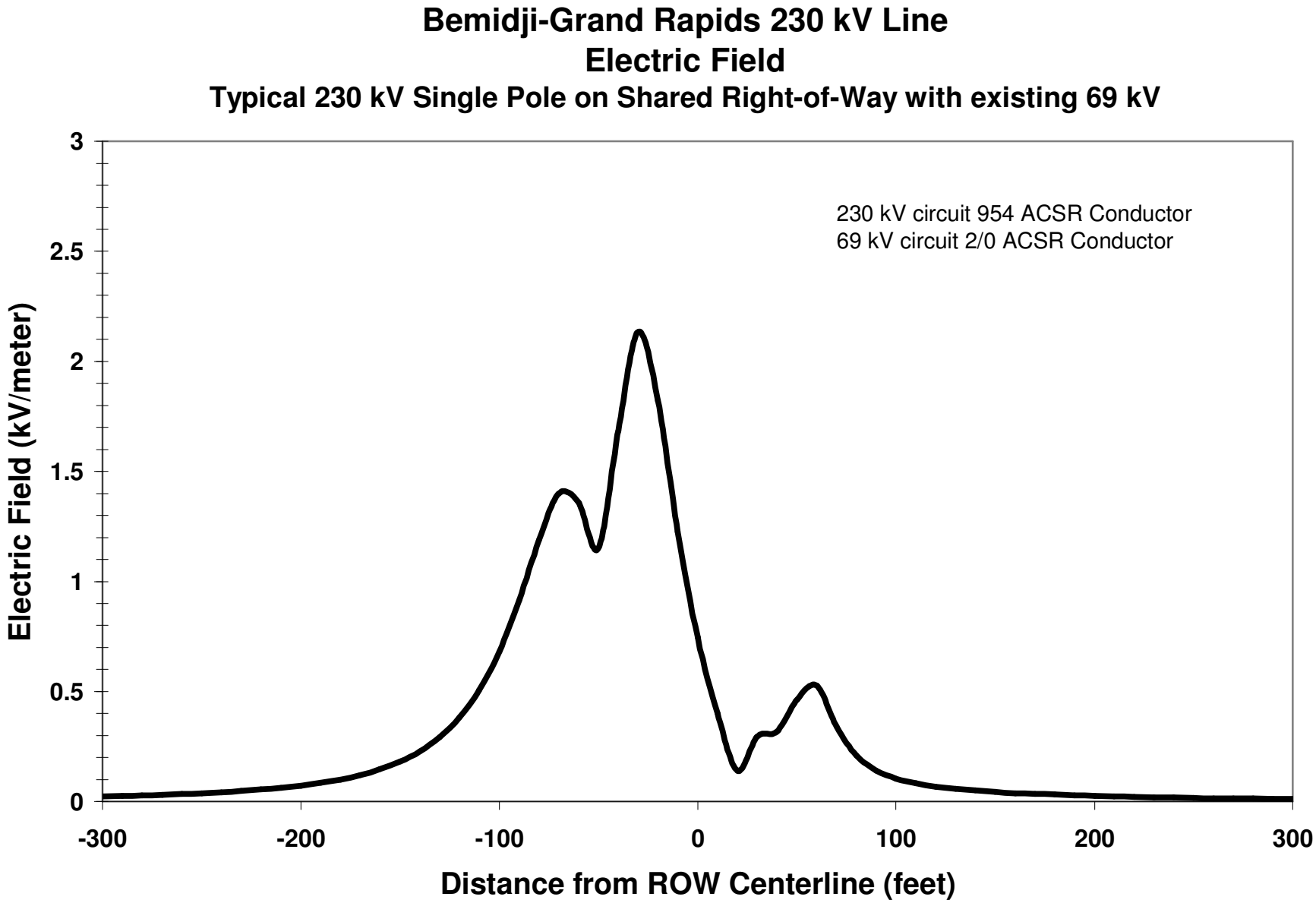

Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV H-Frame on Shared Right-of-Way with existing 115 kV H-Frame
230 kV circuit 954 ACSR Conductor
115 kV circuit 336 ACSR Conductor
Electric Field (kV/meter)
3
2.5
2
1.5
1
0.5
0
-300
-200
-100
0
100
200
300
Distance from ROW Centerline (feet)


Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV Single Pole on Shared Right-of-Way with existing 115 kV H-Frame
230 kV circuit 954 ACSR Conductor
115 kV circuit 336 ACSR Conductor
Electric Field (kV/meter)
3
2.5
2
1.5
1
0.5
0
-300
-200
-100
0
100
200
300
Distance from ROW Centerline (feet)

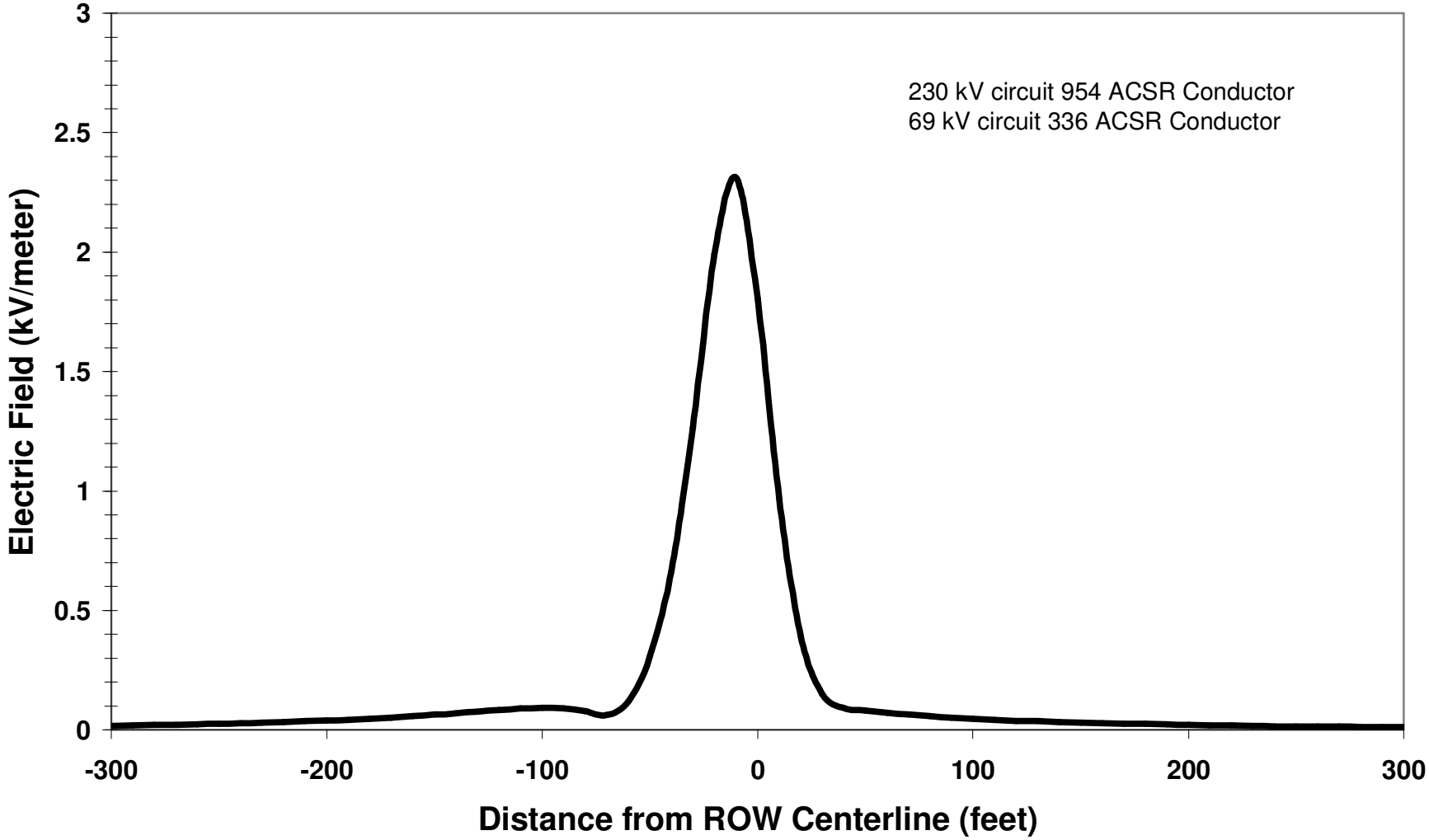
Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230/115 kV Single Pole Double Circuit




Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV H-Frame on Shared Right-of-Way with existing 69 kV
230 kV circuit 954 ACSR Conductor
69 kV circuit 2/0 ACSR Conductor
Electric Field (kV/meter)
3
2.5
2
1.5
1
0.5
0
-300
-200
-100
0
100
200
300
Distance from ROW Centerline (feet)


Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230 kV Single Pole on Shared Right-of-Way with existing 69 kV
230 kV circuit 954 ACSR Conductor
69 kV circuit 2/0 ACSR Conductor
Electric Field (kV/meter)
3
2.5
2
1.5
1
0.5
0
-300
-200
-100
0
100
200
300
Distance from ROW Centerline (feet)

Bemidji-Grand Rapids 230 kV Line
Electric Field
Typical 230/69 kV Single Pole Double Circuit

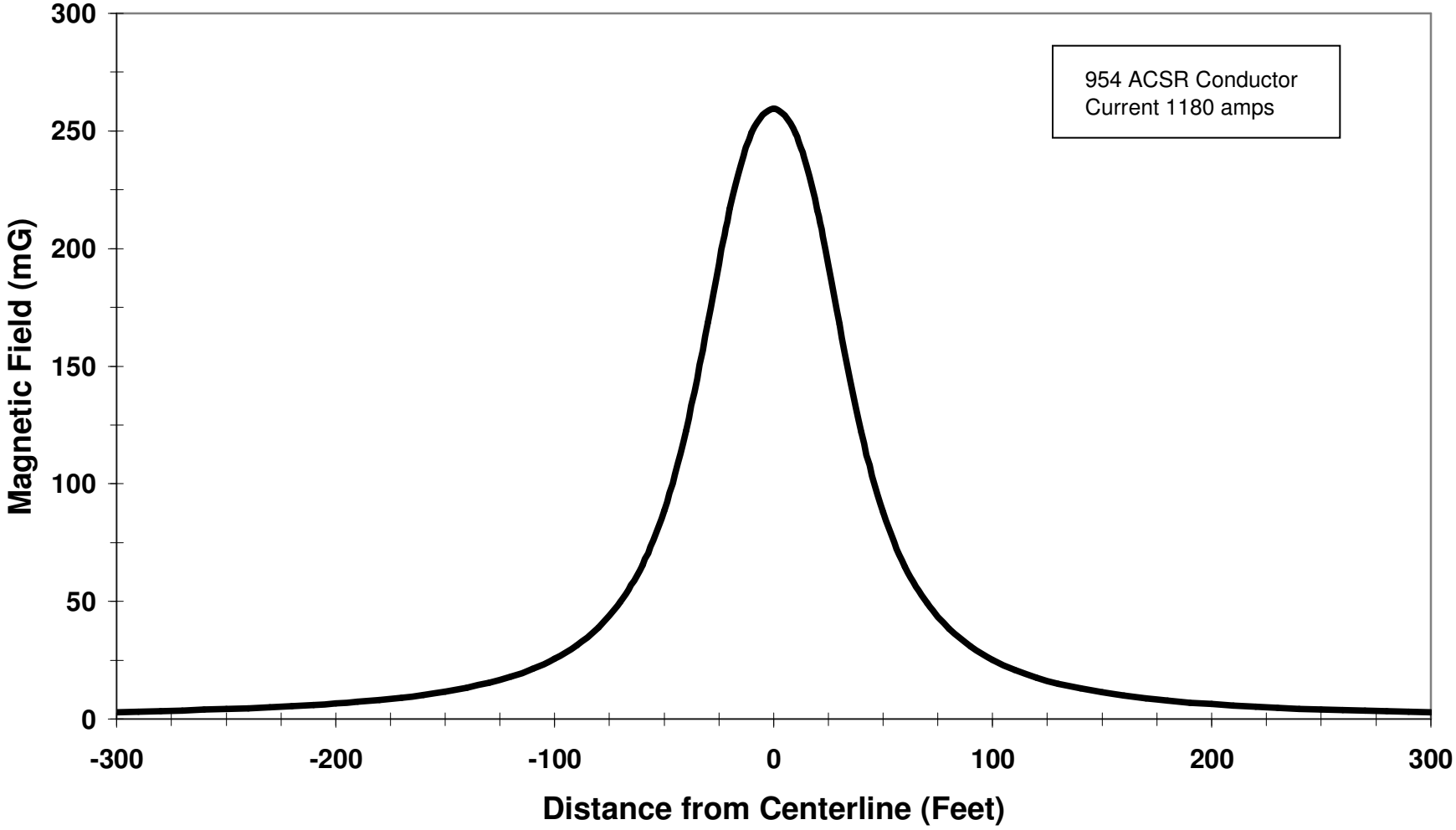


Magnetic Fields for Potential Structure Types and Configurations

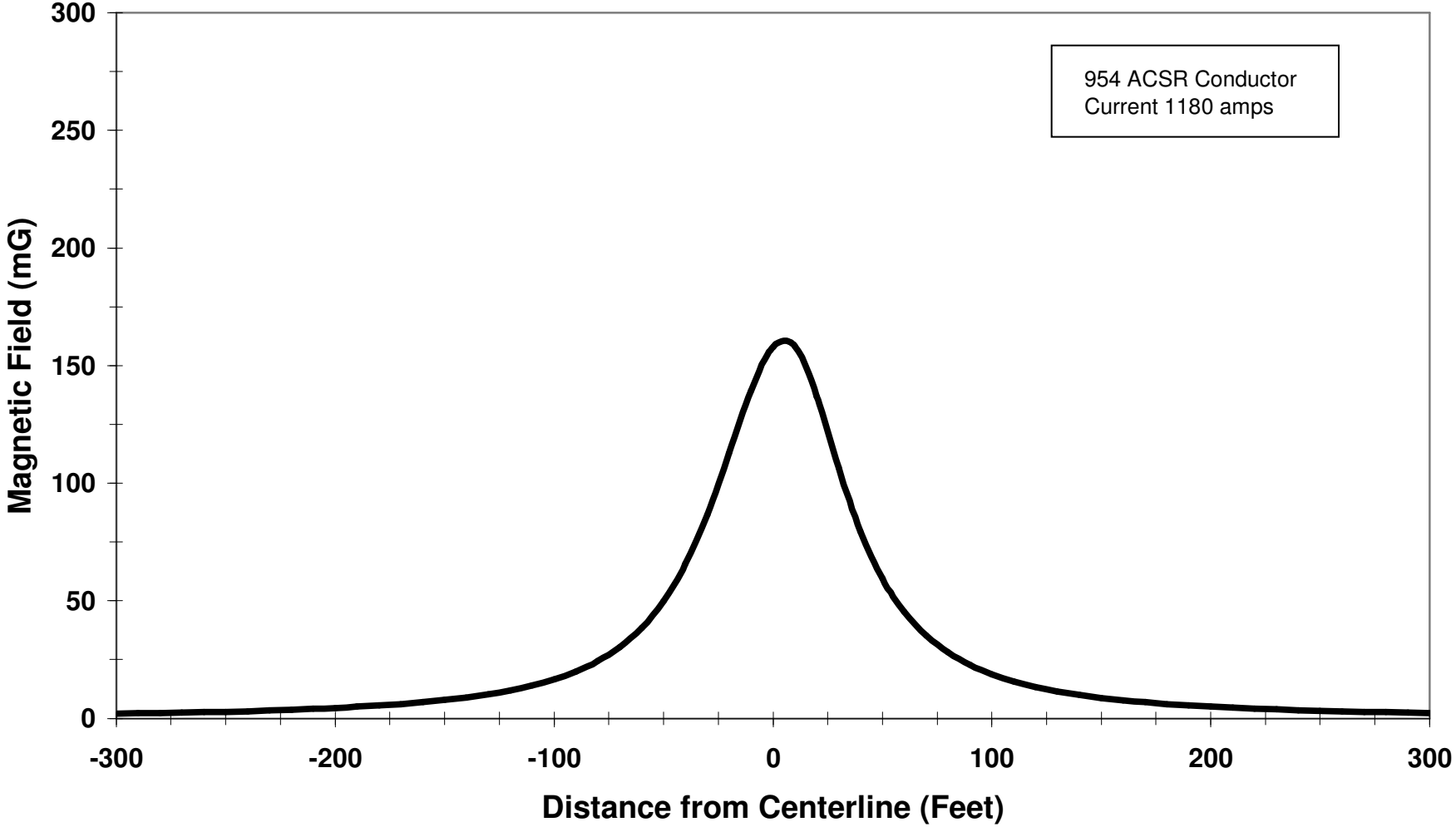
The magnetic fields associated with the structure types and configurations currently being considered for the Bemidji-Grand Rapids Line are shown in the following graphs. The current flow and phase arrangement used in the calculations is shown in the illustrations of the structure types and configurations in Appendix C1.

These magnetic fields were calculated with current flow at a conductor's maximum capacity (its thermal limit), and therefore the graphs represent the upper limit of the magnetic field associated with a structure type and configuration. Load flow analysis indicates that the actual peak current flow will be significantly less than the conductor's maximum capacity, and so the actual magnetic fields will be less than those shown in the graphs.

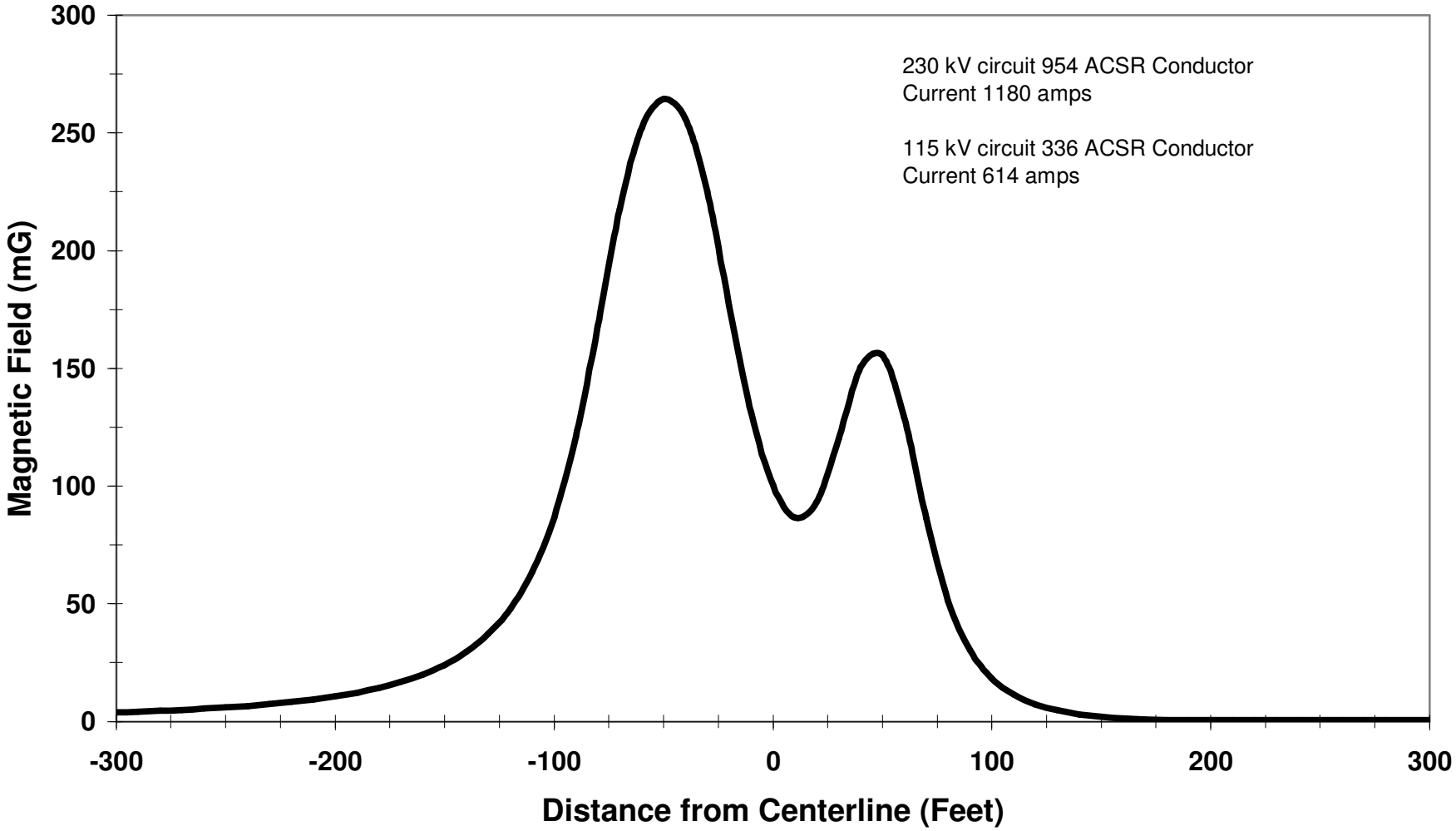
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230 kV H-Frame



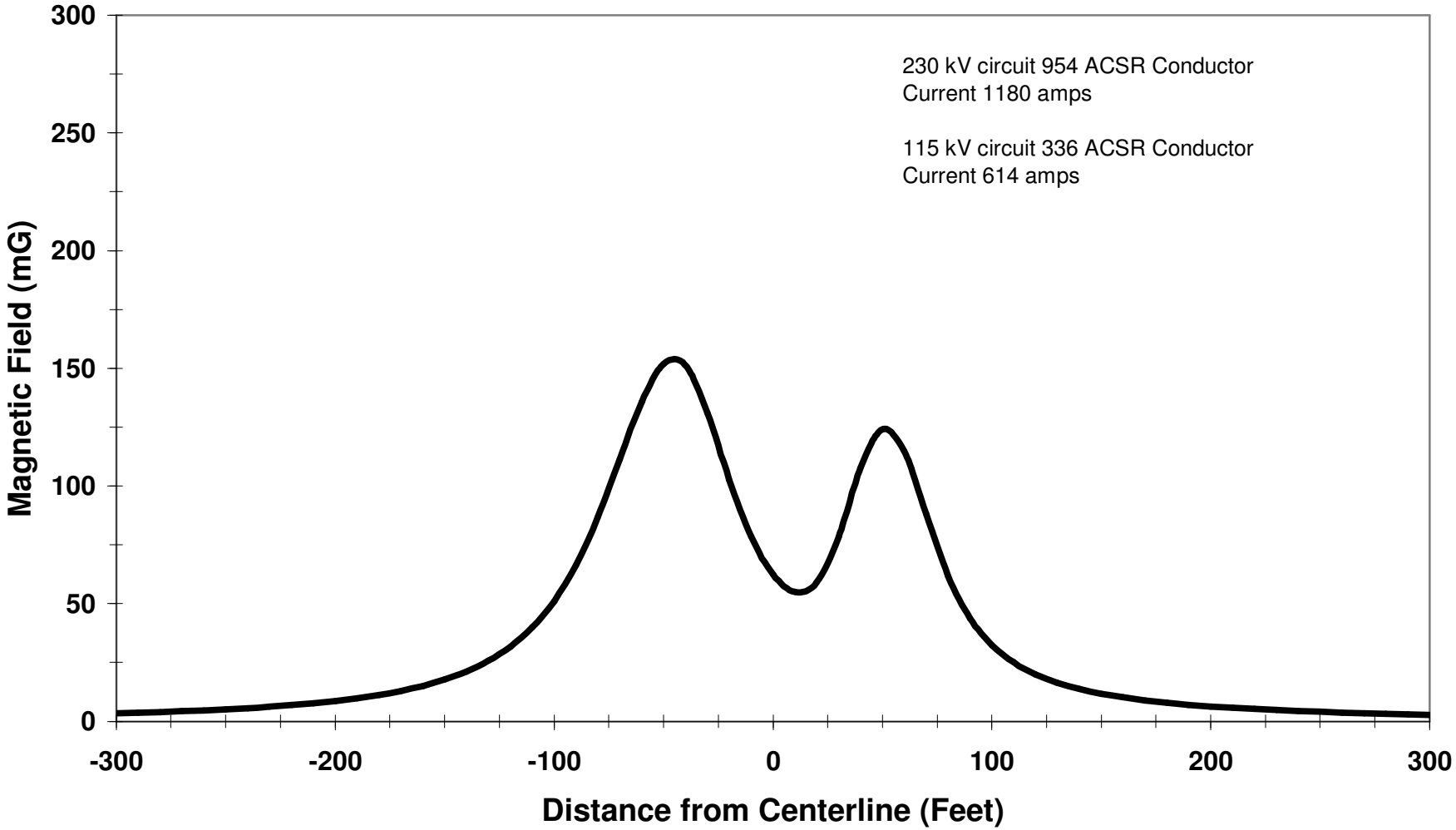
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230 kV Single Pole



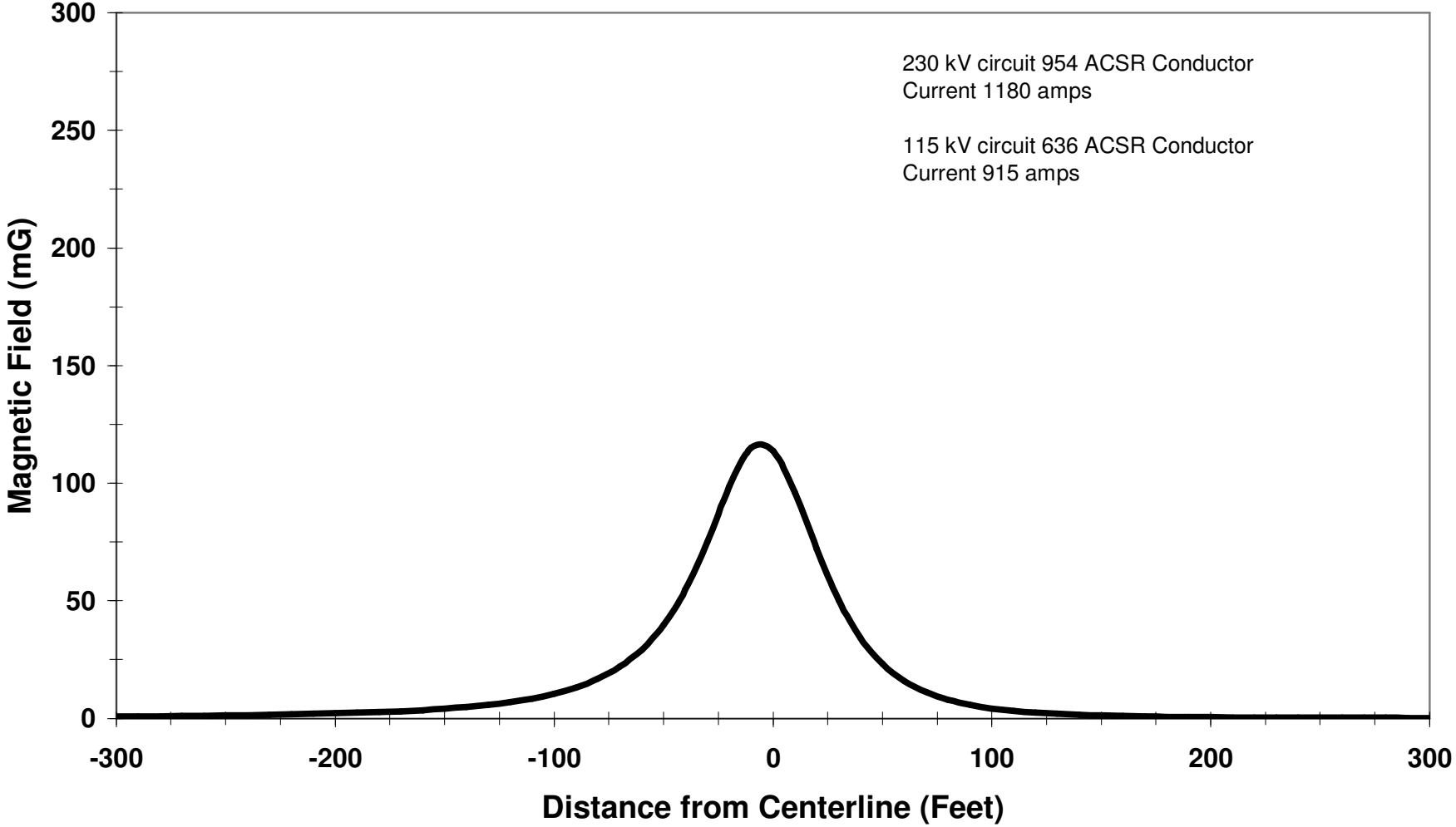
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230 kV H-Frame on Shared Right-of-Way with existing 115 kV H-Frame



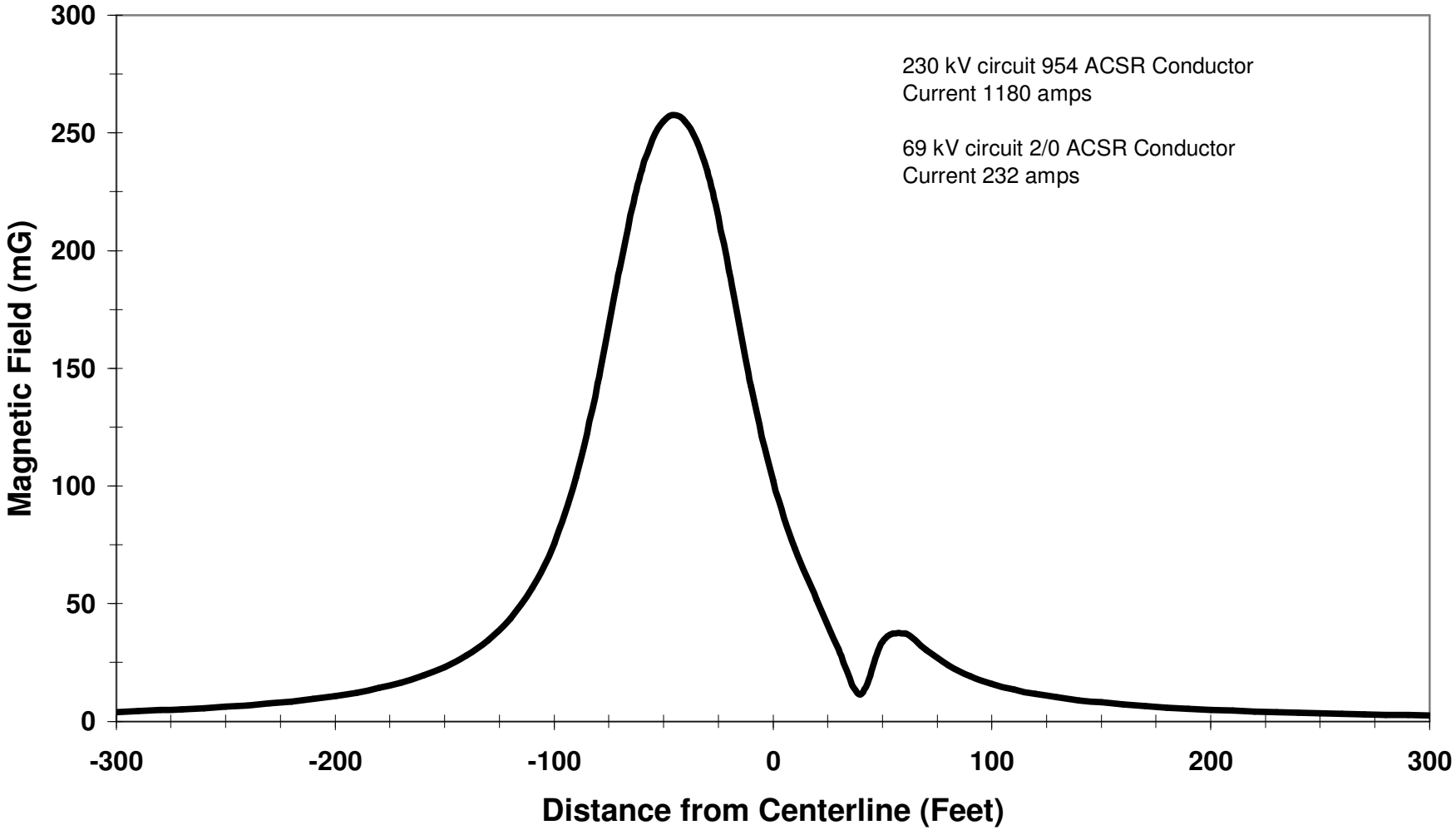
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230 kV Single Pole on Shared Right-of-Way with existing 115 kV H-Frame



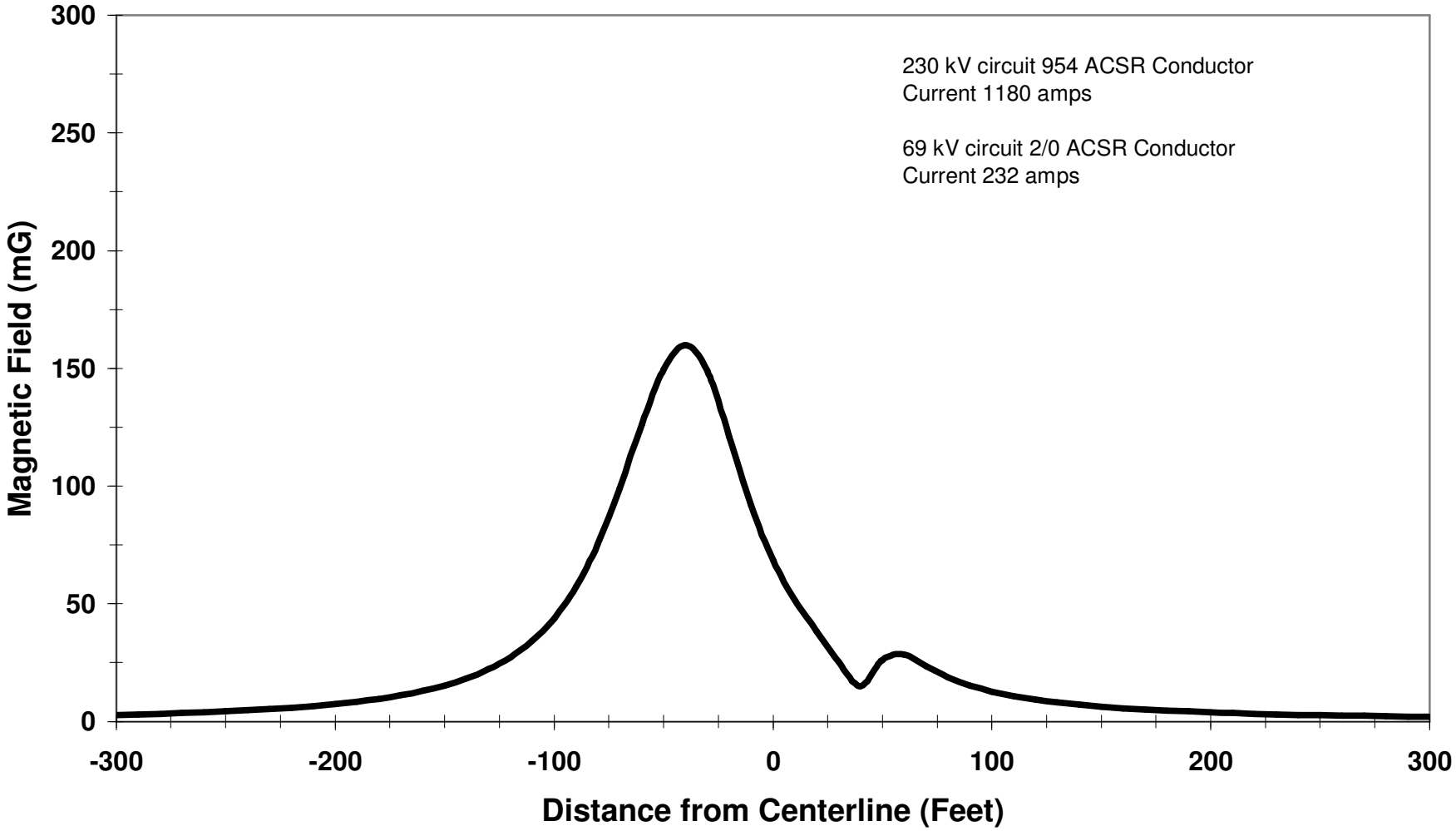
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230/115 kV Single Pole Double Circuit



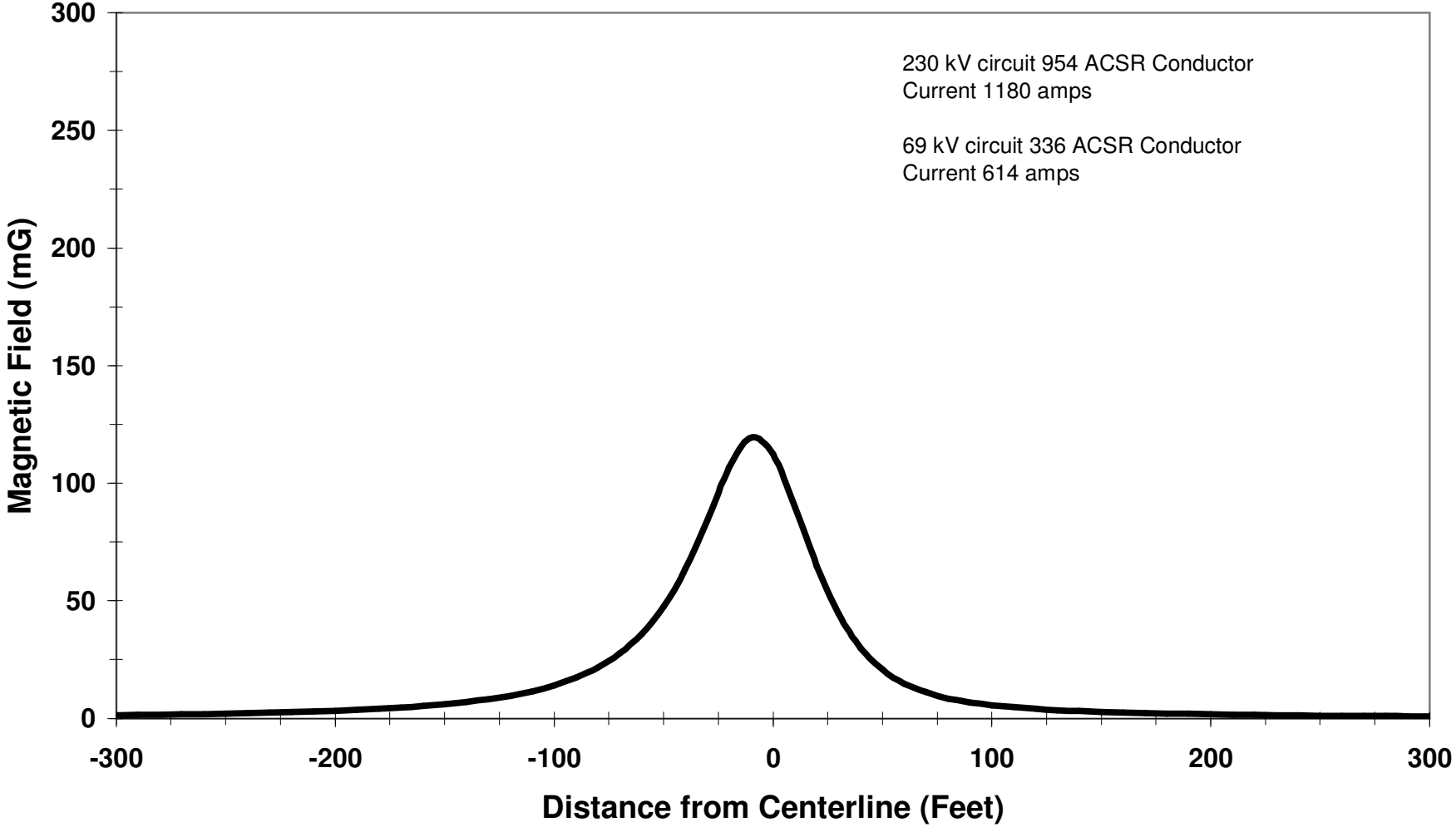
Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230kV H-Frame on Shared Right-of-Way with existing 69 kV



Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230kV Single Pole on Shared Right-of-Way with existing 69 kV



Bemidji-Grand Rapids 230 kV Line
Magnetic Field at Conductor Capacity
Typical 230/69 kV Single Pole Double Circuit

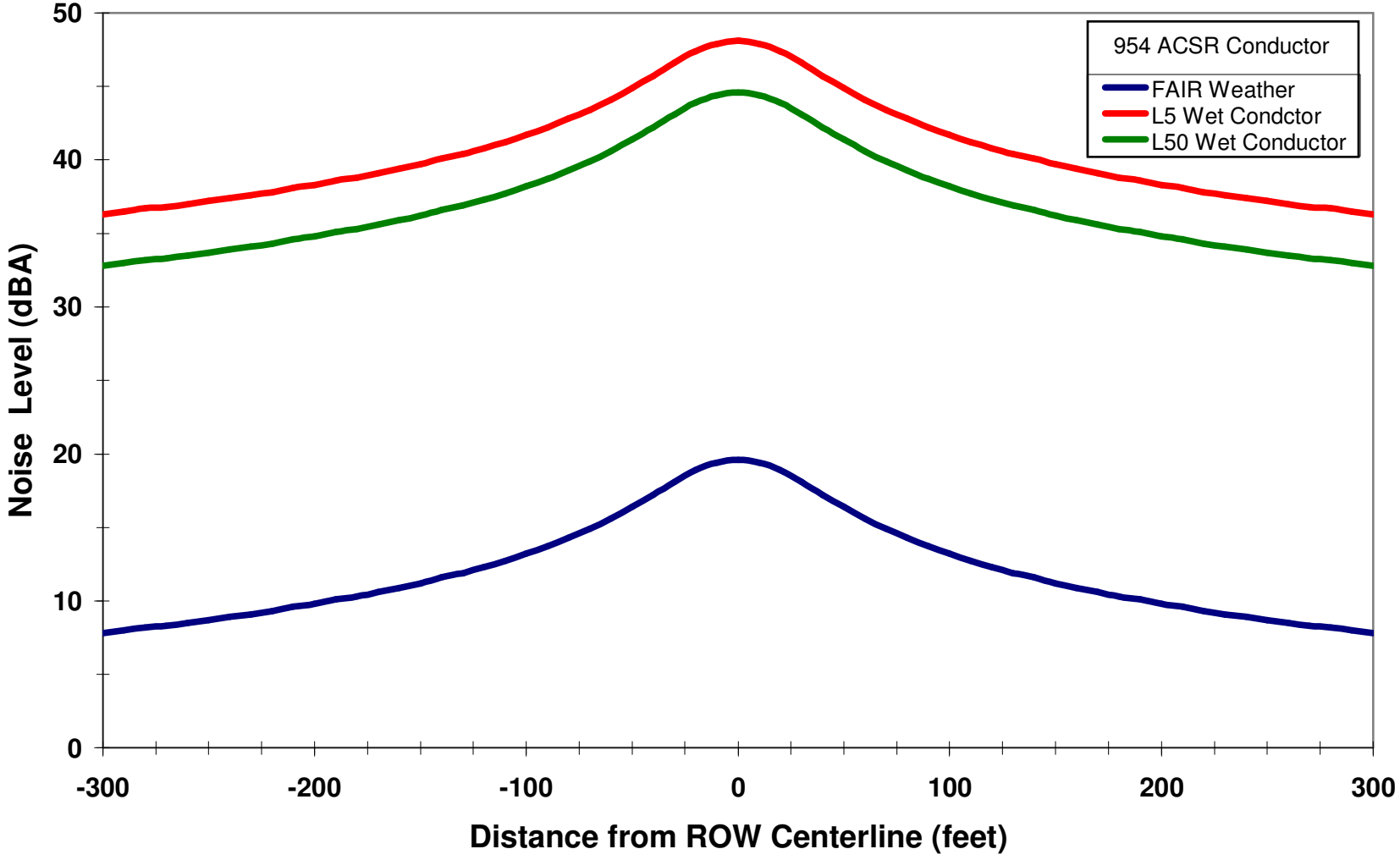


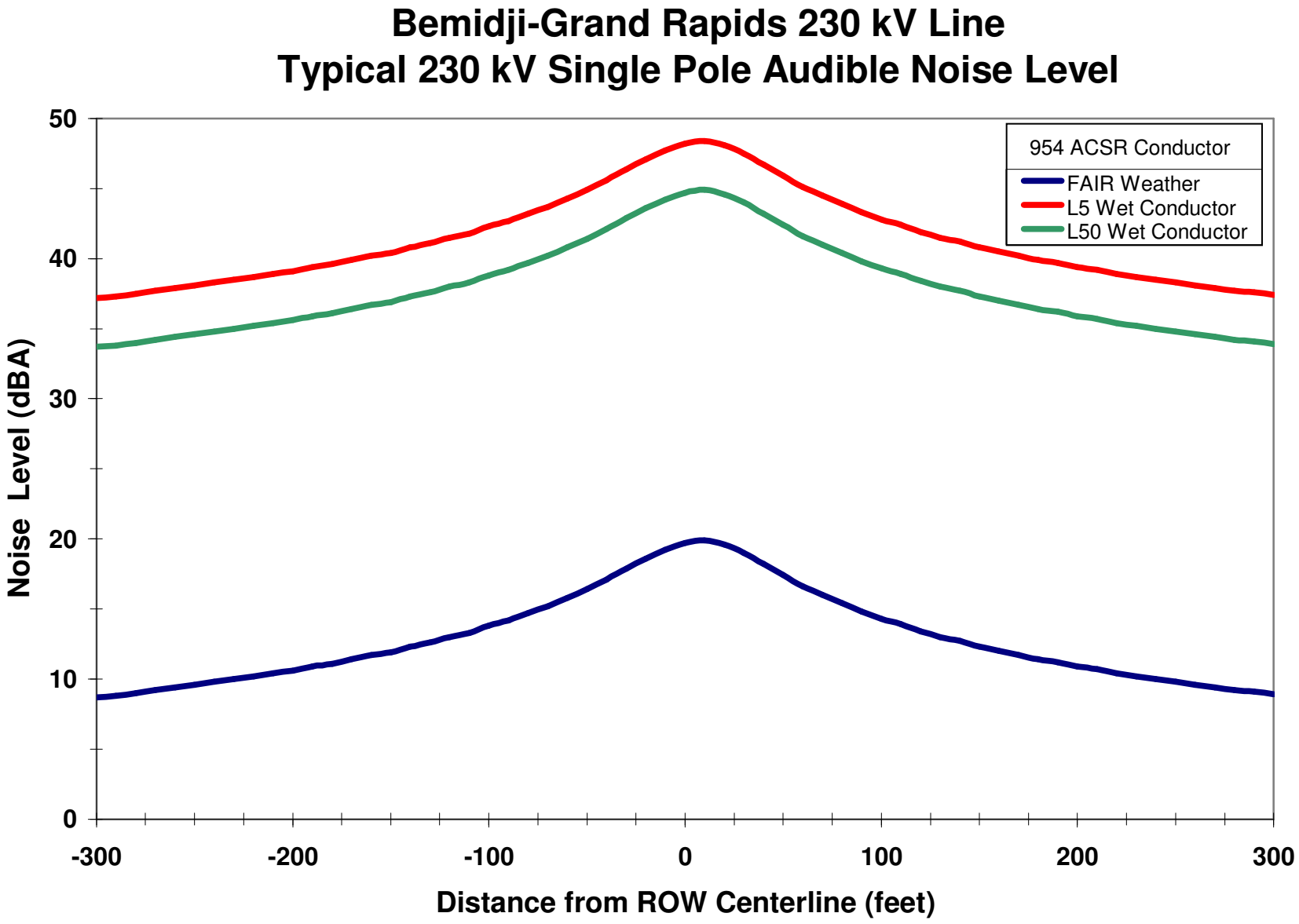
Audible Noise Levels of Potential Structure Types and Configurations

The audible noise levels associated with the structure types and configurations currently being considered for the Bemidji-Grand Rapids Line are shown in the following graphs. Illustrations of the structure types and configurations are in Appendix C1.

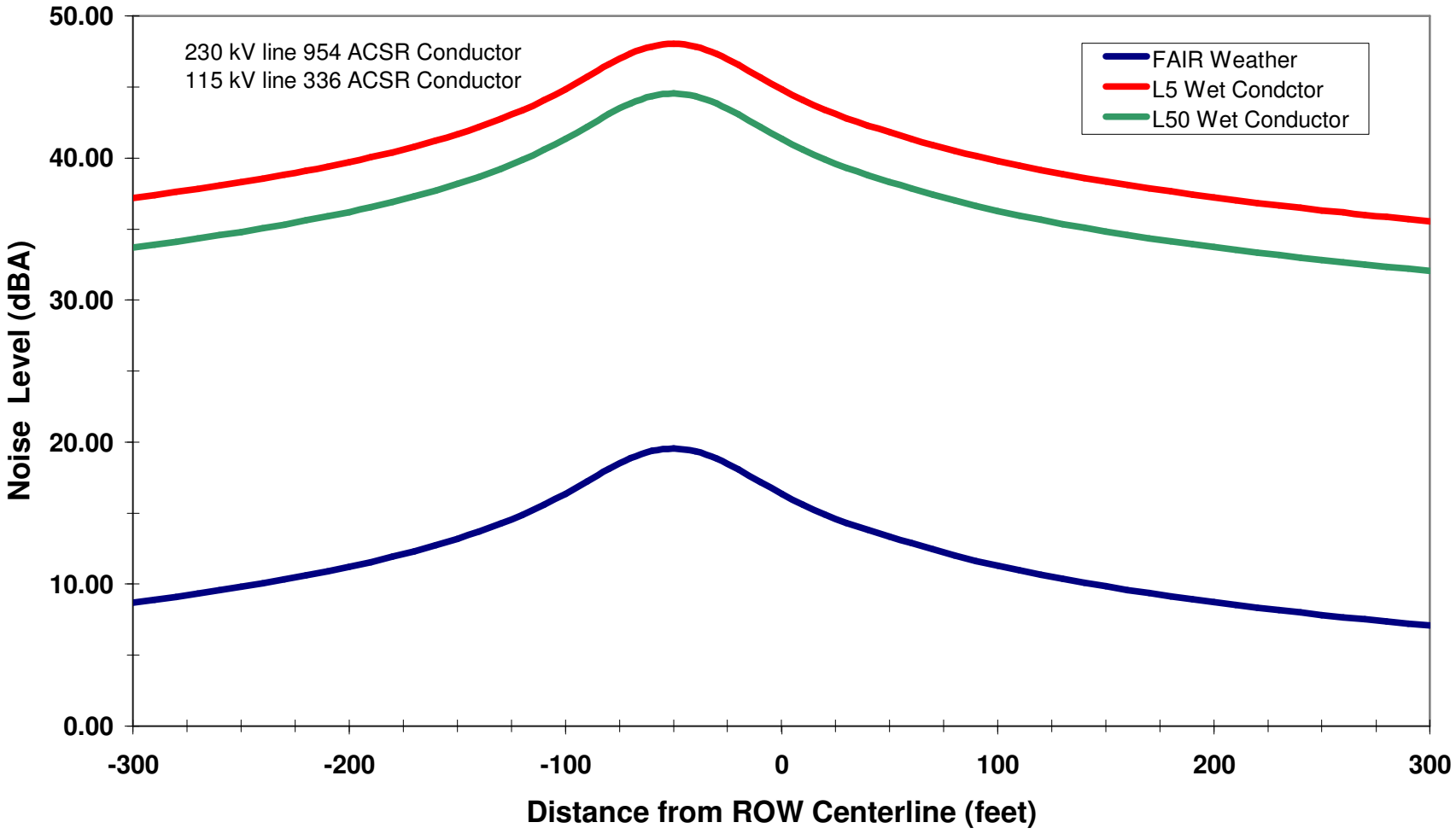
The audible noise levels of a transmission line depend significantly on the prevailing weather conditions and the line's geometry and operating voltage. The audible noise of a 230 kV line during fair weather is very low and seldom noticed, even if one is standing directly under the line. The audible noise of any transmission line is greatest during heavy rain when the conductor is wet. These noise levels are shown on the following graphs as the L50 and L5 wet conductor. Even during the worst case conditions, the graphs show that the expected audible noise levels for the Project will be below Minnesota's most restrictive noise standards.

Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230 kV H-Frame



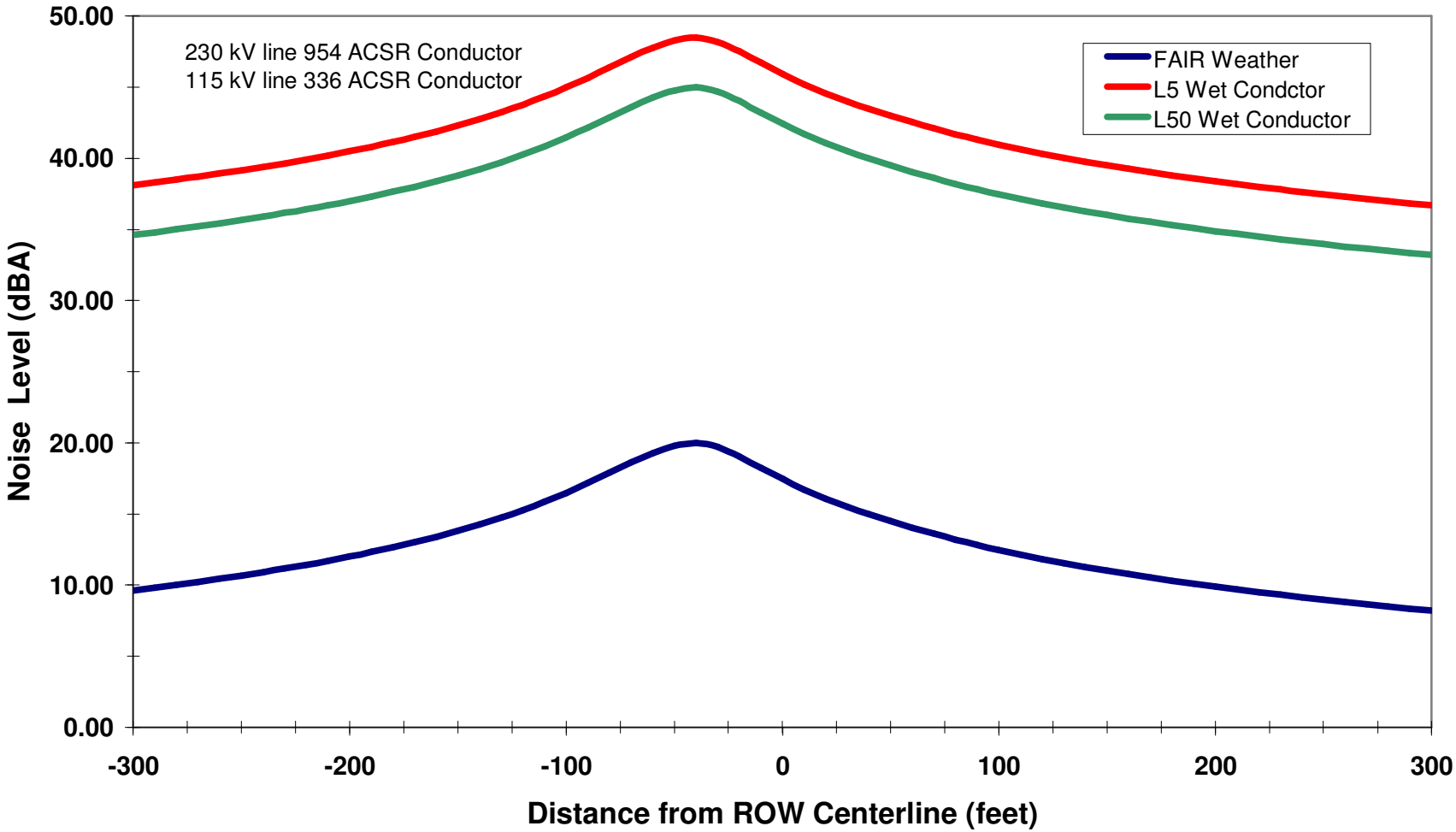

Bemidji-Grand Rapids 230 kV Line
Typical 230 kV Single Pole Audible Noise Level
954 ACSR Conductor
FAIR Weather
L5 Wet Conductor
L50 Wet Conductor
Noise Level (dBA)
50
40
30
20
10
0
-300
-200
-100
0
100
200
300
Distance from ROW Centerline (feet)

Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230kV H-Frame on Shared Right-of-Way with existing 115 kV H-Frame

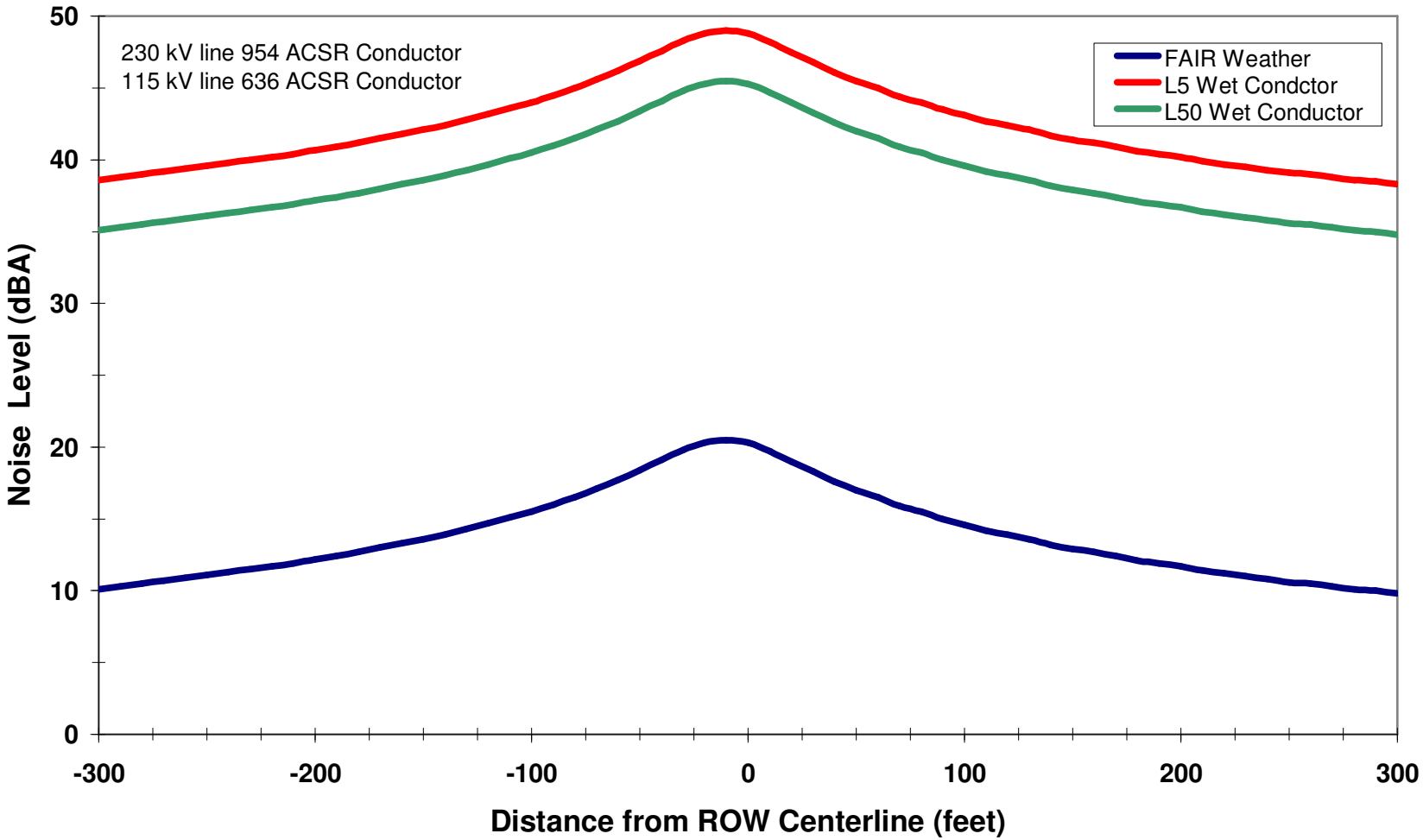


Bemidji-Grand Rapids 230 kV Line
Audible Noise Level

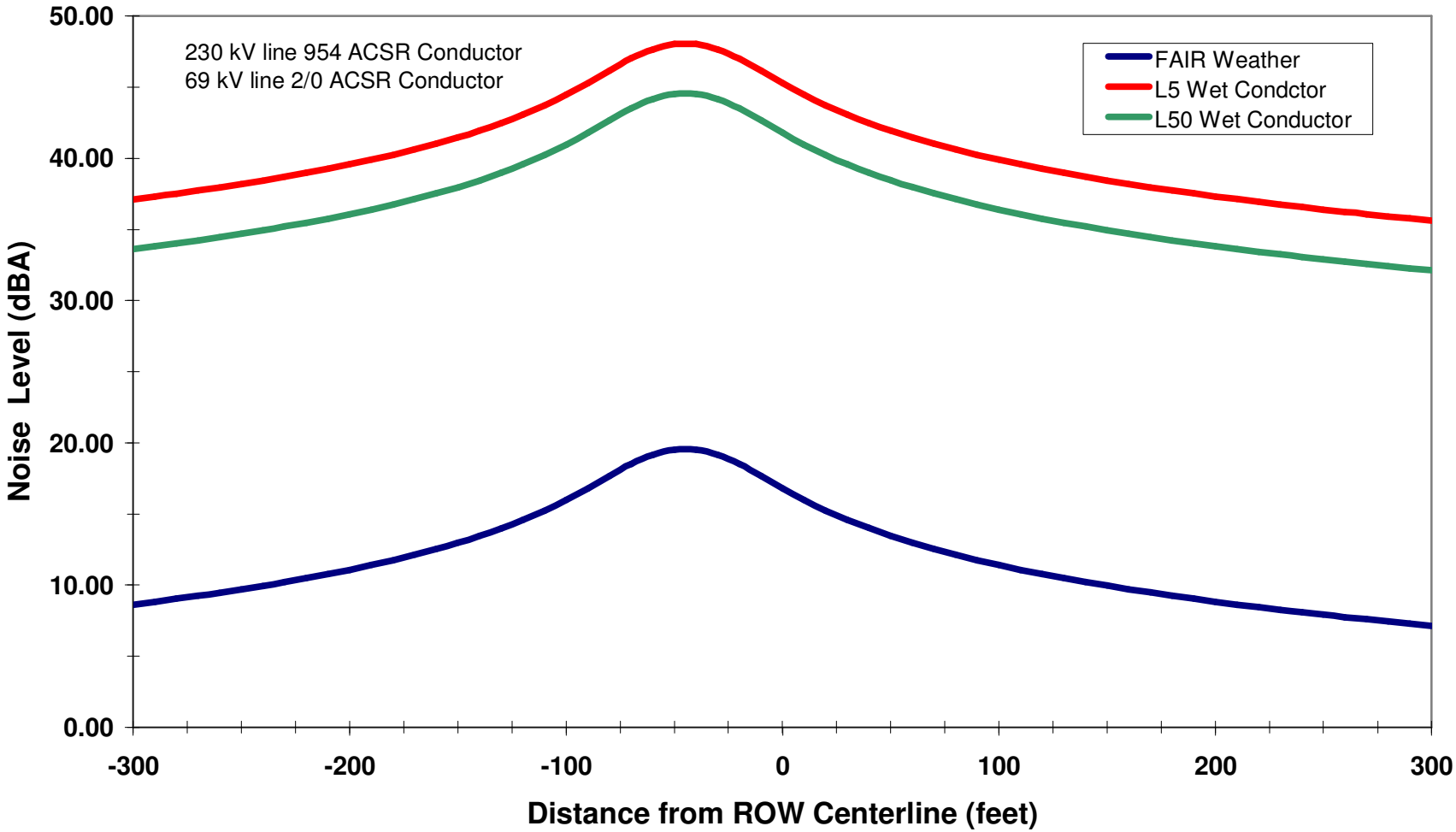
Typical 230kV Single Pole on Shared Right-of-Way with existing 115 kV H-Frame



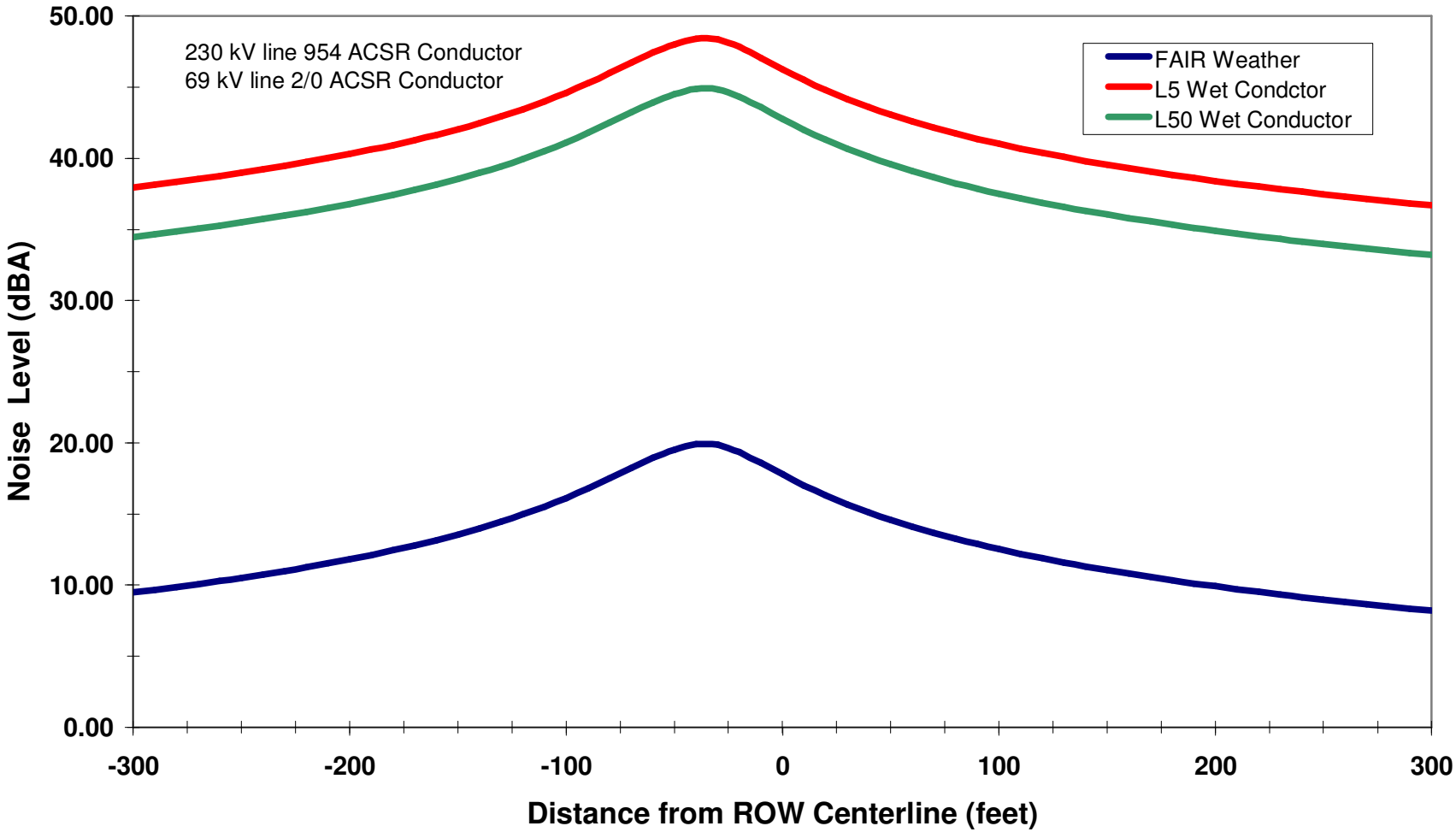
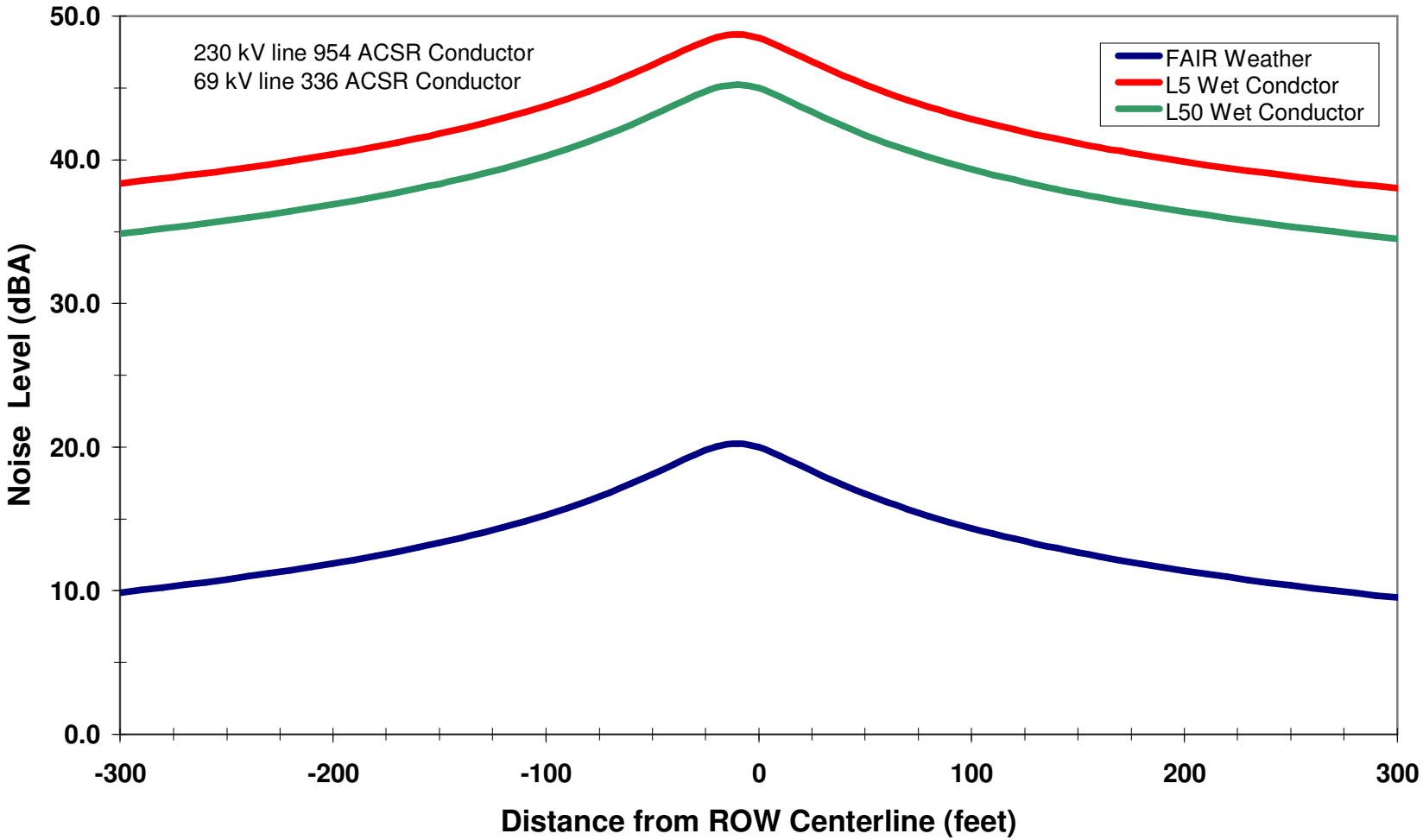
Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230/115 kV Single Pole Double Circuit



Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230kV H-Frame on Shared Right-of-Way with existing 69 kV



Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230kV Single Pole on Shared Right-of-Way with existing 69 kV



Bemidji-Grand Rapids 230 kV Line
Audible Noise Level
Typical 230/69 kV Single Pole Double Circuit