# ATTACHMENT 3-D: DETAILED MAGNETIC FIELD MANAGEMENT PLAN

# Detailed Magnetic Field Management Plan
# East County Substation Project

Project Engineer: **George Nelms** (Transmission Engineering)
Project Designer: **Black & Veatch** (Engineering Consultants)

Work Order No.: **BP 7139**
In-Service Date: **June 2012**

Transmission Lines: Portions of: **TL 50001, TL138xx**

Central File No.: **ELA 140.B.**XX

Prepared by: Gerald Bennett and Environmental Services Date: 08/06/2009

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# I. Project Scope

The East County (ECO) Substation Project (Project) involves building a new substation in the southeastern portion of San Diego County, California approximately one-half (0.5) mile north of the United States (U.S.)-Mexico border, one-half (0.5) mile west of the Imperial County line, and seventy (70) miles east of downtown San Diego. The primary purpose of the ECO Substation is to facilitate interconnection of renewable generation in the vicinity.

The Project is divided into the following five components:

1. ECO Substation
2. Southwest Powerlink (SWPL) loop-in, a short loop-in of the existing SWPL transmission line to the proposed ECO Substation
3. Constructing a new 138 kilovolt (kV) transmission line, TL138xx, approximately 13.3 miles in length, running between the existing Boulevard Substation and the proposed ECO Substation.
4. Boulevard Substation rebuild
5. White Star Communication Facility rebuild

Component 3, the new 138 kV transmission line, will increase the reliability of the existing transmission system and promote the interconnection of renewable generation in the Boulevard area. This Detailed Magnetic Field Management Plan (FMP) is for analysis of the new 138 kV transmission line, TL138xx.

# II. Magnetic Field Management Design Guidelines

The California Public Utilities Commission ("CPUC") requires SDG&E apply its *EMF*[1] *Design Guidelines for Electrical Facilities* ("Guidelines") to all new electric transmission projects to reduce public exposure to magnetic fields. SDG&E filed its Guidelines with the CPUC in accordance with CPUC Decision 93-11-013 and updated them in accordance with the 2006 CPUC Decision 06-01-042.

Consistent with SDG&E's Guidelines and with the CPUC order, magnetic fields and possible magnetic field management measures were evaluated along the existing, and proposed, transmission circuit locations associated with the Project. The results of this evaluation are contained in this FMP.

The FMP deals solely with magnetic fields. Moreover, reducing the magnetic field strength is but one of many factors to be considered in planning and designing a transmission system, along with other issues such as safety, environmental concerns, reliability, insulation and electrical clearance requirements, aesthetics, cost, operations and maintenance.

# III. Methodology

In Decision 06-01-042, the CPUC notes that modeling is used to compare the relative effectiveness of field-reduction options and is not to be used to predict post-construction field levels. CPUC Decision 06-01-042, Finding of Fact 14: "Utility modeling methodology is

[1] EMF refers to electric and magnetic fields.

intended to compare differences between alternative EMF [Electromagnetic Field] mitigation measures and not determine actual EMF amounts."[2] The CPUC also notes that "modeling indicates relative differences in magnetic field reductions between different transmission line construction methods, but does not measure actual environmental magnetic fields."[3]

In accordance with its Guidelines, SDG&E will take the following measures for the Project:

- Apply SDG&E's EMF Guidelines for transmission circuit facilities to the Project design.
- Identify and implement appropriate "no-cost" measures, i.e., those that will not increase overall project costs but will reduce the magnetic field levels.
- Identify and implement appropriate "low-cost" measures, i.e., those measures costing in the range of 4% of the total budgeted project cost that will reduce the magnetic field levels by 15% or more at the edge of the right-of-way (ROW).
- When a sufficiency of "low-cost" measures is available to reduce magnetic field levels, such that it is difficult to stay within the 4% cost guideline, apply these "low-cost" measures by priority, per the Guidelines.

The 15% minimum reduction required for low-cost measures is in addition to any field reduction due to "no-cost" measures. It is not cumulative.

Since the Project requires permitting under General Order 131-D, a Detailed Field Management Plan ("FMP") will be used. The Detailed FMP consists of a project description, a checklist table showing evaluation of magnetic field reduction measures adopted or rejected per segment, evaluation of no-cost and low-cost magnetic field reduction techniques, magnetic field models, and a summary with recommendations, including tables showing resultant magnetic field reduction levels at the edge of the ROW.

Tables showing calculated resultant magnetic field levels at the edges of the ROW are included in "Section VIII- Summary of Calculated Magnetic Field Levels" in this report.

Field levels were calculated using the Resicalc program developed and maintained by the Electric Power Research Institute**.** As the proposed in-service date of the Project is June 2012, the projected high usage currents, "2012 heavy summer," were used in the calculations. For the purpose of evaluating the field management measures, magnetic field levels were calculated and compared at a height of one meter above ground.

To evaluate the effectiveness of various magnetic field reduction measures, calculated values for a given technique were compared to calculated values without the technique. Since all segments of the Project are within defined easements, magnetic field levels were calculated and compared at the adjacent parallel property lines, or edges of ROW.

The edges of the ROW are identified as "Left" or "Right" to distinguish between them with reference to the sketches included in "Appendix 1" and in the tables included in "Section VIII- Summary of Calculated Magnetic Field Levels" in this report.

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[2] CPUC Decision D.06-01-042, Finding of Fact 14, p. 20.
[3] Ibid, p.11.

## IV. Project Description

The primary purpose of the Project is to build the ECO Substation as an interconnection hub into which renewable generation can connect at three voltage levels—138 kV, 230 kV, and 500 kV—eliminating the need for a series of developer-owned switching stations along SWPL. It also includes looping the SWPL 500kV transmission line into it, and constructing approximately 13.3 miles of 138 kV transmission line between the new substation and existing Boulevard Substation to increase the reliability of the existing transmission system and promote the interconnection of renewable generation in the Boulevard area. This Detailed FMP is for analysis of this new 138 kV transmission line.

This 138 kV transmission line, TL138xx, will require a 100-foot-wide, permanent ROW within which it will be located on centerline, approximately 50 feet from either side. There is a nine (9) mile portion of new transmission line ROW that parallels the SWPL line, from the ECO Substation heading west. As shown in the attached "Appendix 1- Segment Map", the first Segment for this report starts at the Boulevard Substation and proceeds in a southerly direction for approximately four and one-half (4.5) miles to a point near SWPL pole "Z50147". There, it turns east on the north side, and adjacent to, the existing 200-foot-wide SWPL ROW for a distance of approximately three miles to a point near SWPL pole "Z50163". At that point, it crosses under the SWPL line to the south side, and continues east, adjacent to the existing 200-foot-wide SWPL ROW for approximately six (6) more miles to the new ECO Substation 138 kV yard. This area is predominantly privately owned undeveloped land.

The structure configuration for the new TL138xx transmission line will be designed as a twin circuit (two conductors per phase) configuration. It will include approximately 95 steel transmission poles and 8 wooden distribution poles. The tallest structure will stand approximately 140 feet above ground. The 138 kV transmission circuit will consist of 900 kcmil[4] aluminum conductor steel supported/alumoweld (ACSS/AW) conductor.

All of the steel poles will have six crossarms, and an extended pole top to accommodate optical ground wire (OPGW) attachment. The majority of the structures will be tangent structures with an I-string configuration. The distance from the ground to the lowest conductor will be at least 30 feet, and the approximate distance between the conductors will be 18 feet horizontally and 12 feet vertically. The span lengths between poles will vary with terrain, but will generally be between 400 and 800 feet.

For magnetic field reduction assessment of the new TL138xx transmission line, the Project was divided into three (3) Segments:

1. **Segment 1** starts at the Boulevard Substation and heads in a southerly direction for approximately four (4) miles to a location where the 138 kV line will meet the north side of the SWPL ROW near structure "Z50147". This segment consists solely of the twin circuit TL138xx transmission line located in the center of a 100-foot-wide ROW.

2. **Segment 2** includes a three (3) mile section heading east from SWPL pole "Z50147" toward the ECO Substation. It includes TL138xx in the center of a 100-foot-wide ROW,

[4] kcmil (1,000 cmils) is a quantity of measure for the size of a conductor; kcmil wire size is the equivalent cross-sectional area in thousands of circular mils. A circular mil (cmil) is the area of a circle with a 0.001-inch-diameter.

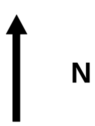
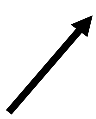
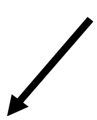
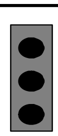
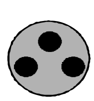
which is north of, and adjacent to, the existing SWPL 200-foot-wide ROW, making it 50 feet from the north ROW edge and 250 feet from the south ROW edge.

3. **Segment 3** starts where TL138xx will cross under the 500kV SWPL line near structure “Z50163” and continue an additional six miles east to the new ECO Substation 138 kV yard. The twin circuit tieline will reside in the center of a 100-foot-wide ROW, which is now south of, and adjacent to, the existing SWPL 200-foot-wide ROW, making it 50 feet from the south SWPL ROW edge and 250 feet from the north SWPL ROW edge. (See “Appendix 1 - Segment map”)

The new TL138xx will traverse land that is primarily privately owned and/or undeveloped, however, it will cross approximately 1.5 miles of land managed by the Bureau of Land Management between approximate Milepost 0.1 and approximate Milepost 1.6. The closest school is Jacumba Elementary in Segment 2, approximately five-thousand (5,000) feet south of the proposed 138 kV ROW near Jacumba.

Drawings and descriptions showing a typical pole top configuration, tieline relative locations to each other and left and right ROW are included in Appendix 1. Figure 1 below shows the drawing symbols; the arrows on the drawings indicate the viewing direction for orienting each drawing and the direction of current flow.

**Figure 1: Drawing Symbol Definitions**

| Symbol | Interpretation | Meaning |
|---|---|---|
|   | Viewing Direction | The orientation as seen when looking toward the north |
|  | Current flow into the page | Direction of current flow is same as viewing direction |
|  | Current flow out of the page | Direction of current flow is opposite of viewing direction |
|  | Underground Transmission Circuit | Location of underground transmission circuit |
|  | Underground Transmission Circuit | Location of Underground Transmission in Bridge Cell |

# V. Field Management Measures Considered

Per the “EMF Design Guidelines for Electrical Facilities, Table 3-1”, all Segments were reviewed for suitable application of magnetic field reduction measures, as listed in “*Table 1: Magnetic Field Reduction Measures Adopted or Rejected*” below. These techniques will be discussed under the “Section VI- Magnetic Field Reduction Measures Evaluated for the Project” that follows.

**Table 1: Magnetic Field Reduction Measures Adopted or Rejected**

<table>
<tr><th>Segment(s)</th><th>Location (Street, Area)</th><th>Adjacent Land Use</th><th>Reduction Measure Considered</th><th>Measure Adopted? (Yes/No)</th><th>Estimated Cost to Adopt</th></tr>
<tr><td rowspan="2">All</td><td>Entire Project Corridor</td><td>Undeveloped Land</td><td>Locate power lines closer to center of the utility corridor to extent possible.</td><td>No</td><td>N/A</td></tr>
<tr><td colspan="5"><u>Reason not adopted</u>: The alignment of the new 138 kV transmission line for the Project is in the center of the 100-foot ROW by design so realignment was not considered.</td></tr>
<tr><td rowspan="2">All</td><td>Entire Project Corridor</td><td>Undeveloped Land</td><td>Increase structure height.</td><td>No</td><td>N/A</td></tr>
<tr><td colspan="5"><u>Reason not adopted</u>: Increasing pole height of the 138 kV transmission line for the Project would not be a “no-cost” option but instead a “low-cost” mitigation. Per SDG&E's Guidelines, “low-cost” EMF mitigation is not necessary when the installation of the tieline is within agricultural and undeveloped land.</td></tr>
<tr><td rowspan="2">All</td><td>Entire Project Corridor</td><td>Undeveloped Land</td><td>Reduce conductor (phase) spacing.</td><td>No</td><td>N/A</td></tr>
<tr><td colspan="5"><u>Reason not adopted</u>: The Project includes new steel poles configured per SDG&E Standards for the 138 kV circuit voltage level that will reside on them. Changes in pole head conductor spacing was not considered since it would be a “low-cost” reduction measure and per SDG&E's Guidelines, when the zoning for a new tieline is within agricultural and undeveloped land, no “low-cost” options need to be considered.</td></tr>
<tr><td rowspan="2">All</td><td>Entire Project Corridor</td><td>Undeveloped Land</td><td>Increase trench depth.</td><td>No</td><td>N/A</td></tr>
<tr><td colspan="5"><u>Reason not adopted</u>: This Project does not include undergrounding of the 138 kV transmission line. Undergrounding consideration for any part of the 138 kV alignment would not be a “no-cost” option but instead a “low-cost” option. Per SDG&E's Guidelines, “low-cost” EMF mitigation is not necessary when the installation of the tieline is within agricultural and undeveloped land.</td></tr>
<tr><td rowspan="2">Segments 2 & 3</td><td>Project Corridor</td><td>Undeveloped Land</td><td>Phasing circuits to reduce magnetic fields.</td><td>Yes</td><td>No-Cost</td></tr>
<tr><td colspan="5">Segment 1 consists of only the 138 kV twin circuit, which must be phased the same on both sides of the pole for safety reasons so changing phase on one side was not considered. Also, to avoid an additional phase change between substations, Segment 1 should be phased the same as that required for Segment 2. Changing the phasing of the 500kV line was not considered due to an extended outage on this very critical resource to do so. Changing the 138 kV twin circuit phasing in Segments 2 and 3 was considered since it parallels the 500kV SWPL line.</td></tr>
</table>

## VI. Magnetic Field Reduction Measures Evaluated for the Project

Per SDG&E EMF Design Guidelines for Electrical Facilities, this FMP is limited to an assessment of phase arrangement as a field reduction technique. Other techniques such as locating the power line closer to the center of the corridor, increasing structure height, reducing conductor (phase) spacing, and undergrounding, were not implemented.

Reduction of magnetic field values through phasing techniques was modeled and analyzed as a method to reduce magnetic fields at the ROW for the Project. (See "no-cost" and "low-cost" options below.)

Initial design of the Project and review of existing phasing of the new 138 kV, twin circuit, transmission line within the 100-foot easement was modeled. Phasing for an overhead twin circuit must be the same on both sides of the pole for safety compliance. Since Segment 1 consists solely of the 138 kV circuit, TL138xx, on centerline of the 100-foot easement, changing phase would provide the same modeling results so this segment was not modeled. However, to avoid an additional phase change between Boulevard Substation and ECO Substation, Segment 1 should be the same phase configuration as Segment 2. In Segments 2 and 3, changing phasing of the 138 kV twin circuit was modeled since the 100-foot easement it resides in parallels, is adjacent to, and on either the north or south side of the 200-foot-wide SWPL 500 kV ROW. The "no-cost" technique that provided optimum reduction in magnetic field values at edge of the ROW for Segment 1 and Segment 2 requires changing the initial design, **A-B-C (t-b)**, on both sides of the pole, to **C-A-B (t-b)**. Segment 3 of the Project should also be changed from **A-B-C (t-b)** on both sides of the structure, to **B-A-C (t-b)** to provide lowest magnetic field values at edge of the ROW. The percent reduction in magnetic field values (milligauss) can be found in the table located in "*Section VIII. - Summary of Calculated Magnetic Field Levels.*"

## VII. Magnetic Field Reduction Measures Recommended for the Project

Reduction of magnetic field values through phasing techniques was adopted as a viable method to reduce magnetic fields at the ROW for the Project. For the percentage of magnetic field reduction see tables located in "*Section VIII. - Summary of Calculated Magnetic Field Levels.*" The recommended field reduction techniques are:

### A. "No-Cost" Field Management Technique:

Change the phasing of the new 138 kV twin circuit transmission circuit, TL138xx, from **A-B-C (t-b)** on both sides to **C-A-B (t-b)** from the Boulevard Substation, south, to a point near SWPL pole "Z50147" (Segment 1). Also, change the phasing of the new 138 kV twin circuit to **C-A-B (t-b)** from that point heading east, to a point near SWPL pole "Z50163" where the new circuit transitions from the north side, to the south side, of the SWPL 200-foot-wide easement (Segment 2). Next, the phasing of the 138 kV twin circuit needs to change to **B-A-C (t-b)** from that point near SWPL pole "Z50163", continuing east to the new East County Substation (Segment 3).

**B. "Low-Cost" Field Management Technique:**

Per the "EMF Design Guidelines for Electric Facilities", 'low-cost' EMF mitigation is not required in areas zoned agricultural and undeveloped land.

## VIII. Summary of Calculated Magnetic Field Levels

The following tables show the initial design and recommended ("no-cost") design magnetic field values (milligauss) and the percent change for Segments 2 and 3 of the Project. A positive percentage value shows a reduction in milligauss, while a negative value shows an increase in milligauss from the initial design. The magnetic field values were calculated at the edges of the ROWs for all segments. Since Segment 1 consists solely of the 138 kV circuit, TL138xx, on centerline of the 100-foot easement, changing phase would provide the same modeling results so this Segment was not modeled. The location of the Segments and their corresponding land uses are included in the attached "Appendix 1".

**Table 2: Segment 2 – From SWPL pole "Z50147" east approximately three miles where TL138xx crosses under SWPL to the south side near pole "Z50163".**

| SEGMENT 2 | | | | | | |
|---|---|---|---|---|---|---|
| From near SWPL pole Z50147, east 3 miles toward new substation | | | | | | |
| 2012 Amps | INITIAL | DESIGN | NO | CHANGE | | |
| | TL50001 (C-A-B) (lft-rt)<br>138 kV twin (A-B-C) (t-b) | | TL50001 (C-A-B) (lft-rt)<br>138 kV twin (C-A-B) (t-b) | | Percent(%) milligauss Reduction | Percent(%) milligauss Reduction |
| Segment | | | | | | |
| | Left ROW | Right ROW | Left ROW | Right ROW | Left ROW | Right ROW |
| SEG2 | 66.24 | 62.43 | 45.00 | 60.78 | 32.1% | 2.6% |
| | | | | | | |

- zoned privately-owned, undeveloped land
- Change phasing of twin circuit **TL138xx** to **C-A-B (t-b)** on both sides provided optimal magnetic field reduction.
- See "**Appendix 1 – Segment 2**" attached for further detail.

**Table 3: Segment 3 – From near SWPL pole "Z50163" east to the new ECO Substation**

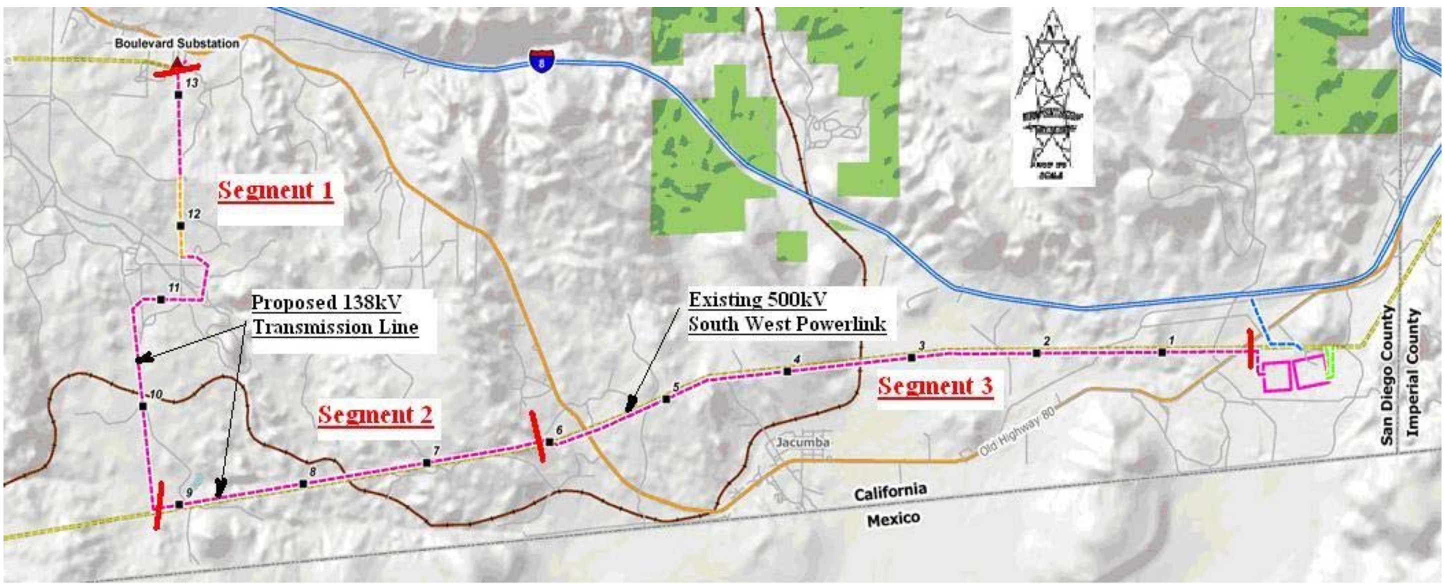
| SEGMENT 3 | | | | | | |
|---|---|---|---|---|---|---|
| From near SWPL pole Z50163, east to new ECO Substation | | | | | | |
| 2012 Amps | INITIAL | DESIGN | NO | COST | | |
| | TL50001 (C-A-B) (lft-rt)<br>138 kV twin (A-B-C) (t-b | | TL50001 (C-A-B) (lft-rt)<br>138 kV twin (B-A-C) (t-b) | | Percent(%) milligauss Reduction | Percent(%) milligauss Reduction |
| Segment | | | | | | |
| | Left ROW | Right ROW | Left ROW | Right ROW | Left ROW | Right ROW |
| SEG3 | 61.00 | 53.40 | 60.78 | 45.00 | 0.4% | 15.7% |
| | | | | | | |

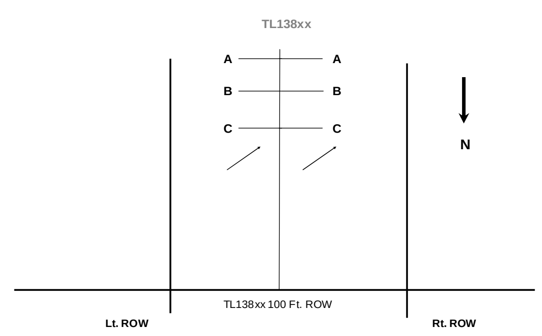
- zoned privately-owned, undeveloped land
- Changing phasing of twin circuit **TL138xx** to **B-A-C (t-b)** on both sides provided optimal magnetic field reduction as the "no-cost" option.
- See "**Appendix 1 – Segment 3**" attached for further detail.

# Appendix 1

## East County Substation Project

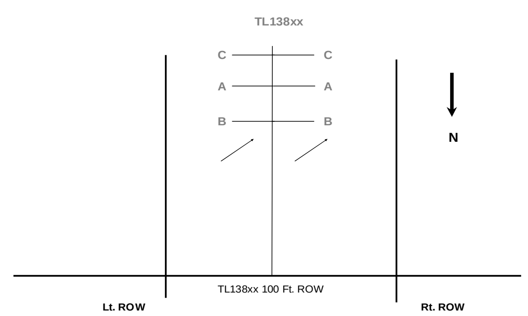
## Segment Map





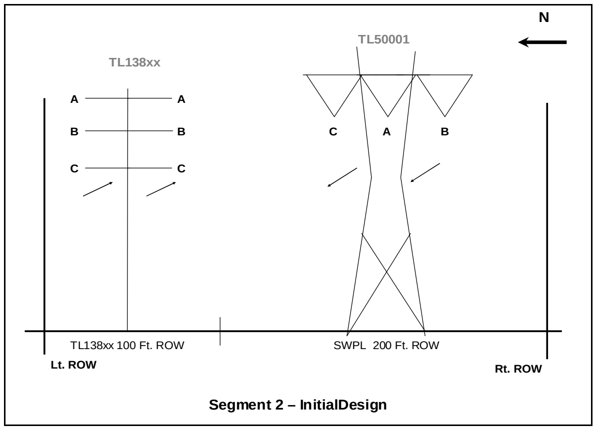
Segment 1 – Initial Design

| | |
|---|---|
| Approximate Location: | From Boulevard Substation south to SWPL pole “Z50147” (Segment 1) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 4.5 mi. |
| Right-of-Way Width: | 100 ft. |

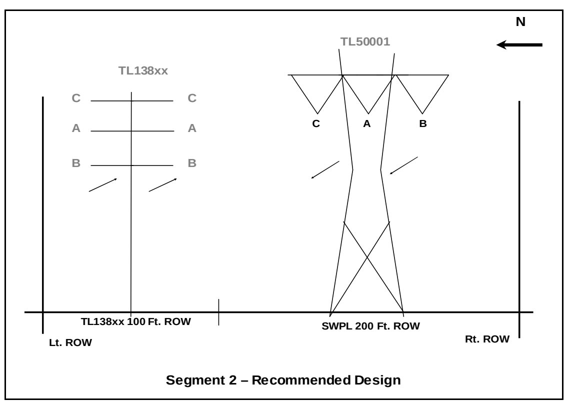


Segment 1 – Recommended Design

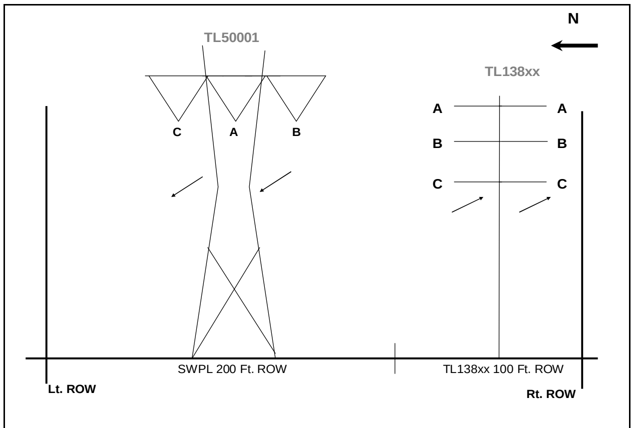
| | |
|---|---|
| Approximate Location: | From Boulevard Substation south to SWPL pole “Z50147” (Segment 1) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 4.5 mi. |
| Right-of-Way Width: | 100 ft. |




| | |
|---|---|
| Approximate Location: | From SWPL pole "Z50147" east approximately three miles where TL138xx crosses under the SWPL to the south side near pole "Z50163" (Segment 2) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 3.0 mi. |
| Right-of-Way Width: | 300 ft. |

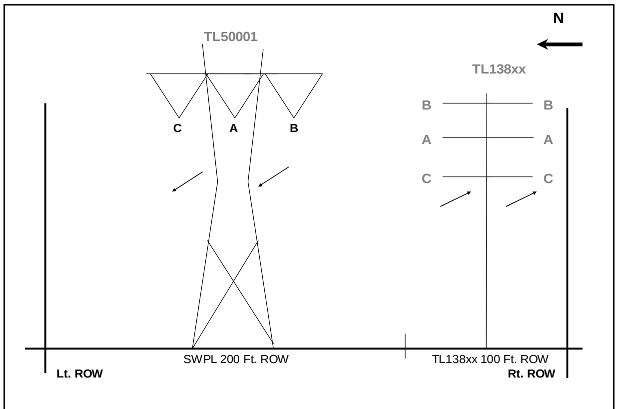



| | |
|---|---|
| Approximate Location: | From SWPL pole "Z50147" east approximately three miles where TL138xx crosses under the SWPL to the south side near pole "Z50163" (Segment 2) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 3.0 mi. |
| Right-of-Way Width: | 300 ft. |




Segment 3 – Initial Design

| | |
|---|---|
| Approximate Location: | From near SWPL pole "Z50163" east to the new ECO Substation (Segment 3) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 6.0 mi. |
| Right-of-Way Width: | 300 ft. |




Segment 3 – Recommended Design

| | |
|---|---|
| Approximate Location: | From near SWPL pole "Z50163" east to the new ECO Substation (Segment 3) |
| Transmission Circuits: | TL50001, TL138xx |
| Land Use: | Undeveloped Land |
| Length: | 6.0 mi. |
| Right-of-Way Width: | 300 ft. |