APPENDIX C:
MAGNETIC FIELD MANAGEMENT PLAN

Detailed Magnetic Field Management Plan for the Sycamore to Peñasquitos 230 kV Transmission Line Project

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Transmission & Power Lines: **TL 23001, 23004, 23051, 230XX, 13804, 13820, 13811, 675, 6906, 6920**

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I. Proposed Project Scope

In an effort to increase the efficiency and supply of renewable generated power to the California Independent System Operator (CAISO) grid, CAISO has identified a policy-driven need for a new 230 kilovolt (kV) transmission line to connect the existing SDG&E Sycamore Canyon and Peñasquitos Substations. In response to the CAISO Request for Proposal (RFP) for this new 230 kV transmission line, SDG&E proposes to construct and operate a new, approximately 16.7 mile, 230 kV transmission line (TL) 230XX[1] between the existing SDG&E Sycamore Canyon and Peñasquitos Substations (Proposed Project). The Proposed Project would also include the consolidation of two existing 69 kV power lines onto new double-circuit, steel structures that would replace existing, predominantly wood structures. All new transmission line facilities will be located within existing SDG&E rights-of-way (ROW) or within franchise position within existing public roadways[2].

The Proposed Project would include the following primary components:

- Construction of approximately thirty-eight (38) new steel tubular 230 kV transmission line poles and two new single-circuit 138 kV power line poles between the existing Sycamore Canyon Substation and Carmel Valley Road (approximately 8.31 miles) all within existing SDG&E ROW;
- Install new 230 kV underground transmission line (approximately 2.84 miles) in Carmel Valley Road utilizing existing franchise position for almost the entire segment[2] and two new 230 kV cable pole structures;
- Bundle a portion of existing TL 23001 and TL 23004 between Carmel Valley Road and Peñasquitos Junction on the east side of existing towers and rename it to TL 23004 from San Luis Rey to Mission Substation. Make minor changes at San Luis Rey and Mission Substations to provide for same phasing of bundled configuration.
- Install new 230 kV conductor on vacated position (west side) of the existing 230 kV steel structures (permitted double-circuit 230 kV structures currently supporting TLs 23001 and 23004) between Carmel Valley Road and Peñasquitos Junction all within existing SDG&E ROW[3];
- Install new 230 kV conductor on vacated position of the existing steel 230 kV structures (permitted double circuit 230 kV steel structures currently supporting TLs 13804 and 6906) between Peñasquitos Junction and Peñasquitos Substation all within existing SDG&E ROW;
- Consolidation, relocation, and reconductoring of existing 230 kV transmission lines and 138 and 69 kV power lines within existing SDG&E ROW; and
- Minor modifications at the Sycamore Canyon and Peñasquitos Substations to allow for connection of the new 230 kV transmission line.

[1] Transmission Line number (TL) to be assigned at a later date.
[2] Note that one small section of underground rights through existing SDG&E ROW would need to be acquired through an amendment to the existing ROW easement at that location.
[3] Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower.

The Proposed Project components are located on the extreme northern portion of Marine Corps Air Station (MCAS) Miramar as well as within a portion of the City of San Diego, California (Please see "Appendix 1 – Proposed Project Segment Map"). Specifically, the Proposed Project route traverses both developed residential and commercial areas as well as densely vegetated undeveloped areas on private and public lands, including lands owned by public agencies (local and federal). The Proposed Project will be constructed within existing SDG&E ROWs and franchise position throughout the entire scope. Minor work will be done at Sycamore and Peñasquitos Substations to provide for connection of the new 230 kV line.

The scope of magnetic field analysis for this "Detailed Magnetic Field Management Plan (FMP)" does not include the distribution lines, per the "SDG&E EMF[4] Design Guidelines for Electrical Facilities*"* which states, "For distribution facilities, utilities would apply no-cost and low-cost measures by integrating reduction measures into construction and design standards, rather than evaluating no-cost and low-cost measures for each project." Thus, for purposes of this FMP, the term "Proposed Project" only includes the new and existing 230 kV transmission lines and 138 and 69 kV power lines.

II. Magnetic Field Management Design Guidelines

The CPUC requires SDG&E apply its *EMF 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 power line locations associated with the Proposed 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 intended to compare differences between alternative EMF mitigation measures and not determine actual EMF amounts."[5] 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."[6]

[4] EMF refers to electric and magnetic fields.
[5] CPUC Decision D.06-01-042, Finding of Fact 14, p. 20.
[6] Ibid, p.11.

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

- Apply SDG&E's EMF Guidelines for transmission circuit facilities to the Proposed 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 Proposed Project requires permitting under General Order 131-D, a Detailed Field Management Plan (FMP) will be used. The FMP consists of a project description, a checklist table showing evaluation of magnetic field reduction measures adopted or rejected per transmission line, evaluation of "no-cost" and "low-cost" magnetic field reduction techniques, magnetic field models where multiple lines are involved within the same easement or ROW, and a summary with recommendations.

Field levels were calculated using the "EMF Workstation" program developed and maintained by the Electric Power Research Institute**.** As the in-service date of the Proposed Project will be May 2017 the projected high usage currents, "2017 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 power lines of the Proposed Project are within easements, or franchise rights-of-way (ROW), magnetic field levels were calculated and compared at the adjacent parallel property lines, or edges of ROW.

IV. Project Description

San Diego Gas & Electric Company (SDG&E) is a regulated public utility that provides electric service to three million customers within a 4,100 square mile service area, covering parts of two counties and 25 cities in the San Diego area. In an effort to increase the efficiency and supply of renewable generated power to the California Independent System Operator (CAISO) grid, CAISO has identified a policy-driven need for a new 230 kilovolt (kV) transmission line to connect the existing SDG&E Sycamore Canyon and Peñasquitos Substations. In response to the CAISO Request for Proposal (RFP) for this new 230 kV transmission line, SDG&E proposes to construct and operate a new, approximately 16.7-mile 230 kV bundled 900 kcmil ACSS/AW

transmission line (Tie Line [TL] 230XX[7]) between the existing SDG&E Sycamore Canyon and Peñasquitos Substations (Proposed Project). The Proposed Project would also include the consolidation of two existing 69 kV power lines onto new double-circuit, steel structures that would replace existing, predominantly wood structures. All new transmission line facilities will be located within existing SDG&E ROW or within franchise position within existing public roadways[8].

The Proposed Project would include the following primary Segments:

- Segment A - Construction of approximately thirty-eight (38) new 230 kV and two (2) 138 kV steel tubular poles between the existing Sycamore Canyon Substation and Carmel Valley Road located within existing SDG&E ROW. Install new 230 kV bundled 900 kcmil ACSS/AW conductor on new double-circuit 230 kV steel tubular poles. Remove approximately 41 wood pole H-frame structures, two tubular steel poles, one 138 kV double-circuit steel cable pole, and two vertical configuration wood poles and relocate existing TL 13820 or TL 13811[9] (currently a looped in 138 kV circuit at Chicarita Substation) to second position on the new double-circuit 230 kV steel tubular poles. Approximate length of this Segment is 8.31miles. Land use includes schools, residential, commercial and undeveloped open space along the route. These schools include: Mt. Carmel High School, The Cambridge School, Innovation Academy, Dingeman Elementary, and Ellen Browning Scripps Elementary and are within an approximate four (4) mile portion of Segment "A", centering on an area where two major highways, Ted Williams Pkwy (Hwy 56) and Interstate I-15 cross the existing SDG&E ROW;

- Segment B - Construction of new 230 kV "split-phase" underground transmission line, within franchise of Carmel Valley Road for almost the entire segment[7] and construction of 230 kV tubular steel cable pole structures[10] at each end of the Carmel Valley Road underground segment within existing SDG&E ROW. The new 230 kV cable pole located on the east end of the Carmel Valley Road underground segment would replace an existing 138 kV wood H-frame structure while the new 230 kV cable pole on the west end would replace an existing 230 kV steel lattice tower. Approximate length of this Segment is 2.84 miles. Land use includes daycare center, residential, commercial and undeveloped open space along the route. The daycare center is named, "The Kids Bay Learning Center", and is located near the west end of this underground Segment;

- Segment C - Install new 230 kV bundled 900 kcmil ACSS/AW conductor on the vacated position of the existing 230 kV steel structures (10 steel lattice towers) and on one new tubular steel pole that will replace an existing steel lattice tower at the Peñasquitos Junction.[11]All structures are located within existing SDG&E ROW between Carmel Valley Road and Peñasquitos Junction. Existing tielines TL 23001 and TL 23004 would be reconductored and bundled on the east side of the existing structures and re-named TL

[7] Transmission Line number (TL) to be assigned at a later date.
[8] Note that two small sections of underground rights through existing SDG&E ROW would need to be acquired through an amendment to the existing ROW easements at these locations.
[9] TL 13811 between Chicarita and Shadow Ridge Substations was previously named TL 13825 in 2013. Now the name "TL 13825" only includes the segment between Shadow Ridge and Batiquitas Substations.
[10] The new 230 kV cable pole structure on the east end of the new underground segment would consist of 3 separate structures (horizontal arrangement), each supporting one phase each of the new 230 kV transmission line.
[11] Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower.

23004 from San Luis Rey to Mission Substation. Minor changes at San Luis Rey and Mission Substations will be needed to provide for same phasing of this bundled configuration. Approximate length of this Segment is 2.19 miles and land use is residential and undeveloped open space;

- Segment D - Install new 230 kV bundled 900 kcmil ACSS/AW conductor on vacated position of the existing fourteen (14) steel lattice structures and one (1) steel tubular pole (permitted double circuit 230 kV steel structures) currently supporting power lines TL 13804 and TL 6906 between Peñasquitos Junction and Peñasquitos Substation all within existing SDG&E ROW. Also within the corridor in this Segment, existing 69 kV power lines (TL 675 and TL 6906) would be consolidated onto approximately seventeen (17) new 69 kV, double-circuit steel tubular poles that would replace fifteen (15) existing 69 kV wood H-frame structures and five wood monopole structures that currently support TL 675 and TL 6906. Construction of two new 69 kV tubular steel cable poles that would replace existing wood 69 kV cable poles located immediately outside of the Peñasquitos Substation. Approximate length of this Segment is 3.34 miles with some residential, but primarily undeveloped open space along both sides of easement;
- Existing Lines and Substations – Consolidation, relocation, and reconductoring of existing 230 kV transmission lines, and 138 kV and 69 kV power lines, within existing SDG&E ROW; and minor modifications at the Sycamore Canyon and Peñasquitos Substations to allow for connection of the new 230 kV transmission line.

The Proposed Project components are located on the extreme northern portion of Marine Corps Air Station (MCAS) Miramar as well as within a portion of the City of San Diego, California (Please see "Appendix 1 – Proposed Project Segment Map"). Specifically, the Proposed Project route traverses both developed residential and commercial areas as well as densely vegetated undeveloped areas on private and public lands, including lands owned by public agencies (local and federal). The Proposed Project will result in a new 230 kV transmission line that will connect the existing Sycamore Canyon and Peñasquitos Substations through utilization of existing SDG&E ROWs and franchise position within the City of San Diego.

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 Distribution Circuit	Location of underground distribution circuit

V. Field Management Measures Considered

Per the "EMF Design Guidelines for Electrical Facilities, Table 3-1", all portions of the power lines, TL 675, TL 6906, TL 6920, TL 13804, TL 13811, TL 13820, and transmission lines TL 23001, TL 23004, and new TL 230XX within scope of the Proposed Project 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

Segment(s)	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Estimated Cost to Adopt
ALL	Within existing ROW and franchise	Schools, Residential, Commercial, Undeveloped	**Locate power lines closer to center of the utility corridor to extent possible.**	**No**	**N/A**
	Reason not adopted: The alignment of the new steel poles in Segment "A" for TL 230XX and TL 13820 or TL 13811[12], and in Segment "D" for TL 6906 and TL 675 cannot move closer to center of easement due to other tie lines within the corridor and separation requirements. Segment "C" uses existing pole structures which already are as close to center of easement as possible. Segment "B" is underground and located as close to centerline of franchise without conflicting with other existing underground utilities. By design, the underground is on the south side of centerline where it passes the daycare center (The Kids Bay Learning Center) near the west end of the Segment. Therefore, no "no-cost" or "low-cost" alternatives were considered for this reduction measure.				
A, C, & D	Within existing ROW	Schools, Residential, Commercial, Undeveloped	**Increasing structure height (increasing the height of the conductor from ground level)**	**Yes**	**No-Cost**
	Per SDG&E Standards for 230 kV transmission lines and 138 kV / 69 kV power lines, either double circuit or single circuit with no distribution underbuild or single distribution underbuild, minimum sag height is 30 feet from lowest circuit wire to ground as per *GO-95 Design Standards* and 35 feet from lowest circuit wire for double underbuild. After reviewing the Preliminary design plans for Segments "A" and "D" where new overhead poles will be installed, it has been determined that no-cost options exist. The new design will utilize taller "soldiered" pole locations relative to the existing structures which allows wire sagging to become more uniform and minimizes the potential for blowout conflicts. In addition, the sag height was designed at heights consistent with those of existing structures. This proposed sag height averages a height increase of eleven (11) feet **(41 ft. sag)** providing a reduction in milligauss values of approximately **18%** at the closer (west) ROW without raising milligauss values at the opposite ROW. The proposed sag height for the 69 kV power lines in Segment "D" also averages a height increase of eleven (11) feet **(41 ft. sag)**, providing a reduction in milligauss values of approximately **1%** at the closer (north) ROW without raising milligauss values at the opposite ROW. This should be considered as a **"no-cost"** EMF reduction measure for both Segments, as it indeed reduces fields at no additional Proposed Project cost. (See "no-cost" options below.) Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower. Therefore, raising pole height was rejected for Segment "C".				

[12] TL 13811 between Chicarita and Shadow Ridge Substations was previously named TL 13825 in 2013. Now the name "TL 13825" only includes the segment between Shadow Ridge and Batiquitos Substations.

Segment(s)	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Estimated Cost to Adopt
	Within existing ROW and franchise	Schools, Residential, Commercial, Undeveloped	**Increasing structure height (increasing the height of the conductor from ground level)**	**No**	**N/A**
A, C, & D	**Reason not adopted**: After reviewing the Preliminary design plans for Segments "A" and "D" where new overhead poles will be installed, it has been determined that no-cost options exist while additional measures would not qualify as low-cost. The new design will utilize taller "soldiered" pole locations relative to the existing structures which allows wire sagging to become more uniform and minimizes the potential for blowout conflicts. In addition, the sag height was designed at heights consistent with those of existing structures. While further reviewing of Segment "A" where nearby land uses include schools, and residential and commercial properties, raising pole heights beyond the initial design height was examined as a possible "low-cost" measure. Calculations indicate that an increase of 12 feet would yield a reduction of 15% in magnetic field values at the west edge of ROW, but a slight increase at the east edge. For height increases greater than 12 feet, calculations yielded only marginal decreases (less than 1%) at the east edge of ROW. Therefore, increasing structure height as a "low-cost" field reduction measure was rejected for Segment "A" of this Proposed Project. Raising heights of the new 69 kV poles in Segment "D" beyond the initial design height also was examined as a possible "low-cost" measure. Calculations indicate that for sag height increases of 5 to 15 feet, the reduction in magnetic field values at the west edge of ROW would be no more than 1.5%, with a slight increase at the east edge. Even for a sag height increase of 40 feet, calculations yielded only 5% decrease at the west edge, and only a marginal decrease (less than 1%) at the east edge. Therefore, increasing height of the new 69 kV poles as a "low-cost" field reduction measure was rejected for Segment "D" of this Proposed Project. Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower. Therefore, raising pole height was rejected for Segment "C".				
ALL	Within existing ROW and franchise	Schools, Residential, Commercial, Undeveloped	**Reduce conductor (phase) spacing.**	**No**	**N/A**
	Reason not adopted: Segment "A" - New poles needed in this Segment would have the conductor spacing configuration for 230/138 kV double circuit steel poles per "*SDG&E Electric Transmission Standards*", which provides optimum magnetic field reduction at edge-of-ROW. Segment "B"- The underground portion of the Proposed Project would use "*SDG&E Electric Transmission Standards*" for underground phase spacing. Segment "C" - The existing power and transmission lines within the utility corridor (TL 23004, TL 23001, TL 230XX, TL 13804) would remain on existing structures with existing pole top configuration. Modifications to their existing conductor phase spacing is out of scope of the Proposed Project. Segment "D" - The new steel poles in the Proposed Project for TL 675 and TL 6906 would comply with "*SDG&E Electric Transmission Standards*" for 69 kV double circuit configurations which provide optimum magnetic field reduction. Therefore this reduction measure was rejected.				

Segment(s)	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Estimated Cost to Adopt
A, D	Within existing ROW and franchise	Schools, Residential, Commercial, Undeveloped	**Phasing Circuits to Reduce Magnetic Fields**	**No**	**N/A**
	Reason not adopted: Reduction of magnetic field values (milligauss) through phasing techniques was considered and modeled for the Proposed Project for all overhead Segments where two tie lines share a common corridor. Modifying current phasing of any existing circuit needs to be done at both of the terminating substations for that circuit and therefore includes the entire circuit length. Where a portion of this distance becomes out-of-scope of the Proposed Project, changing existing circuit phasing was discarded as a field reduction measure since modifying those circuits phasing could inadvertently increase milligauss values in areas out-of-scope of this Project. Only the portion of Segment "A" where TL 13820 extends from Sycamore Canyon to Chicarita Substation was modeling performed to see if milligauss would be reduced by changing phase of TL 13820 and/or TL 230XX. Modeling performed to try and reduce magnetic fields in Segment "D" and the remaining portion of Segment "A" only included various phase configurations of the new transmission line, TL 230XX, since all other circuits extended out-of-scope of the Proposed Project. The Preliminary Design phase for new TL 230XX is A-B-C (top-to-bottom). Modeling for Segments "A" and "D" showed the proposed phasing of TL 230XX, **A-B-C (t-b),** provides lowest milligauss values throughout its path from Sycamore Canyon to Peñasquitos Substation. Therefore, no "no-cost" or "low-cost" alternatives were considered for this reduction measure of the overhead portion of Segments "A" and "D" for the Proposed Project.				
	Within existing ROW and franchise	Schools, Residential, Commercial, Undeveloped	**Phasing Circuits to Reduce Magnetic Fields**	**Yes**	**No-Cost**
B, C	Reduction of magnetic field values (milligauss) through phasing techniques was considered and modeled for the Proposed Project Segment "B" underground. All overhead Segments show the new 230 kV TL230XX as a "bundled 900 kcmil ACSS/AW" circuit (two circuit wires per phase) which would be installed as a "split-phase" configuration once installed in underground conduit. When undergrounding a "split-phase" single circuit tie line, phasing can be reversed on one set of circuit wires. Since current flows in the same direction for all circuit wires, reverse phasing one set of circuit wires will reduce milligauss values approximately **97%** at edge-of-ROW, which indeed reduces fields at no additional Project cost. Therefore reverse phasing of the "split-phase" configuration should be considered a "no-cost" reduction measure for Segment "B". Reduction of magnetic field values through phasing techniques was considered and modeled for the Proposed Project Segment "C" where TL 23004 (C-B-A) and TL 23001(A-B-C) become a bundled circuit between San Luis Rey and Peñasquitos Junction and be located on the east side of existing structures (re-named TL 23004), to allow room for new TL 230XX tieline on the west side of the same structures. When these two tielines are bundled, each bundled pair of circuit wires must have the same phase. Since current flow of the new TL 230XX goes from north-to-south and new TL 23004 goes south-to-north, having the same phasing would provide lowest milligauss values at edge-of-ROW. By reverse phasing existing **TL 23004** to be **A-B-C (t-b)** as TL 23001 currently is, the new TL 23004 bundled circuit will be the same phase as TL 230XX (A-B-C). Therefore reverse phasing of existing TL 23004 when creating this bundled configuration with existing TL 23001 should be considered as a "no-cost" reduction measure for Segment "C".				

Segment(s)	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Estimated Cost to Adopt
A, C, & D	Within existing ROW	Schools, Residential, Commercial, Undeveloped	**Placing Overhead Underground**	**No**	**N/A**
	Reasons not adopted: Reduction of magnetic field values (milligauss) through undergrounding was considered and modeled for the Proposed Project for overhead Segments where two or more tielines or power lines share a common corridor, a total of approximately 13.8 miles of the 16.7 mile total Project length. This is considered a "low-cost" reduction measure for these Segments, and 4% of the total Proposed Project cost would provide for a length of approximately 0.37 miles of undergrounding. Per the *SDG&E Guidelines,* group prioritization for land use categories was used in determining how mitigation costs should be applied[13]. These priorities are: (1) Schools, licensed day care, hospitals; (2) Residential; (3) Commercial; (4) Recreational; (5) Agricultural; and (6) Undeveloped land with permanent residence. Highest priority was given to Segment "A", the 8.31 mile segment of overhead, where five (5) schools are adjacent to or within 1,000 feet of the proposed 230 kV tie line. These schools include: Mt. Carmel High School, The Cambridge School, Innovation Academy, Dingeman Elementary, and Ellen Browning Scripps Elementary. While detailed engineering for an underground transmission line within Segment "A" has not been performed, the route is assumed to be the same as the overhead route for the Proposed Project, to the greatest extent possible. The schools are within an approximate four (4) mile portion of Segment "A", centering on an area where two major highways, Ted Williams Pkwy (Hwy 56) and Interstate I-15 cross the existing SDG&E ROW. The area also includes sections with extreme terrain making, undergrounding much more difficult and expensive to accomplish, if not impossible, not to mention the additional expense to go under the two major highways. These excessive costs would significantly increase the overall cost of the Project beyond the range of 4% of the total budgeted Project cost. The length of undergrounding for "low-cost" reduction measures within 4% of total Project cost would be reduced to less than the calculated length of 0.37 miles. Since equitable mitigation for an entire class is a desirable goal, and this "low-cost" measure of 4% of total Proposed Project cost would cover less than 9% of the four (4) mile distance, undergrounding as a "low-cost" field-reduction measure was not adopted. A more broadly effective "no-cost" measure is proposed for use under "Increasing structure height" in this Table. (see "Magnetic Field Reduction Measures Evaluated for the Project" below)				

[13] SDG&E Guidelines, p. 12: "When spending for "low-cost" measures would otherwise disallow equitable magnetic field reduction for all areas within a single land use class, prioritization can be achieved by considering location and/or density of permanently occupied structures on lands adjacent to the projects, as appropriate."

Segment(s)	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Estimated Cost to Adopt
B	Within existing franchise	Schools, Residential, Commercial, Undeveloped	**Increase trench depth**	**No**	**N/A**
	Reasons not adopted: Trench depth of the proposed TL230XX in Segment "B" is per SDG&E Standards designed to be at 3 feet top-of-conduit (TOC). This underground portion of the Proposed Project is the limiting factor for ampacity rating values due to degradation caused by heat created by compaction of underground installations. Increasing the depth of Segment "B" underground would further degrade line rating of the new 230 kV making it not meet the ampacity rating requirement for the Proposed Project. Therefore, this "low-cost" reduction measure was not considered for the underground portion, Segment "B" of the Proposed Project.				

VI. Magnetic Field Reduction Measures Evaluated for the Project

Per SDG&E's Guidelines this FMP is limited to an assessment of increasing structure height as a field reduction technique, and phasing circuits to reduce magnetic fields for those double circuit pole portions of the Proposed Project. Other techniques such as locating power lines closer to the center of the easement, reducing conductor (phase) spacing, placing overhead underground to reduce magnetic fields, and increasing trench depth were not implemented.

Locating power lines closer to the center of the easement: The alignment of the new steel poles in Segment "A" for TL 230XX and TL 13820 or TL 13811[14], and in Segment "D" for TL 6906 and TL 675 cannot move closer to center of easement due to other tie lines within the corridor and separation requirements. Segment "C" uses existing pole structures which already are as close to center of easement as possible. Segment "B" is underground and located as close to centerline of franchise without conflicting with other existing underground utilities. By design, the underground is on the south side of centerline where it passes the daycare center (The Kids Bay Learning Center) near the west end of the Segment. Therefore, no "no-cost" or "low-cost" alternatives were considered for this reduction measure.

Increasing structure height (increasing the height of the conductor from ground level): Per SDG&E Standards for 230 kV transmission lines and 138 kV / 69 kV power lines, either double circuit or single circuit with no distribution underbuild or single distribution underbuild, minimum sag height is 30 feet from lowest circuit wire to ground as per *GO-95 Design Standards* and 35 feet from lowest circuit wire for double underbuild. In some Segments in this Proposed Project there will be single distribution 12 kV underbuild.

[14] TL 13811 between Chicarita and Shadow Ridge Substations was previously named TL 13825 in 2013. Now the name "TL 13825" only includes the segment between Shadow Ridge and Batiquitas Substations.

After reviewing the Preliminary design plans for Segments "A" and "D" where new overhead poles will be installed[15], it has been determined that no-cost options exist while additional measures would not qualify as low-cost. The new design will utilize taller "soldiered" pole locations relative to the existing structures which allows wire sagging to become more uniform and minimizes the potential for blowout conflicts. In addition, the sag height was designed at heights consistent with those of existing structures. This proposed sag height averages a height increase of eleven (11) feet **(41 ft. sag)** providing a reduction in milligauss values of approximately **18%** at the closer (west) ROW without raising milligauss values at the opposite ROW. The proposed sag height for the 69 kV power lines in Segment "D" also averages a height increase of eleven (11) feet **(41 ft. sag)** providing a reduction in milligauss values of approximately **1%** at the closer (north) ROW without raising milligauss values at the opposite ROW. This should be considered as a **"no-cost"** EMF reduction measure for both Segments, as it indeed reduces fields at no additional Proposed Project cost. (See "no-cost" options below.)

While further reviewing of Segment "A" where nearby land uses include schools, and residential and commercial properties, raising pole heights beyond the initial design height was examined as a possible "low-cost" measure. Calculations indicate that an increase of 12 feet would yield a reduction of 15% in magnetic field values at the west edge of ROW, but a slight increase at the east edge. For height increases greater than 12 feet, calculations yielded only marginal decrease (less than 1%) at the east edge of ROW. Therefore, increasing structure height as a "low-cost" field reduction measure was rejected for Segment "A" of this Proposed Project.

Raising heights of the new 69 kV poles in Segment "D" beyond the initial design height also was examined as a possible "low-cost" measure. Calculations indicate that for sag height increases of 5 to 15 feet, the reduction in magnetic field values at the west edge of ROW would be no more than 1.5%, with a slight increase at the east edge. Even for a sag height increase of 40 feet, calculations yielded only 5% decrease at the west edge, and only a marginal decrease (less than 1%) at the east edge. Therefore, increasing height of the new 69 kV poles as a "low-cost" field reduction measure was rejected for Segment "D" of this Proposed Project.

Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower. Therefore, raising pole height was rejected for Segment "C".

Reducing conductor (phase) spacing: New poles needed in Segment "A" would have the conductor spacing configuration for 230/138 kV double circuit steel poles per "*SDG&E Electric Transmission Standards*", which provides optimum magnetic field reduction at edge-of-ROW. Segment "B", the underground portion of the Proposed Project, would use "*SDG&E Electric Transmission Standards*" for underground phase spacing. Segment "C", the existing power and transmission lines within the utility corridor (TL 23004, TL 230XX, TL 13804) would remain on existing poles with existing pole top configuration for double circuit poles per "*SDG&E Electric Transmission Standards*". Modifications to their existing conductor phase spacing would be out of scope of the Proposed Project. The new steel poles in the Proposed Project for Segment "D" regarding TL 675 and TL 6906 would comply with "*SDG&E Electric Transmission Standards*"

[15] Only existing structures will be used for the Proposed Project Segment "C", from Carmel Valley Road to Peñasquitos Junction where one (1) new steel pole will replace the existing steel lattice tower. Therefore raising pole height was rejected.

for 69 kV double circuit configurations which provide optimum magnetic field reduction. Therefore, reducing conductor phase spacing to reduce magnetic fields was rejected as a reduction technique.

Phasing Overhead (OH) Circuits to Reduce Magnetic Fields (Segment "A" and "D"): Reduction of magnetic field values (milligauss) through phasing techniques was considered and modeled for the Proposed Project for all overhead Segments where two tie lines share a common corridor. Modifying current phasing of any existing circuit needs to be done at both of the terminating substations for that circuit and therefore includes the entire circuit length. Where a portion of this distance becomes out-of-scope of the Proposed Project, changing existing circuit phasing was discarded as a field reduction measure since modifying those circuits phasing could inadvertently increase milligauss values in areas out-of-scope of this Project. However, the portion of Segment "A" where TL 13820 extends from Sycamore Canyon to Chicarita Substation was modeled to see if milligauss would be reduced by changing phase of either TL 13820 and/or TL 230XX. The milligauss values increased at edge-of-ROW when TL 13820 phasing was modified. Modeling performed to try and reduce magnetic fields in Segments "D" and the remaining portion of Segment "A" only included various phase configurations of the new transmission line, TL 230XX, since all other circuits extended out-of-scope of the Proposed Project. The Preliminary Design phase for new TL 230XX is A-B-C (top-to-bottom). Modeling for Segments "A" and "D" showed the proposed phasing of TL 230XX, **A-B-C (t-b),** provides lowest milligauss values throughout its path from Sycamore Canyon to Peñasquitos Substation. Therefore, no "no-cost" or "low-cost" alternatives were considered for this reduction measure of the overhead portion of the Proposed Project.

Phasing Overhead (OH) Circuits to Reduce Magnetic Fields (Segment "C"):
Reduction of magnetic field values through phasing techniques was considered and modeled for the Proposed Project Segment "C" where TL 23004 (C-B-A) and TL 23001(A-B-C) become a bundled circuit between San Luis Rey and Peñasquitos Junction and are located on the east side of existing structures (re-named TL 23004), to allow room for new TL 230XX tieline on the west side of the same structures. When these two tielines are bundled, each bundled pair of circuit wires must have the same phase. Since current flow of the new TL 230XX goes from north-to-south and new TL 23004 goes south-to-north, having the same phasing would provide lowest milligauss values at edge-of-ROW. By reverse phasing existing **TL 23004** to be **A-B-C (t-b)** the "new TL 23004" bundled circuit will be the same phase as TL 230XX (A-B-C). This provides a reduction in milligauss values of approximately **13%** at the west ROW and **36%** at east ROW. Therefore reverse phasing of existing TL 23004 when creating this bundled configuration with existing TL 23001 should be considered as a "no-cost" reduction measure for Segment "C". As part of the Proposed Project, minor changes at San Luis Rey and Mission Substations will be needed to provide for same phasing of this bundled configuration as it enters the substation.

Phasing Underground (UG) Circuits to Reduce Magnetic Fields: Reduction of magnetic field values (milligauss) through phasing techniques was considered and modeled for the Proposed Project Segment "B" underground. All overhead Segments show the new 230 kV TL230XX as a "bundled 900 kcmil ACSS/AW" circuit (two circuit wires per phase) which is installed as a "split-phase" configuration once installed in underground conduit. When undergrounding a "split-phase" single circuit tie line, phasing can be reversed on one set of circuit wires. Since current flows in the same direction for all circuit wires, reverse phasing one set of circuit wires will reduce milligauss values by approximately **97%** at edge-of-ROW, which

indeed reduces fields at no additional Project cost. Therefore reverse phasing of the "split-circuit" configuration should be considered a "no-cost" reduction measure for Segment "B".

Undergrounding to reduce magnetic fields: Reduction of magnetic field values (milligauss) through undergrounding was considered and modeled for the Proposed Project for overhead Segments where two or more tielines or power lines share a common corridor, a total of approximately 13.8 miles of the 16.7 mile total Project length. This is considered a "low-cost" reduction measure for these Segments and 4% of the total Proposed Project cost would provide for a length of approximately 0.37 miles of undergrounding. Per the *SDG&E Guidelines,* group prioritization for land use categories was used in determining how mitigation costs should be applied[16]. These priorities are: (1) Schools, licensed day care, hospitals; (2) Residential; (3) Commercial; (4) Recreational; (5) Agricultural; and (6) Undeveloped land. Highest priority was given to Segment "A", the 8.31 mile segment of overhead, where five (5) schools are adjacent to or within 1,000 feet of the proposed 230 kV tie line. These schools include: Mt. Carmel High School, The Cambridge School, Innovation Academy, Dingeman Elementary, and Ellen Browning Scripps Elementary. While detailed engineering for an underground transmission line within Segment "A" has not been performed, the route is assumed to be the same as the overhead route for the Proposed Project to the greatest extent possible. The schools are within an approximate four (4) mile portion of Segment "A", centering on an area where two major highways, Ted Williams Pkwy (Hwy 56) and Interstate I-15 cross the existing SDG&E ROW. The area also includes sections with extreme terrain making undergrounding much more difficult and expensive to accomplish if not impossible, not to mention the additional expense to go under the two major highways. These excessive costs would significantly increase the overall cost of the Project beyond the range of 4% of the total budgeted Project cost. The length of undergrounding for "low-cost" reduction measures within 4% of total Project cost would be reduced to less than the calculated length of 0.37 miles. Since equitable mitigation for an entire class is a desirable goal, and this "low-cost" measure of 4% of total Proposed Project cost would cover less than 9% of the four (4) mile distance, undergrounding as a "low-cost" field-reduction measure was not adopted. A more broadly effective "no-cost" measure is proposed for use under "Increasing structure height" in this Table. (see "Magnetic Field Reduction Measures Evaluated for the Project" below)

Increasing trench depth: Trench depth of the proposed TL230XX in Segment "B" is per SDG&E Standards designed to be at 3 feet top-of-conduit (TOC). This underground portion of the Proposed Project is the limiting factor for ampacity rating values due to degradation caused by heat created by compaction of underground installations. Increasing the depth of Segment "B" underground would further degrade line rating of the new 230 kV making it not meet the ampacity rating requirement for the Proposed Project. Therefore, this "low-cost" reduction measure was not considered for the underground portion, Segment "B" of the Proposed Project.

[16] SDG&E Guidelines, p. 12: "When spending for "low-cost" measures would otherwise disallow equitable magnetic field reduction for all areas within a single land use class, prioritization can be achieved by considering location and/or density of permanently occupied structures on lands adjacent to the projects, as appropriate."

VII. Magnetic Field Reduction Measures Recommended for the Project

Reduction of magnetic field values by increasing structure height as a field reduction technique was adopted as a viable method to reduce magnetic fields at the edge-of-ROW for the Proposed Project. The recommended field reduction techniques are:

A. "No-Cost" Field Management Technique:

Segment "A" and Segment "D" - After reviewing the Preliminary design plans for Segments "A" and "D" where new overhead poles will be installed the sag height was designed at heights similar to those of existing structures to minimize visual impact. This proposed sag height averages **41 feet** which achieves a maximum magnetic field reduction of **18%** for no underbuild or single underbuild, at the west edge-of-ROW without raising milligauss values at the east ROW for Segment "A". For Segment "D" there is a slight reduction of **1%** on the north edge-of-ROW with no increase at the south edge-of-ROW. This constitutes a "no-cost" EMF reduction measure, as it indeed reduces fields at no additional Project cost.

Segment "B" - Reduction of magnetic field values (milligauss) through phasing techniques was considered and modeled for the Proposed Project Segment "B" underground which would be a "split-phase" configuration once installed in the underground conduit. When undergrounding a "split-phase" single circuit tie line, phasing can be reversed on one set of circuit wires. Since current flows in the same direction for a "split phase" single circuit, reverse phasing one set of circuit wires will reduce milligauss values approximately **97%**, which indeed reduces fields at edge-of-ROW at no additional Project cost. Therefore reverse phasing of the "split-phase" configuration should be considered a "no-cost" reduction measure for Segment "B

Segment "C" - Reduction of magnetic field values through phasing techniques was considered and modeled for the Proposed Project Segment "C" where TL 23004 (C-B-A) and TL 23001(A-B-C) become a bundled circuit between San Luis Rey and Peñasquitos Junction and are located on the east side of existing structures (re-named TL 23004), to allow room for new TL 230XX tieline on the west side of the same structures. When these two tielines are bundled, each bundled pair of circuit wires must have the same phase. Since current flow of the new TL 230XX goes from north-to-south and new TL 23004 goes south-to-north, having the same phasing would provide lowest milligauss values at edge-of-ROW. By reverse phasing existing **TL 23004** to be **A-B-C (t-b)** the "new TL 23004" bundled circuit will be the same phase as TL 230XX (A-B-C). This provides a reduction in milligauss values of approximately **13%** at the west ROW and **36%** at east ROW. Therefore reverse phasing of existing TL 23004 to **A-B-C (t-b)** when creating this bundled configuration with existing TL 23001 should be considered as a "no-cost" reduction measure for Segment "C".

B. "Low-Cost" Field Management Technique:

There are no "low-cost" magnetic field reduction techniques recommended for the Proposed Project.

VIII. Summary of Calculated Magnetic Field Levels for the Transmission Portion of the Proposed Project

The following tables show the initial design and recommended ("no-cost") design magnetic field values (milligauss) and the percent change for SEG "A", SEG "B", SEG "C", and SEG "D" of the Proposed 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-ROWs, or edge-of-easement for all Segments. Since "increasing structure height" and "phasing circuit" field reduction techniques were the only viable techniques, other modeling tables were not included. The location of the Segments are included in the attached "Appendix 1".

Table 2: Segment "A" – Overhead TL 230XX from Sycamore Canyon Substation, north to Carmel Valley Rd.

SEG A			Raise SAG Height				
Overhead - Sycamore Substation to Carmel Valley Rd.							
Standard SAG Height 30 feet			Initial Design SAG Height 41 feet			Percent (%) Milligauss Reduction	
West	East		West	East		West	East
59.4	46.3		48.9	46.5		18%	0%

- Land Use = Schools, Residential, Commercial, Undeveloped Open Space
- Length = approx. 8.31 miles
- Right-of-Way = 200 ft.
- Make SAG similar to existing SAG height to avoid visual or aesthetic concerns
- See "**Appendix 1 – Segment A**" attached for location.

Table 3: Segment "B" – Underground TL 230XX within Franchise of Carmel Valley Rd.

SEG B			Reverse Phase Underground 10 Ft. South Centerline				
Underground - Within Franchise - Carmel Valley Rd.							
Initial Phase A-B-C_A-B-C			Reverse Phase A-B-C_C-B-A			Percent (%) Milligauss Reduction	
North	South		North	South		North	South
4.4	8.4		0.1	0.3		98%	96%

- Land Use = Daycare Center, Residential, Undeveloped Open Space
- Length = approx. 2.84 miles
- Right-of-Way = average 130 ft. (120 ft. – 170 ft.)
- Reverse Phase the Split Phase underground
- See "**Appendix 1 – Segment B**" attached for location.

Table 4: Segment "C" – Overhead TL 230XX from Carmel Valley Rd. south to Peñasquitos Junction on Existing Structures

SEG C			Reverse Phase bundled TL 23004 SA - MS				
TL 230XX_A-B-C							
Initial Phase A-B-C_C-B-A			Reverse Phase TL23004 A-B-C_A-B-C			Percent (%) Milligauss Reduction	
West	East		West	East		West	East
140.9	142.4		122.3	91.0		13%	36%

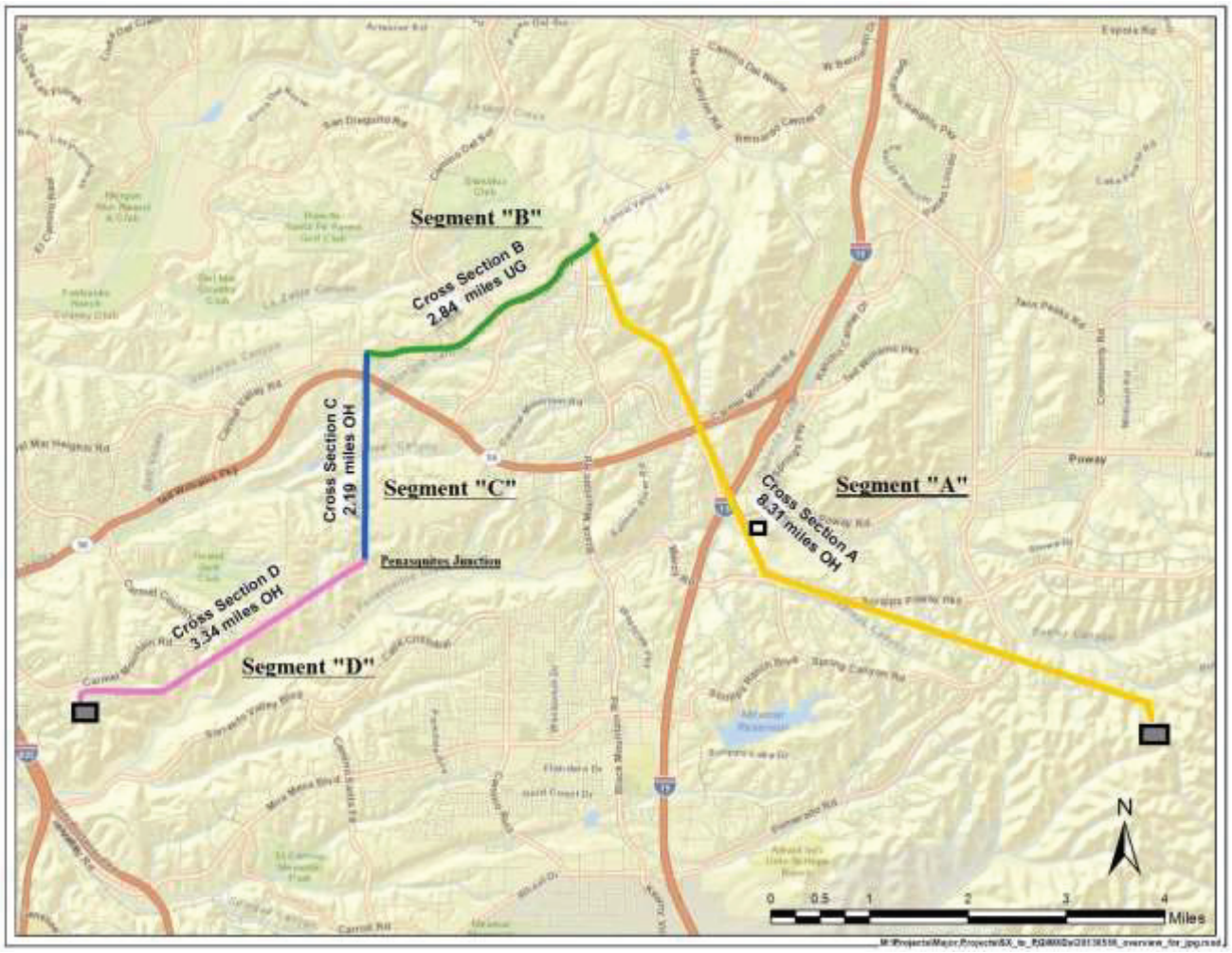
- Land Use = Residential, Undeveloped Open Space
- Length = approx. 2.19 miles
- Right-of-Way = 100 ft.
- Make new bundled TL 23004 **A-B-C (t-b)** by reverse phasing it at San Luis Rey and Mission Substation.
- See "**Appendix 1 – Segment B**" attached for location.

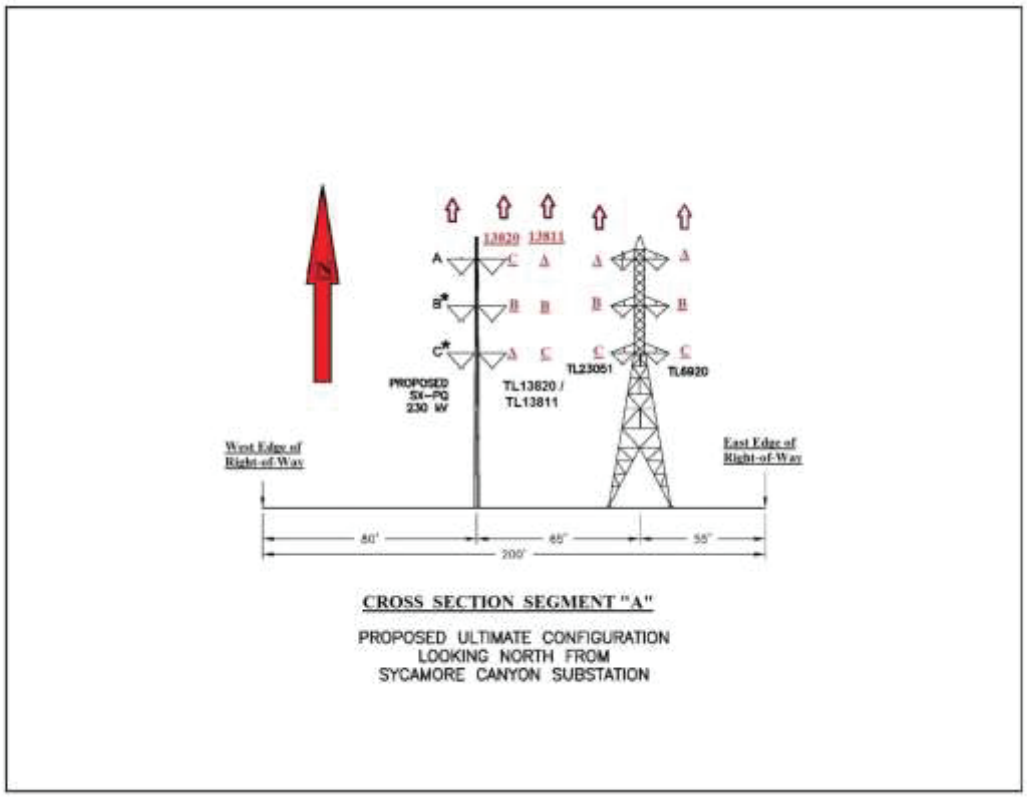
Table 5: Segment "D" – Overhead TL 230XX west from Peñasquitos Junction to Peñasquitos Substation

SEG D		Raise SAG Height				
Overhead - From SEG "D" easement to Penasquitas Substation						
Standard SAG Height		Initial Design SAG Height			Percent (%) Milligauss Reduction	
North	South	North	South		North	South
9.6	135.7	9.5	135.9		1%	0%

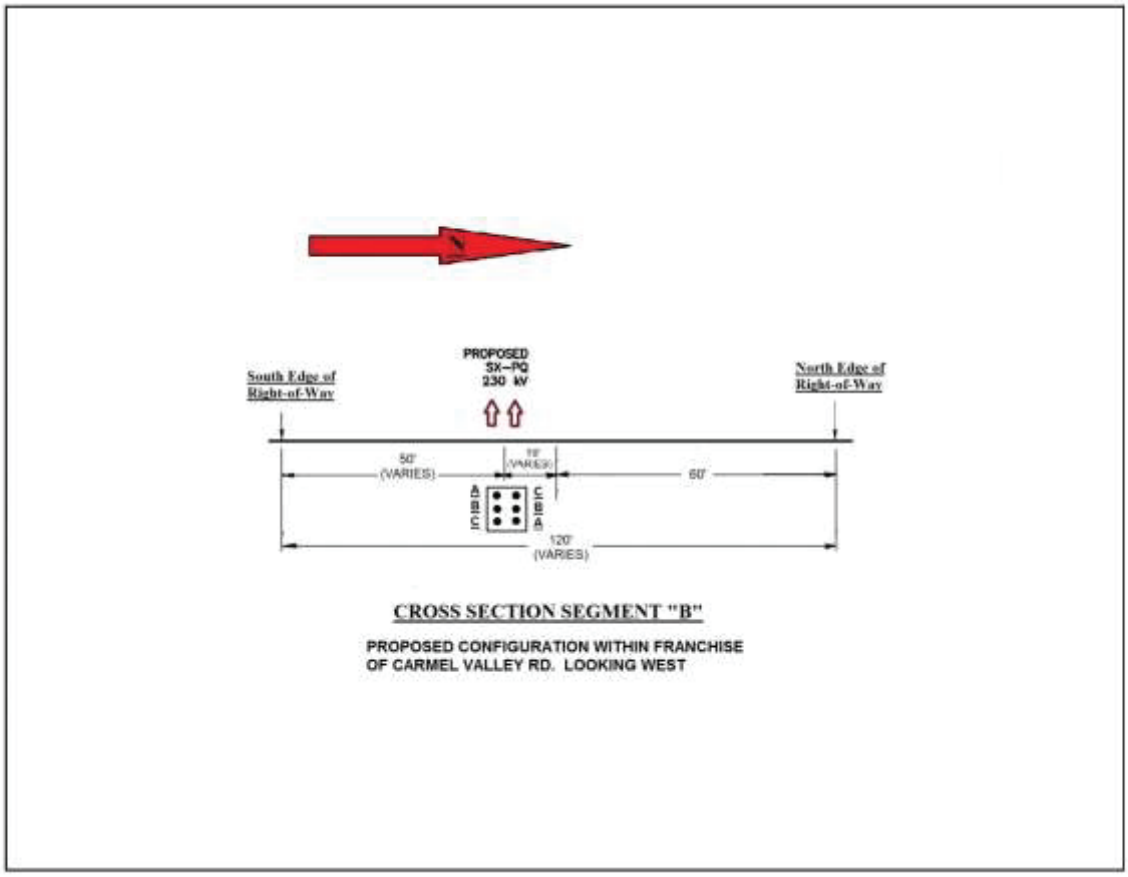
- Land Use = Residential, Undeveloped Open Space
- Length = approx. 3.34 miles
- Right-of-Way = 300 ft.
- Make SAG similar to existing SAG height to avoid visual or aesthetic concerns
- See "**Appendix 1 – Segment D**" attached for location.

Appendix 1
Proposed Project
Segment Map

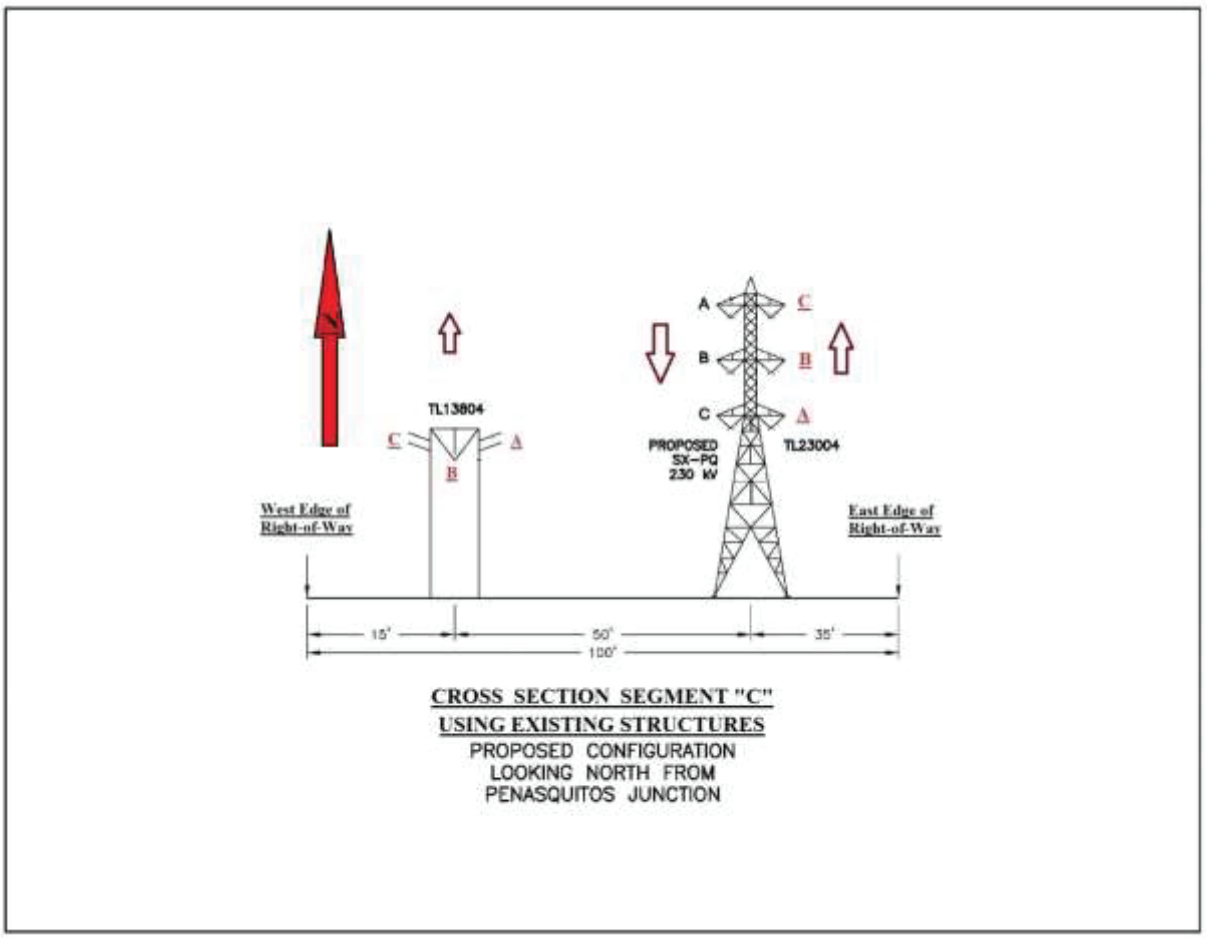




Approximate Location:	Within overhead easement, Sycamore Substation north to Carmel Valley Rd.
Transmission Circuits:	TL 13820, TL 13811, TL 23051, TL 6920, TL 230XX
Land Use:	Schools, Residential, Undeveloped Open Space
Length:	8.31 mi.
Right-of-Way Width:	200 ft.

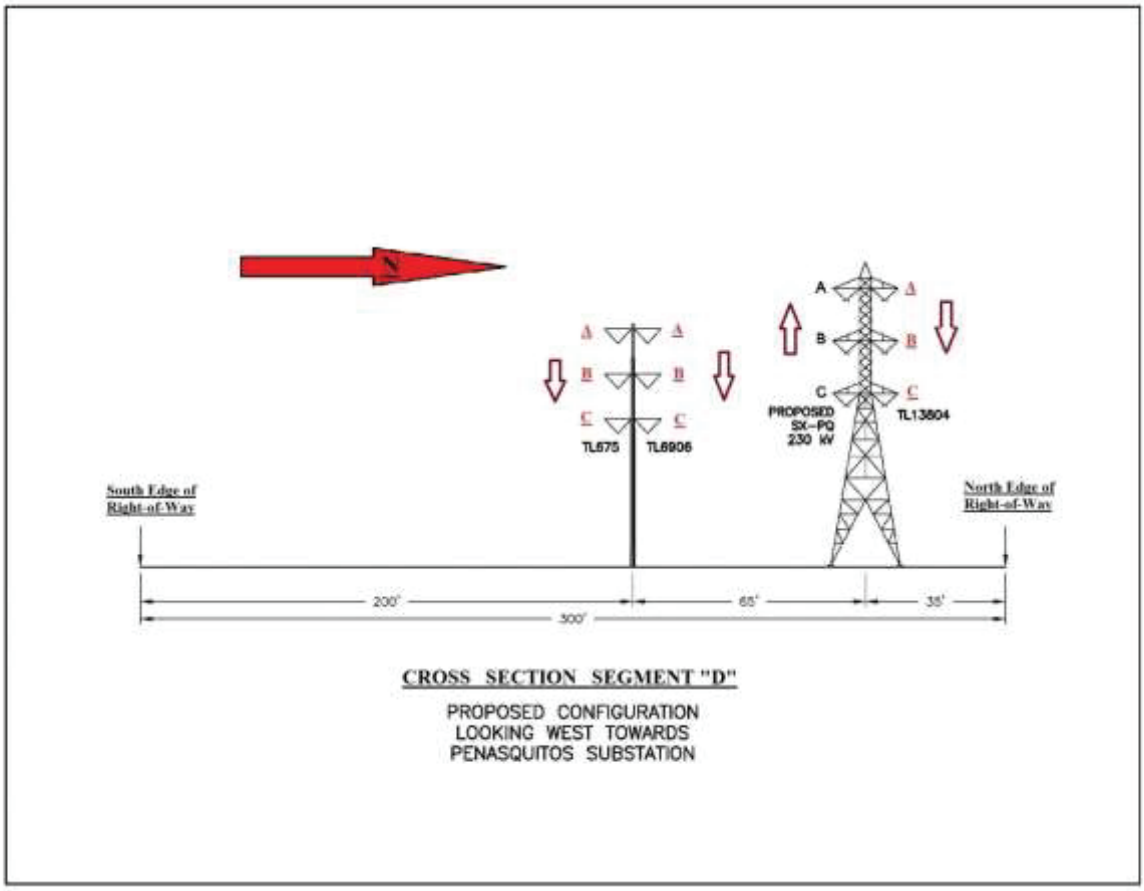


Approximate Location:	Underground within franchise of Carmel Valley Rd.
Transmission Circuits:	TL 230XX split phase
Land Use:	Daycare Center, Residential, Undeveloped Open Space
Length:	2.84 mi.
Right-of-Way Width:	130 ft. average (120 ft. – 170 ft.)



CROSS SECTION SEGMENT "C"
USING EXISTING STRUCTURES
PROPOSED CONFIGURATION
LOOKING NORTH FROM
PENASQUITOS JUNCTION

Approximate Location:	From Carmel Valley Rd. to Peñasquitos Junction
Transmission Circuits:	TL 13804, TL 230XX, TL 23004
Land Use:	Residential, Undeveloped Open Space
Length:	2.19 mi.
Right-of-Way Width:	100 ft.



CROSS SECTION SEGMENT "D"

PROPOSED CONFIGURATION
LOOKING WEST TOWARDS
PENASQUITOS SUBSTATION

Approximate Location:	From Peñasquitos Junction to Peñasquitos Substation
Transmission Circuits:	TL 675, TL 6906, TL 230XX, TL 13804
Land Use:	Residential, Undeveloped Open Space
Length:	3.34 mi.
Right-of-Way Width:	300 ft.