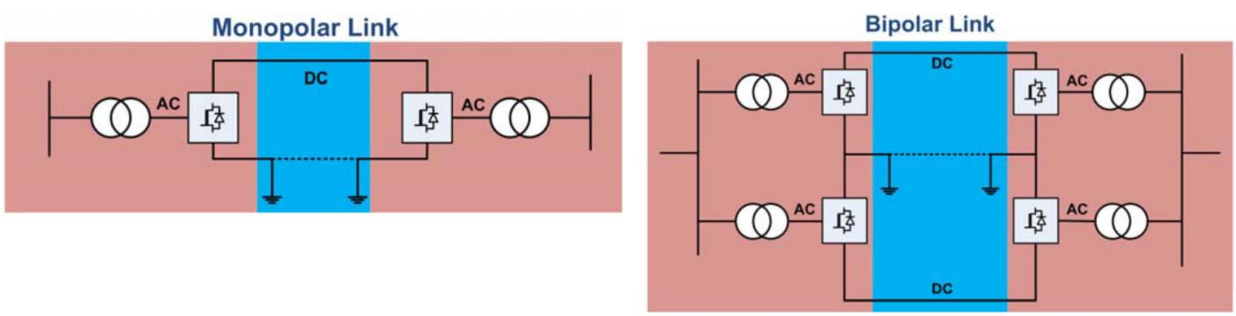
HVDC Transmission Configurations

HVDC transmission lines include the energized conductors for transmitting power and include some form of current return path using either earth electrodes or a lower voltage ground cable. When using earth electrodes, they are located at some distance (about 10 miles) from the converter stations and require a medium voltage overhead line to interconnect them to the system. Earth electrodes have a significant land requirement, and the use of earth return may have problems related to corrosion of long-buried metal objects, such as pipelines. Commonly HVDC submarine systems use a metallic return path by installing a lower-voltage ground cable. For an HVDC interconnection between the SCE and SDG&E transmission systems, the use of an earth return is not considered due to the added environmental concerns of installing the earth electrodes.

There are three primary ways to configure a HVDC transmission line between converters: monopole, symmetrical monopole, and bipole. Figure 16 shows the schematic configurations of monopolar and bipolar DC systems.

Figure 16: Monopolar and Bipolar DC Systems



Source: National Renewable Energy Laboratory, 2011

The choice of configuration type results in different numbers of subsea cables, which directly influence costs. The selection of a specific configuration also affects the power transfer capacity and reliability of the HVDC system.

- For a monopole configuration, one full-rated cable is installed as the "pole," and a second lower-voltage ground cable is installed as the return path. In the event that one cable is not operational, the system is out of service. (Examples are the existing Neptune Cable and Trans Bay Cable.)

- For a symmetrical monopole configuration, two full-rated cables are installed and operated at opposite voltage levels (plus/minus). A high-impedance ground is used, and a separate return path is not required. In the event that one cable is not operational, the system is out of service. (An example is the existing Cross Sound Cable.)

- For a bipole configuration, two full-rated cables are installed and operated at opposite voltage levels (plus/minus polarities), and a third lower-voltage ground cable is installed as the return path. In the event that one cable is not operational, the system can remain service at a 50 percent power transfer level.

Cable Types

There are three primary types of power cable used for HVDC submarine cables: fluid-filled cable, mass-impregnated cable, and extruded dielectric cable.

- *Self-contained fluid–filled* (SCFF) cables use a paper-tape type of insulation around the current carrying conductor. The insulating tape is impregnated with a low-viscosity synthetic fluid that is maintained in place by keeping the cable under pressure by oil-pumping stations at one or both ends of the cable.

- *Self-contained mass-impregnated* (MI) cables use a paper-tape type of insulation around the current carrying conductor. The insulating tape is impregnated with a very high-viscosity oil-based dielectric fluid that is substantially nondraining, even when installed at significant water depths, thereby avoiding the need for oil-pumping stations.

- *Self-contained extruded dielectric* cable used for HVDC uses a modified, cross-linked polyethylene (XLPE) insulation around the current carrying conductor.

- Generally SCFF cables have only been used for relatively short routes with MI cables accounting for more than 75 percent of installed HVDC cable. Considered a relatively new development, the modified XLPE-type cable has seen more recent use at lower voltage levels (150 kV DC).

Cable Components

Regardless of the type of insulation used, there is no standard design for submarine cables, and they tend to be custom-designed and fabricated to the specific requirements of each project. Submarine cables for high-voltage power transmission may typically contain multiple subcables and generally include the following typical components:

- Conductor. Usually copper due for high conductivity, although aluminum is sometimes used due to its lighter weight.

- Conductor screen. Semiconducting tape to maintain uniform electric field.

- Insulation. MI tape or modified XLPE around each conductor.

- Insulation screen. Extruded semiconducting material around each conductor cable to maintain uniform electric field.

- Sheath. Extruded lead alloy or conductive tape, copper or aluminum, around each conductor cable used as a path for fault and leakage currents.

- Anticorrosion jacket. Extruded polyethylene jacket over each conductor cable to insulate the metallic sheath from ground and to act as an impermeable water barrier.

- Fiber optic cable. Optionally used for communication.

- Fillers. As needed for voids between components.

- Binder tapes. Helically applied tape to maintain subcomponents in position within the overall cable.

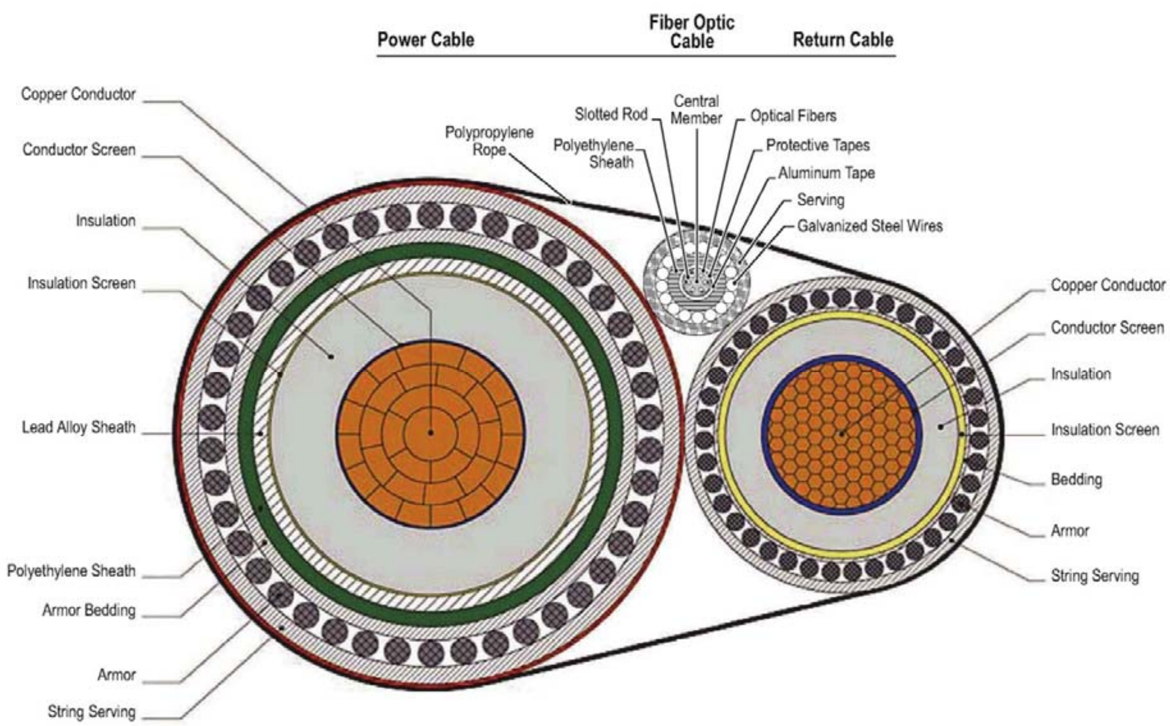
- Armor bedding. Polypropylene or polyethylene material around the overall cable for mechanical protection and to bed the metallic armor.

- Armor. Helically wrapped galvanized steel wires for mechanical protection.

- Outer sheath. Continuously extruded polymer sheath or helically wrapped polypropylene.

The cross-section of a typical monopole HVDC configuration with one ground return cable in a bundle is shown in Figure 17.

Figure 17: Cross-Section of HVDC Cable Bundle



Source: Trans Bay Cable, 2006

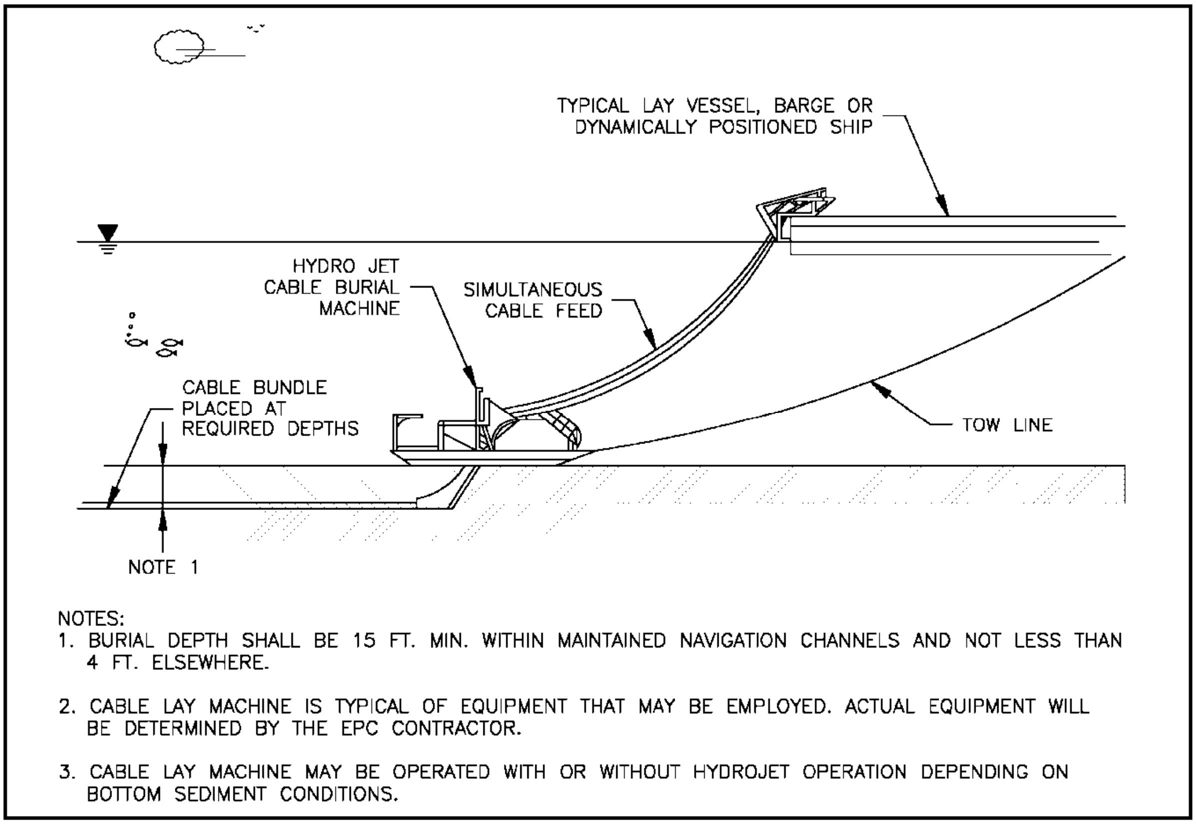
Submarine Cable Configuration

Similar to AC transmission lines, to transfer large amounts of power over an HVDC line, it may necessary to use more than one conductor/cable per voltage pole. In these instances the conductors may be "bundled" within a single submarine cable or they may be laid as separate cables. Similarly, the poles for an HVDC line may be bundled or laid separately. The determination of whether to bundle the poles of an HVDC line depends on project specifics and several factors, such as size of the conductors, cost, and reliability.

Submarine HVDC cables may be placed in a couple of ways, including direct laying on the bottom or trenching into the bottom. Directly laid cables may be left exposed on the bottom or there are a variety of coverings that can be used to protect the cables from currents and or mechanical damage from fishing or anchor dragging. Cable covering may employ rock coverage, concrete mattress placement, or split pipe covering. Trenching or plowing the cable into the seafloor provides simultaneous lay and burial. For trenched cables they may be buried using hydrojetting at the time of laying or they can be laid on the bottom and then trenched in after the initial cable lay. Post-lay burial may involve use of a remotely operated vehicle (ROV). The cable trench results in a disturbed area roughly a meter wide. The depth of cable trenching depends on the composition of the bottom, and cable can be buried at depths up to 10 meters.

The submarine cable installation process is illustrated in Figure 18.

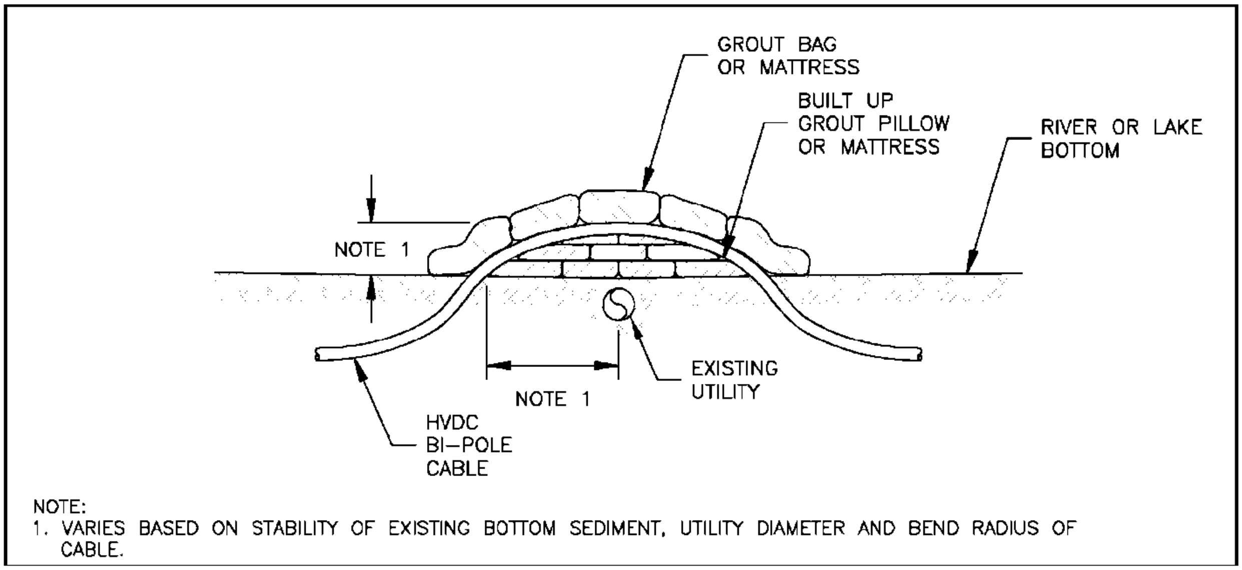
Figure 18: Submarine Cable Installation Process



Source: Champlain Hudson Power Express, 2013

Cable covering and armoring for providing protection for crossing existing utility pipelines or cables may use flexible concrete blankets or mattresses lowered into place around the existing utilities and over the submarine cable, as illustrated in Figure 19.

Figure 19: Submarine Cable Protection Measures



Source: Champlain Hudson Power Express, 2013

Precisely placing the submarine cable on the sea floor depends upon the water depth and positioning systems used on the cable-laying ship. Sophisticated monitoring and control systems can control cable placement to within 5 to 10 percent of the depth of water where the cable is being placed. When more than one cable is being placed, they may be horizontally positioned relatively close to each other. Horizontal spacing of a bipole, two-cable system would need to provide a sufficient buffer so that the second cable does not disturb or impinge on the first cable. The degree of control in placing the cables may dictate spacing on the order of 5 to 10 meters, increasing as water depths become greater. In addition, the potential future need to grapple one of the cables to raise it for repair may also require some minimum spacing.

Routing/laying of submarine cable also needs to consider the slope of the seafloor and/or the need for gradual turns. Cable routing should minimize traversing underwater slopes, because installation on steep slopes requires anchoring the cables to the sloping seafloor. Cable anchorage may be necessary for direct laid cable on slopes greater than 30 degrees. Slopes of 45 degrees or steeper should be avoided to the greatest extent possible, as these areas would require more complex anchorages and pose additional risks to the cable. The alignment generally cannot follow course changes that vary more frequently than the length of cable that is suspended from the back of the cable laying ship. The alignment should follow gradual course changes (no more than 30 degrees).

Coastal Landings

Coastal landings of the submarine cables would normally be housed within a durable conduit or pipe to add protection as the cables cross between the coastal zone and the onshore underground.

Coastal landings of the cables may be installed using either a direct lay approach or horizontal directional drilling (HDD). The direct lay approach requires soil or sandy bottom that allows the cables to be installed using conventional excavation methods, such as jetting or trenching. To directly bury the cable across a beach or sandy bottom, it may be suspended by floats from the offshore vessel and lowered into a trench, as shown in Figure 20.

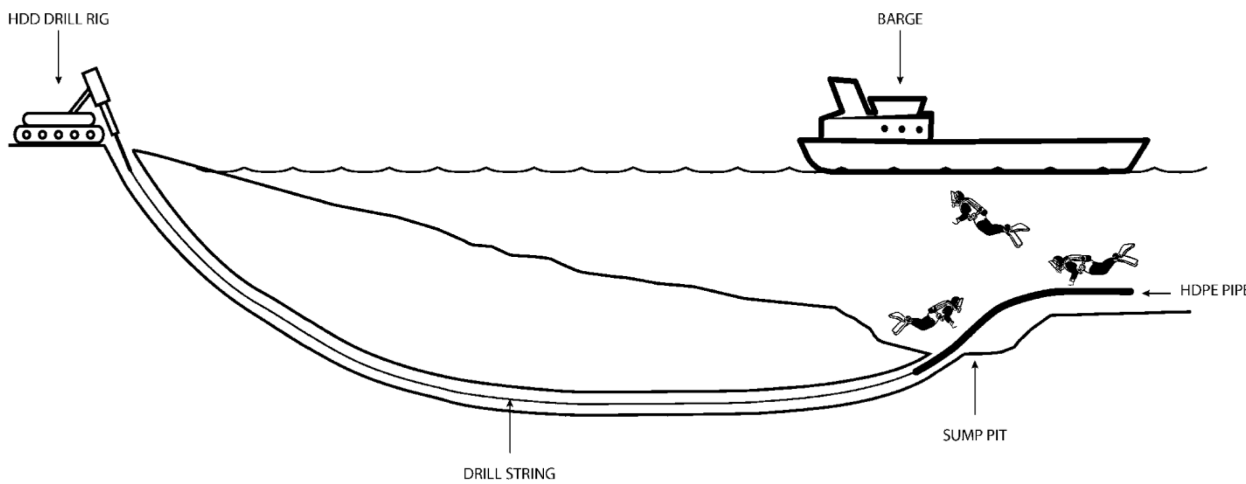
Figure 20: Coastal Landing of Buoyed Cable

Source: Sharples, 2011

Where a steep slope occurs, HDD may be used to bring the submarine cable onto land areas. HDD can be characterized as drilling a microtunnel through the ground and installing a protective pipe into this microtunnel. The submarine cable is then installed within the pipe. HDD can be used in soils or bottom conditions that are not conducive to jetting or trenching. HDD can also mitigate construction in environmentally sensitive shore areas by passing beneath tidal zones, coastal features, dunes, or other shoreline critical habitat. The protective pipe installed via HDD generally ends once reaching water depths of 70 to 100 feet or a distance of up to 2,500 feet. This 2,500-foot limit is not dictated by HDD technology, but rather is due to the limitations on the maximum distance that a submarine cable could be pulled through a pipe due to cable characteristics and strength. HDD construction methods require a work area onshore of roughly one to two acres for pipe laydown, drilling pads, and cable pulling equipment. This work area can be set back from the shore area as necessary, but the setback is limited by the 2,500-foot cable pulling distance.

Figure 21 shows the arrangement of a coastal landing constructed by HDD.

Figure 21: Coastal Landing of Cable Installed by HDD



Source: Pacific Gas and Electric Company, 2012

Terrestrial Underground Cable Configuration

Once a submarine cable makes landfall, there is typically a transition from a submarine-type cable to an underground-type cable. The transition point is installed in a large underground vault 15 to 20 feet wide, 30 to 40 feet long, and 10 feet high. The underground cable has a similar configuration to the submarine cable, but without the armoring that protects the cable in the marine environment. Removing the armoring reduces the weight of the cable and facilitates placing it in an underground trench or pulling into an underground duct bank.

Between coastal landings and the converter stations, underground cable would be placed in a trench and/or duct bank. There are several considerations for placing underground high-voltage cables. In general, it is preferred to place the cable in lengths as long as possible and to minimize the number of cable splices, as these can be a source of cable failure. When placing underground cables, there are also limitations on the bending radius that can be used for turns in the cable route and, in the case of cables pulled into duct banks in lieu of being laid in an open trench, pulling tensions need to be kept within an allowable range. The pulling tension when placing cables is a function of the cable weight and the friction within the duct the cables are pulled into. Of these two factors, the cable weight is the factor that varies the most from project to project and depends upon the specific electrical characteristics required for the cable.

The choice between placing underground cable as direct bury in an excavated trench or in an underground duct bank is dictated mostly by the nature of the area the cable route passes through.

The use of direct bury is most common and practical in rural or open areas, where there are few man-made obstructions or conflicting land uses that would preclude opening long sections of open trench and having a large amount of cable laying and trench excavation equipment along the cable route for extended periods. When direct bury methods are used, the cable route frequently is adjacent to or in close proximity to a roadway as these roads represent an existing linear corridor or right-of-way and they greatly facilitate movement of equipment. In cases where direct bury can be used, the dimensions for a trench with two HVDC cables would generally be a depth of at least 3 to 4 feet and of similar width. In this form of construction, the cables would be placed within the trench and surrounded by some type of homogeneous thermal backfill. It is also common to place a thin concrete cap above the cables and thermal fill as a physical barrier to protect the cable from unintended dig-ins. Native soils are then used as backfill to final grade. For direct bury cable, the distance between cable splices is generally dictated by the length of cable that can be manufactured and placed on a cable reel for shipping. Again, the length of cable on a reel will be project-specific, depending upon the size and characteristics of the cable and any transportation limits, but generally several thousand feet and as much as a mile or more of cable can be placed on a cable reel.

When splices are made in direct bury cable, these can be placed either in a cable pit or cable vault. During construction the cable splice area needs to be a controlled environment to manage contamination and limit exposure to the elements during splicing. Since cable splices can be a source of cable failure, there is a higher probability of a potential need to access the cable splices after construction is complete and the cables are in service. This presents a choice of whether to use a cable vault that provides immediate access to the splices or to use a cable pit that is much less costly but would require additional repair time for careful excavation to expose the splices. In any event, greater physical separation is provided between the cables in splice areas to provide working room so for a short distance a cable pit or cable vault will require a wider footprint of 10 to 20 feet.

The use of a cable duct bank and vault system is most common and practical in developed suburban and urban areas where there are many man-made obstructions or conflicting land uses that make it impractical to open long sections of trench and have a large amount of cable laying and trench excavation equipment along the cable route for extended periods. In this environment, securing a continuous linear right-of-way is extremely difficult, meaning that when duct banks methods are used, the cable route is most often beneath city streets or other disturbed rights-of-way. Placing the cables within a conduit provides protection against external damage and heat management. A backfill of low thermal resistivity material is typically placed around the conduits to aid in transferring heat away from the conductors. This form of construction also allows the construction of the duct bank and placement or pulling of the cable to occur as two construction activities.

The excavation of a trench to construct a duct bank holding two HVDC cables in an urban environment would need to address other existing underground utilities or facilities and could generally be a depth of 8 to 12 feet and a width at the surface of 4 to 6 feet. However, if individual duct banks are used for each cable in a bipole configuration, the duct bank for individual cables could be as few as two feet wide and as shallow as three feet. Along underground portions of the HVDC route, underground vaults would also need to be installed. Based on cable-pulling limitations, these vaults could be spaced roughly anywhere from every 1,200 to 2,000 feet apart. The distance between underground vaults would be dictated by the specific cable design. Cable vaults may also be required at a smaller spacing as needed where the cable route makes significant turns or changes in alignment. From the foregoing it can be seen that a cable duct bank and vault system can have a substantial amount of variance from one project to the next as dictated by the specifics of the urban environment and the design of the HVDC cable. Underground vaults would be similar to the vault where the transition from submarine cable to terrestrial cable occur. Vaults containing cable splices and their sizes would again depend upon the cable design but are typically 15 to 20 feet wide, 20 to 30 feet long, and 10 feet deep.

HVDC System Suppliers and Manufacturers

HVDC systems and high-voltage power cables (submarine and underground) rely upon very specialized technologies, for which there are a limited number of manufacturers and installers. Worldwide there may be a half-dozen to a dozen companies that can manufacture and install projects of this type. For this reason, it is most common that a turnkey or design-build approach is used to complete HVDC and submarine cable projects.

Major HVDC Installations Reviewed

Worldwide HVDC Installations

The earliest major HVDC systems came on-line in the 1950s and 1960s. Some of the original applications in Sweden and New Zealand were for submarine crossings, and these have remained in service, although many early HVDC systems have been upgraded in recent decades. About 100 systems are in use globally, with the lengths of the lines, service voltages, and power rating capacities growing steadily over the years. Among the largest, completed in 2010, are overhead HVDC systems completed in China ranging up to distances of more than 1,000 miles and more than 5,000 MW capacity. (Electric Power Research Institute, 2008; University of Idaho, 2012)

California is served by three major HVDC transmission lines: the 3,100 MW Pacific Intertie; the 2,400 MW Intermountain Power Project (Path 27), and the 400 MW Trans Bay Cable. The Pacific Intertie and Intermountain Project are long-distance overhead lines for importing out-of-state power to Southern California. The only HVDC transmission line within the California bulk transmission system is the submarine Trans Bay Cable in the San Francisco Bay, which was placed into service in late 2010.

Table 6 includes a sampling of HVDC installations illustrating the range of voltages, capacities, and distances crossed. The table identifies projects that have included significant lengths of submarine cable, although for some projects, the length may be a combination of submarine and terrestrial segments. Table 7 provides a broader overview of worldwide HVDC projects.

Table 6: Notable Recent HVDC Projects and Successful Submarine Installations					
Name of Project (Technology)	**Location**	**Year Online**	**Maximum Depth of Water (feet)**	**Power Rating (MW)**	**Length of HVDC Submarine**
Trans Bay Cable	USA, San Francisco Bay	2010	100	400	53 mi underwater
Neptune Cable	USA, New Jersey–New York	2007	80	660	50 mi underwater; 64 mi total
Cross Sound Cable	USA, Connecticut–New York	2002	115	330	24 mi underwater
Cross Channel	UK-France	2011	140	2,000	29 mi underwater; 45 mi total
New Zealand Inter Island	New Zealand	1992	760	1,240	379 mi total
Grita	Greece-Italy	2001	N/A	500	196 mi total
Estlink	Estonia-Finland	2006	N/A	350	65 mi total
Basslink	Australia, Victoria-Tasmania	2006	N/A	500	180 mi submarine; 217 mi total
Norned	Norway-Netherlands	2008	450	700	360 mi total
Jindo-Jeju	Korea, Mainland-Jeju	2011	N/A	400	65 mi total
Britned	UK-Netherlands	2011		1,000	161 mi total
Murraylink	Australia, S. Australia–Victoria	2002	N/A	200	110 mi underground

Source: Aspen, 2014

Table 7: Overview of Worldwide HVDC Projects					
Name of Project (Technology)	**Location**	**Online**	**Power Rating (MW)**	**DC Voltage (kV)**	**Length of HVDC Line/Cable (miles)**
Konti-Skan 1 (Merc)	Denmark-Sweden	1965	250	±250	112
New Zealand Hybrid Inter Island Link (Merc)	New Zealand	1965	600	±250	378
Sacoi 1 (Thy)	Italy	1965	200	200	239
Pacific Intertie (Merc)	USA	1970	1,440	±400	844
Nelson River 1 (Merc)	Canada	1973	1,854	±463	552
Skagerrak I (Thy)	Norway-Denmark	1976	275	±250	149
Skagerrak II (Thy)	Norway-Denmark	1977	275	±250	149
Square Butte (Thy)	USA	1977	500	±250	464
Nelson River 2 (Thy)	Canada	1978	900	±250	583
Hokkaido-Honshu (Thy)	Japan	1979	150	125	104
Hokkaido-Honshu (Thy)	Japan	1980	300	250	104
Pacific Intertie (Merc)	USA	1982	1,600	±400	844
Gotland II (Thy)	Sweden	1983	130	150	62
Itaipu 1 (Thy)	Brazil	1984	1,575	±300	487
Itaipu 1 (Thy)	Brazil	1985	2,383	±300	487
Nelson River 2 (Thy)	Canada	1985	2,000	±500	583
Pacific Intertie Upgrade (Thy)	USA	1985	2,000	±500	844
Des Cantons–Comferford (Thy)	Canada-USA	1986	690	±450	107
Intermountain Power Project (Thy)	USA	1986	1,920	±500	487

Itaipu 1 (Thy)	Brazil	1986	3,150	±600	487
Gotland III (Thy)	Sweden	1987	260	±150	64
Itaipu 2 (Thy)	Brazil	1987	3,150	±600	499
Konti-Skan 2 (Thy)	Denmark-Sweden	1988	300	285	93
Pacific Intertie Expansion (Thy)	USA	1989	3,100	±500	844
Gesha (Gezhouba-Shanghai) (Thy)	China	1990	1,200	±500	620
Rihand-Delhi (Thy)	India	1991	750	500	505
New Zealand Inter Island (Thy) *[Depth: 760 feet]*	New Zealand	1992	1,240	+270/-350	379
Rihand-Delhi (Thy)	India	1992	1,500	±500	505
Hokkaido-Honshu (Thy) *[Depth: 780 feet]*	Japan	1993	600	±250	104
Sacoi (Codrongianos and Suvereto) (Thy)	Italy-Corsica-Sardinia	1993	300	±200	239
Skagerrak III (Thy)	Norway-Denmark	1993	500	±350	149
Baltic Cable (Thy)	Sweden-Germany	1994	600	450	162
Kontek (Thy)	Denmark-Germany	1995	600	400	106
Sylmar East (Valve Reconstruction) (Thy)	USA	1995	550	500	744
Haenam-Cheju (Thy)	Korea	1997	300	±180	63
Leyte-Luzon (Thy)	Philippines	1998	440	350	282
Gotland HVDC Light (Tra)	Sweden	1999	50	±60	43
Kii Channel (Thy) *[Depth: 190 feet]*	Japan	2000	1,400	±250	63
Swepol Link (Thy)	Sweden-Poland	2000	600	±450	157
Grita (Thy)	Greece-Italy	2001	500	400	196
Thailand-Malaysia (Thy)	Thailand-Malaysia	2001	300	±300	68

Tian-Guang (Thy)	China	2001	1,800	±500	595
Cross Sound (Tra)	USA	2002	330	±150	25
Murraylink (Tra)	Australia	2002	200	±150	110
East-South Interconn. II (Thy)	India	2003	2,000	±500	899
Three Gorges–Changzhou (Thy)	China	2003	3,000	±500	533
Celilo (Valve Replacement) (Thy)	USA	2004	3,100	±400	744
Gui-Guang I (Thy)	China	2004	3,000	±500	608
Three Gorges–Guangdong (Thy)	China	2004	3,000	±500	583
Konti-Skan 1 (Thy)	Denmark-Sweden	2005	250	±250	112
Basslink (Thy)	Australia	2006	500	400	217
Estlink (Tra)	Estonia-Finland	2006	350	±150	65
Three Gorges–Shanghai (Thy)	China	2006	3,000	±500	558
East-South Interconn. II Upgrade (Thy)	India	2007	2,500	±500	899
Gui-Guang II (Thy)	China	2007	3,000	±500	744
Neptune (Thy)	USA	2007	660	500	65
Cahora-Bassa (Thy)	South Africa–Mozambique	2008	1,920	±533	880
Norned (Thy) [depth: 450 feet]	Norway-Netherlands	2008	700	±450	360
Ballia-Bhiwadi (Thy)	India	2010	2,500	500	496
Caprivi (Tra)	Namibia	2010	300	350	589
Hulunbeir (Inner Mongolia) – Shenyang (Thy)	China	2010	3,000	± 500	570
Intermountain Power Project Upgrade (Thy)	USA	2010	2,400	± 500	487

Storebaelt (Thy)	Denmark	2010	600	400	35
Three Gorges–Shanghai 3 (Thy)	China	2010	3,000	±500	620
Trans Bay Cable (Tra)	USA	2010	400	200	55
Xianjiaba-Shanghai (Thy)	China	2010	6,400	±800	1,228
Yunnan-Guangdong (Thy)	China	2010	5,000	±800	879
Britned (Thy)	UK-Netherlands	2011	1,000	±400	161
Fenno-Skan II (Thy) *[Depth: 300 feet]*	Finland-Sweden	2011	800	500	188
Jindo-Jeju (Thy)	Korea	2011	400	±250	65
Ningdong-Shangdong (Thy)	China	2011	4,000	±660	828

Source: U. Idaho, 2012 (abridged); CIGRE, 2009. Converter Technology: Mercury (Merc), Thyristor (Thy), or Transistor (Tra).

Domestic HVDC Proposals Under Development

Other major HVDC projects that are under development elsewhere in the United States are briefly described below. Aside from the Hawaii proposal, these projects are sponsored by investment companies that aim to develop a transmission interconnection that may be used by others to exchange power, for a fee, similar to how a toll road may be paid for by users. Development timelines typically extend up to 10 years.

Port Angeles–Juan de Fuca Transmission Project. The U.S. Department of Energy (DOE) released a final EIS in October 2007 and issued a decision in May 2008 to implement this 34-mile international HVDC line from the greater Victoria area, British Columbia, Canada, across the Strait of Juan de Fuca (depths up to about 500 feet) to the United States at Port Angeles, Washington. The application was made in December 2004 by Sea Breeze Olympic Converter LP (under Sea Breeze Power Corp.) to secure approvals from DOE for the cable that would be capable of carrying up to 550 MW in either direction. The DOE's Bonneville Power Administration (BPA) offered the terms for interconnection with the federal Columbia River Transmission System, which is owned and operated by BPA, and the DOE's Office of Electricity Delivery and Energy Reliability issued a Presidential permit to Sea Breeze for the border crossing. Approvals from the Canadian National Energy Board remain pending.

Champlain Hudson Power Express Transmission Line Project. The U.S. DOE, Office of Electricity Delivery and Energy Reliability, released a draft EIS in September 2013 for an international submarine and overland HVDC line from the Canadian border about 336 miles through New York State, under Lake Champlain (with water depths approaching 400 feet) and in the Hudson River. The application for a Presidential permit was made in January 2010 by Champlain Hudson Power Express, Inc. (under Transmission Developers, Inc.) for the line, which would deliver 1,000 MW to the New York City grid. Any decisions or approvals for this project would occur after release of a final EIS.

Hawaii Inter-Island Renewable Energy Program (HIREP). The Hawaii Department of Business, Economic Development and Tourism and Hawaiian Electric Co. (HECO) have jointly studied the feasibility of a third party developing a 400 MW HVDC cable system in the ocean (depths up to about 2,600 feet) between Oahu and other islands with abundant renewable energy resources. The HIREP studies were triggered by a statewide renewable energy goal being set in 2008, and the DOE initially announced and then amended its notice of preparing a programmatic EIS in 2010 and 2012, respectively. Although various planning-level studies have been commissioned by the State of Hawaii (Navigant Consulting, Inc., 2011) and prepared for DOE by the National Renewable Energy Laboratory (NREL), no project application has yet been filed.

Description of Trans Bay Cable

Trans Bay Cable LLC (TBC) owns and maintains the Trans Bay Cable, a 400 MW HVDC transmission line that includes 53 miles of underwater cable in the San Francisco Bay and Carquinez Straits from Pittsburg, in Contra Costa County, to Potrero Point in San Francisco. The project was developed in cooperation with the City of Pittsburg and Pittsburg Power Company (a municipal utility). In early 2004, TBC started the environmental review process, and the project came on-line in late 2010. The City of Pittsburg acted as the lead agency under CEQA and certified the final environmental impact report in November 2006. Allowing one year for feasibility studies prior to starting the environmental review, the development timeline for TBC was about seven years.

The transmission line includes an onshore HVDC converter station at each endpoint, each with a footprint of about 5.5 acres, within sites that are smaller than 8 acres. Short (0.3 mile) AC cable and overhead transmission lines connect the HVDC converter stations to the PG&E Pittsburg and Potrero substations.

During cable installation most of the cable alignment, except at utility crossings, was buried to a depth of 3 to 6 feet in the San Francisco Bay floor using a hydroplow. At utility crossings the cable was laid on top of existing pipelines and cables, which are protected from the overlying cable by concrete mattress or rock riprap. The cable bundle, which consists of a power transmission cable and a return cable with a fiber-optic cable for communication between the converter stations, is about 10 inches in diameter.

Since coming on-line, the line has achieved a high level of service. The owner of the system filed for subsequent environmental review of submarine maintenance. The owner also recently proposed to add black start capability. The black start capability, or "dead bus energization," would improve the functionality of the existing line if it is tripped out of service. Each of these changes is described below.

Maintenance Requirements

To conduct maintenance along the areas where the cable is exposed, TBC applied to the U.S. Army Corps of Engineers (USACE) to allow in-water activities needed to protect the cable over a 10-year period. Over the next 10 years, TBC would need to add protection to locations that coincide with areas where the cable could not be buried or where the current has exposed the buried utilities. TBC seeks approval for placing concrete mattresses and rock fill in areas surrounding the exposed cable. The maintenance activities include hand jetting to increase the depth of the burial of the cable in sand and sediment, placing additional protective mattresses, and adding rock fill to support an eroded area where the cable crosses over a pipeline. These activities would mitigate environmental impacts by adhering to seasonal work windows, slowly moving the concrete and rock fill into position, and using low-pressure jets to minimize disturbance and turbidity (U.S. Army Corps of Engineers, 2013).

Upgrading to Provide Black Start Capability

TBC plans to modify the existing HVDC line to allow energizing the Potrero 115 kV bus in the event of a loss of power in San Francisco coinciding with a loss in service of the cable. The California ISO approved the Dead Bus Energization Project in early 2013. This project would allow TBC to energize the HVDC cable so it could quickly supply power from Pittsburg to Potrero to foster restoring service to a portion of San Francisco. The upgrade would install fast-ramping generation, potentially two 1.5 MW units, at TBC's Potrero substation to establish bus voltage and frequency allowing power to flow from Pittsburg. TBC hopes to place this feature into service in 2015 (California Independent System Operator, 2013). Depending on the final design, the new generation could cause environmental impacts as a minor emergency-use-only stationary source of air pollution and mechanical noise.

Perspective on the Trans Bay Cable

The TBC project and other projects worldwide demonstrate that the HVDC technology is proven and viable. The TBC project achieved commercial operations in November 2010, with about nine months of delays, and it was the first use of VSC technology supplied by Siemens (called HVDC Plus) (Navigant Consulting, Inc., 2011). The technology has become more common, and a 2010 survey of potential developers for the Hawaii Inter-Island cable project found that a VSC HVDC system would be the likely choice of technology for that application, which involved radially connecting remote wind farms. However, the potential developers at that time held concerns with the commercial status of the VSC technology. As a competing manufacturer of similar technology, ABB (called HVDC Light) has commissioned at least 10 other VSC HVDC facilities elsewhere in the world (ABB, 2013). During the subsequent years of operation, relatively minor submarine maintenance activities have been necessary, and the proposal to add black start capability indicates an ongoing interest in investing in the TBC to improve its capabilities.

Regulatory Requirements for Submarine-Based Alternative

This section summarizes the regulatory requirements for submarine cables in general and identifies permits or approvals potentially required for a new submarine HVDC cable between the SCE and SDG&E territories. Table 8 on page 97 lists the permits that may be required for the submarine HVDC cable. Applicable agency jurisdictions and laws are also described below.

Lead Agencies for NEPA and CEQA

The lead agencies carry the primary burdens for conducting the environmental impact assessment, preparing environmental documentation, ensuring the appropriate level of public review, and coordinating consultation with every involved agency.

The USACE has jurisdiction over structures and work in navigable waters, and the USACE would be the likely federal lead agency in the NEPA process.

Either the California Coastal Commission or the California State Lands Commission would be likely to take the role of lead agency in the CEQA process.

In Chapter 4, the section on "Environmental Considerations" elaborates on agency jurisdiction and highlights the timelines for the environmental review process and other issues that may influence the viability of installing a new submarine cable system.

Ocean Jurisdiction

In general, offshore construction activities are under State of California jurisdiction if they occur within 3 nautical miles of the shoreline, and federal jurisdiction applies to construction activities more than 3 nautical miles from shore.

Federal Submerged Lands Act (43 United States Code (U.S.C.) § 1301 et seq.) granted ownership of lands and resources within 3 nautical miles (5.6 kilometers) of the shore to California (and other coastal states).

Outer Continental Shelf (OCS) Lands Act (43 U.S.C. § 1331 et seq.), passed in coordination with the Submerged Lands Act, confirmed federal jurisdiction over the resources beyond 3 nautical miles from shore and created a legal process for developing those resources. Section 4(f) of the OCS Lands Act requires a permit for the construction or artificial islands, installations, and other devices on the seabed to the seaward limit of the outer continental shelf.

The Bureau of Ocean Energy Management (BOEM), within the U.S. Department of the Interior, administers activities related to development on the OCS and conducts environmental studies, including NEPA analyses for offshore energy development. The OCS Lands Act establishes the authority of the U.S. Department of the Interior (DOI) to grant rights-of-way for pipelines and other facilities for transmission of energy through the OCS. The submarine HVDC cable would not require a lease or easement from BOEM because the project would not qualify as an activity that supports development or production of energy on the OCS (30 CFR 585).

Federal Requirements

Clean Water Act (CWA). The purpose of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Clean Water Act Section 404 and the Rivers and Harbors Act of 1899 Section 10 define waters of the United States and wetlands. The definition of "waters of the United States" includes rivers, streams, estuaries, the territorial seas, ponds, lakes, and wetlands. Wetlands are defined as those areas "that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 Code of Federal Regulations (CFR) 328.3 7b). Section 404 of the CWA prohibits fill of and dredging of waters of the United States without prior authorization from the USACE. Section 401 requires California (via the nine Regional Water Quality Control Boards) to issue Water Quality Certifications (WQC) for licenses or permits issued for, among other things, the discharge of dredged or fill materials to federally jurisdictional waters, or waters of the United States.

Rivers and Harbors Act (33 U.S.C. § 403) addresses effects to navigable waters and regulates "excavation, fill, or alterations or modifications to the course, location, condition, or capacity of any port, …harbor, canal, lake, …or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers." Under Section 10 of the Rivers and Harbors Act, the USACE has the authority to regulate the navigable capacity of any of the waters of the United States.

USACE Nationwide Permit Program (NWP). Nationwide Permit No. 12 for Utility Line Activities, if applicable, could be used to satisfy Section 404 of the CWA and Section 10 of the Rivers and Harbors Act. The NWP covers limited activities, including those "...required for the construction, maintenance, repair, and removal of utility lines and associated facilities in waters of the United States, provided the activity does not result in the loss of greater than 1/2-acre of waters of the United States for each single and complete project."

Coastal Zone Management Act (CZMA). The CZMA outlines two national programs, the National Coastal Zone Management Program and the National Estuarine Research Reserve System. The 34 coastal programs aim to balance competing land and water issues in the coastal zone. The overall program objectives of CZMA remain balanced to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." The National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean and Coastal Resource Management (OCRM) administers the CMZA.

Marine Mammal Protection Act (MMPA). The 1972 MMPA established a federal responsibility to conserve marine mammals. The Department of Interior has jurisdiction over sea otters, walruses, polar bears and manatees, and the Department of Commerce is responsible for cetaceans and pinnipeds other than the walrus. Under the MMPA of 1972 (as amended in 2007), it is unlawful to take or import marine mammals and marine mammal products. The MMPA defines "take" as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." (16 U.S.C. §1362(13).) Under Section 101(a)(5)(D) of the MMPA, an Incidental Harassment Authorization (IHA) Permit may be issued for activities other than commercial fishing that may affect small numbers of marine mammals. An IHA covers activities that extend for periods of no more than one year and that will have a negligible effect on the impacted species. If the potential for serious injury and/or mortalities exists, and there are no measures that could be taken to prevent this form of "take" from occurring, a Letter of Authorization (LOA) must be obtained.

Federal Endangered Species Act (ESA). The federal ESA is implemented by U.S. Fish and Wildlife Service (USFWS) and NOAA's National Marine Fisheries Service (NMFS, also known as NOAA Fisheries). The federal ESA protects plants and wildlife that are listed as endangered or threatened by USFWS and NMFS. Section 9 of the ESA prohibits the take of listed fish and wildlife, where "take" is defined as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in such conduct" (50 CFR 17.3). For plants, this statute governs removing, possessing, maliciously damaging, or destroying any listed plant on federal land and removing, cutting, digging up, damaging, or destroying any listed plant on nonfederal land in knowing violation of state law (16 U.S.C. 1538).

Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801-1884). The Magnuson-Stevens Act of 1976 (as amended in 1996 and reauthorized in 2006) applies to fisheries resources and fishing activities in federal waters, which extend to 200 miles offshore. The act is intended to facilitate conservation and management of U.S. fisheries, development of domestic fisheries, and phasing out of foreign fishing activities. Sections 305(b)(2) to (4) of the Magnuson-Stevens Act outline a process for NMFS to comment on activities proposed by federal action agencies that may adversely impact areas designated as Essential Fish Habitat (EFH). Specifically, federal action agencies are required to consult with NMFS on any action authorized, funded, or undertaken that may adversely impact EFH.

Migratory Bird Treaty Act (16 U.S.C. §§ 703–711). The MBTA of 1918 protects all migratory birds. Birds protected under the MBTA include all native waterfowl, shorebirds, hawks, eagles, owls, doves, and other common birds such as ravens, crows, sparrows, finches, swallows, and others, including their body parts (for example, feathers and plumes), active nests, and eggs. A complete list of protected species is found at 50 CFR 10.13. The USFWS is responsible for enforcing the provisions of the MBTA.

National Historic Preservation Act. Section 106 of the National Historic Preservation Act requires consultation regarding cultural resources listed in or eligible for inclusion in the National Register of Historic Places. The regulations implementing Section 106 (36 CFR 800) specify a consultation process to assist in satisfying this requirement. Consultation with the appropriate State Historic Preservation Office, the Advisory Council, Native American tribes, the public, and state and federal agencies is required by Section 106 of the National Historic Preservation Act. The State Historic Preservation Office would be responsible for reviewing all project-related reports.

Abandoned Shipwreck Act. The Abandoned Shipwreck Act establishes government ownership over the majority of abandoned shipwrecks located in waters of the United States and creates a framework within which shipwrecks are managed. It affirms the authority of state governments to claim and manage abandoned shipwrecks on state submerged lands. The Abandoned Shipwreck Act protects any wreck that is claimed by the government from open-sea laws of salvage and finds and preserves shipwrecks as multiple-use resources. Additional protections are provided by the Sunken Military Craft Act, which does not allow any person to possess, disturb, remove, or injure any sunken military craft.

Clean Air Act (42 U.S.C. §7401-7626). Section 176(c) of the federal Clean Air Act requires federal agencies to ensure that actions undertaken in nonattainment or maintenance areas are consistent with federally enforceable air quality management plans. General conformity requirements apply to those aspects of the federal action that involve ongoing federal agency responsibility and control over direct or indirect sources of air pollutant emissions. Compliance with the conformity rule can be demonstrated in several ways. Compliance is presumed if the net increase in direct and indirect emissions from a federal action would be less than the relevant *de minimis* levels for the nonattainment area. If net emissions increases exceed a *de minimis* value, a formal conformity determination process must be followed. Federal agency actions subject to the general conformity rule cannot proceed until there is a demonstration of consistency with the local State Implementation Plan.

State Requirements

California Coastal Act. The California Coastal Act is intended to protect the state's 1,100 miles of coastline. The policies of the Coastal Act form the standards by which the California Coastal Commission approves coastal development permits (CDP) and the Local Coastal Programs (LCP) developed by local agencies. Development activities within 1,000 yards of the mean high tide are generally subject to the Coastal Act and would require a CDP.

Coastal Act Section 30108.2 defines "fill" as "earth or any other substance or material, including pilings placed for purposes of erecting structures thereon, placed in a submerged area." Coastal Act Section 30233(a)(5) allows the filling of open coastal waters for "incidental public service purposes, including but not limited to, burying cables and pipes or inspection of piers and maintenance of existing intake and outfall lines." The two tests that must be met to qualify under this subsection are that (1) the use must be for incidental purposes, including the burying of cables, and (2) the use must offer a public service.

California State Lands Commission. The California State Lands Commission has jurisdiction over the state's tidal and submerged coastal lands from the mean high tide line to 3 nautical miles offshore, including filled lands formerly covered with water, offshore islands, bays, estuaries, and lagoons. Determinations made by the State Lands Commission on the need to permit or agree to lease facilities on submerged lands must consider whether the lease is in the best interest of the State (2 California Code of Regulations [CCR] 2802).

Unified Port District of San Diego. The Port District manages roughly 33 miles of San Diego shoreline and has been granted 5,483 acres of tidelands on the San Diego Bay and submerged lands that were conveyed to the Port District by the California State Lands Commission. The Port District is governed by the San Diego Unified Port District Act, San Diego Port District Code, and the Unified Port of San Diego Port Master Plan.

California Endangered Species Act (CESA) (CFGC §§ 2050-2098). Sections 2050-2098 of the California Fish and Game Code (CFGC) prohibit the take of state-listed endangered and threatened species unless specifically authorized by CDFW. The state definition of "take" is to hunt, pursue, catch, capture, or kill a member of a listed species or attempt to do so. CDFW administers the California Endangered Species Act (CESA) and authorizes take through permits or memoranda of understanding issued under Section 2081 of CFGC or through a consistency determination issued under Section 2080.1. A consistency determination allows CDFW to authorize a project to proceed if that agency agrees with terms and conditions developed for a federal Biological Opinion and Incidental Take Permit. Section 2090 of CFGC requires state agencies to comply with threatened and endangered species protection and recovery and to promote conservation of these species.

Marine Protected Area (CFGC §§ 2852[c]). Marine protected areas (MPA) are designated by law, administrative action, or voter initiative to protect or conserve marine life and habitat. The Marine Life Protection Act of 1999 required CDFW to redesign its system of MPAs to increase coherence and effectiveness. MPA classifications include Marine Life Reserves (the equivalent of the State Marine Reserve classification); State Marine Parks, which allow recreational fishing and prohibit commercial extraction; and State Marine Conservation Areas, which allow for specified commercial and recreational activities, including fishing for certain species but not others, fishing with certain practices but not others, and kelp harvesting, provided that these activities are consistent with the objectives of the MPA and relevant California Fish and Game Code. MPA classifications are described in more detail below:

- **State Marine Reserve**: Prohibits all take and consumptive use (commercial and recreational, living or geologic). Scientific research and nonconsumptive uses are allowed.

- **State Marine Park**: Prohibits commercial take but may allow select recreational harvest to continue. Scientific research and nonconsumptive uses allowed.

- **State Marine Conservation Area**: May allow select recreational and commercial harvest to continue. Scientific research and nonconsumptive uses are allowed. Some state marine conservation areas are designated as "no-take."

- **State Marine Recreational Management Area**: Provides subtidal protection equivalent to an MPA, while allowing legal waterfowl hunting. Scientific research and nonconsumptive uses are allowed.

- **Special Closure**: An area designated by the Fish and Game Commission that prohibits access or restricts boating activities in waters adjacent to the sea bird rookeries or marine mammal haul-out sites.

MPAs are a subset of marine managed areas (MMAs), which are broader groups of named, discrete geographic areas along the coast that protect, conserve, or otherwise manage a variety of resources and uses, including living marine resources, cultural and historical resources, and recreational opportunities. MMA classifications include state water quality protection area, state marine cultural preservation area, and state marine recreational management area. There are 50 MPAs in the South Coast Region, which covers the California coast from Point Conception in Santa Barbara County south to the California/Mexico border; these MPAs include 19 State Marine Reserves (SMR), 21 State Marine Conservation Areas (SMCA), 10 No-Take SMCA, and 2 Special Closure Areas.

Table 8: Permits That May Be Required for the Submarine HVDC Cable

Agency	Jurisdiction	Requirements
Federal Agencies		
Council on Environmental Quality, National Environmental Policy Act	Environmental review of major federal actions	Compliance with NEPA: preparation of EIS
U.S. Army Corps of Engineers (USACE), Los Angeles District	Waters of the United States	▪ Permit (i.e., a federal action) and Environmental Assessment for marine cable installation in open waters under the Clean Water Act Section 404 and the Rivers and Harbors Act Section 10. ▪ Determination of applicability of Nationwide Permit (NWP) No. 12 for Utility Line Activities. ▪ Likely lead agency for the NEPA process and agency consultation. ▪ Determination of General Conformity applicability under Clean Air Act Section 176.
U.S. Coast Guard (USCG) - Los Angeles-Long Beach Sector; San Diego Sector; 11th Coast Guard District (Alameda)	Navigable waterways	▪ Establish Vessel Traffic Safety zone ▪ Issuance of appropriate Notice to Mariners
U.S. Department of Defense	Marine Corps Camp Pendleton for SONGS; San Diego Bay for Old Town, Silvergate, or South Bay	Consultation

Table 8: Permits That May Be Required for the Submarine HVDC Cable

Agency	Jurisdiction	Requirements
Marine Corps Base (MCB) Camp Pendleton	Construction on MCB Camp Pendleton	▪ Federal Aviation Regulation (FAR) Part 77 Request (via FAA) ▪ Secretary of the Navy Instructions (SECNAVINST) 11011.47A (access road outside easement) ▪ License for nonfederal use of real property
U.S. Fish and Wildlife Service (USFWS), Sacramento, Ventura, and Carlsbad Field Office	Pacific Ocean	▪ Biological Assessment, Section 7 Consultation, Biological Opinion ▪ Enforcement of the Migratory Bird Treaty Act (MBTA)
Federal Communications Commission (FCC)	Licenses/permits related to FCC frequencies and paths	Telecommunication permit as required
U.S. Bureau of Indian Affairs, Pacific Regional Office	Section 106 of the National Historic Preservation Act of 1966	National Historic Preservation Act, Section 106 consultation
Advisory Council on Historic Preservation	▪ National Register of Historic Places ▪ Abandoned Shipwreck Act	National Historic Preservation Act, Section 106 consultation
National Marine Fisheries Service/National Oceanic and Atmospheric Administration Fisheries, Southwest Regional Office	Marine fisheries, special-status species and habitats	▪ Consultation or technical assistance under Section 7 of the Endangered Species Act (ESA) regarding USACE permit; ▪ Potential impact to Essential Fish Habitat (EFH); ▪ Potential Incidental Harassment Authorization (IHA) permit under Marine Mammal Protection Act (MMPA)
United States Fish and Wildlife Service	Special-status species and habitats, migratory birds	▪ Consultation under Section 7 of the Endangered Species Act (ESA); ▪ Enforcement of the Migratory Bird Treaty Act (MBTA)

State Agencies, Regional Agencies, and Port Districts		
California Coastal Commission	Development activities within 1,000 yards of the mean high tide	▪ Coastal development permits ▪ Consistency with California Coastal Act ▪ Consistency with the federal Coastal Zone Management Act (CZMA) ▪ Likely Lead Agency for CEQA and certification of EIR
California State Lands Commission (CSLC)	Tidal waterways and submerged lands below the mean high tide line	▪ Alternative acting lead agency or responsible agency for CEQA process ▪ Residual and review authority over actions managing lands legislatively granted to City of Long Beach, which owns Port of Long Beach lands, and the San Diego Unified Port District.
Port of Long Beach	Long Beach Harbor District	Not applicable. Eastern limit of Harbor District is at the Los Angeles River.
Port of San Diego	San Diego shoreline and tidelands on the San Diego Bay	Consultation regarding consistency with the Port Master Plan
California Department of Fish and Wildlife (CDFW)	Special-status species and habitats, including Marine Protected Areas	▪ California Endangered Species Act coordination, Section 20801 Incidental Take Permit or Consistency Determination under California Fish and Game Code Section 2080.1 ▪ Native Plant Protection Act, and other provisions of the Fish and Game Code as applicable ▪ Marine Life Protection Act and rules for Marine Protected Areas
California Department of Water Resources	Water crossings	Encroachment/crossing permit (as required)

California State Water Resources Control Board, and Regional Water Quality Control Board (RWQCB) – Los Angeles Region; Santa Ana Region; San Diego Region	Clean Water Act, Section 401	▪ National Pollution Discharge Elimination System (NPDES); ▪ General Construction Storm Water Pollution Prevention Plan (SWPPP); ▪ Water Quality Certification under Section 401 of the Clean Water Act
California Department of Industrial Relations Division of Occupational Safety and Health		Construction activities permit
California Department of Transportation (Caltrans)	State-owned streets and highways Code 660-711.21 CCR 1411.1-1411.6	Encroachment permit and design review
South Coast Air Quality Management District (SCAQMD); or San Diego Air Pollution Control District (SDAPCD)	South Coast Air Basin; or San Diego Air Basin	Portable Equipment Registrations; Emissions Standards for Marine Vessels; Authority to Construct and Permit to Operate backup diesel generator for black start capability (if required).
Local Agencies: Alamitos		
City of Long Beach	City streets and sidewalks	ROW Acquisition and/or establish utility franchise area
City of Seal Beach	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit
Local Agencies: Huntington Beach		
City of Huntington Beach	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit

Local Agencies: San Onofre, Japanese Mesa, or SONGS Mesa		
Marine Corps Base (MCB) Camp Pendleton (see Federal Agencies)	See above.	See above.
Local Agencies: Encina or Cannon		
City of Carlsbad	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit
Local Agencies: Penasquitos		
City of San Diego	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit
Local Agencies: South Bay or Bay Boulevard		
Port of San Diego	San Diego Bay	See Port Districts, above.
City of Chula Vista	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit
Local Agencies: Old Town		
Port of San Diego	San Diego Bay	See Port Districts, above.
City of San Diego	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit
Local Agencies: Silvergate		
Port of San Diego	San Diego Bay	See Port Districts, above.
City of San Diego	City streets and sidewalks	▪ Traffic Management Plan; ▪ Excavation Permit

Source: Aspen Environmental, 2014

CHAPTER 4: Submarine Transmission Considerations

Developing a submarine HVDC submarine cable connecting the SCE and SDG&E electrical transmission systems would be an extremely complex project. In-depth surveys and evaluations would need to be conducted by viable project sponsors with experience and access to sufficient resources to establish an optimum route and design. This work presents an early stage evaluation of installing a submarine HVDC power cable in the Southern California study area

This effort reviews publicly available reports, presentations, and studies of impacts or feasibility of comparable concepts to assess the state of the industry and highlight some of the unique limitations or concerns (Gevorgian, 2011; Bureau of Ocean Energy Management, 2007; Sharples, 2011).

The considerations identified here provide an overview of requirements stemming from regulatory agency oversight, environmental issues, and technical or construction engineering concerns. Comprehensive environmental and technical studies would still need to occur before any agency could approve a project of this nature.

Feasibility Metrics for Submarine HVDC Cable

Successful completion of a submarine HVDC cable project could be threatened by several considerations summarized here. This list highlights the issues that represent potential fatal flaws. Proper project route selection and design should be able to address each of these issues so that they do not fatally affect the feasibility or viability of building new submarine transmission in the study area.

Ensuring Project Viability

Table 9 summarizes the primary early stage concerns and how an electric transmission project in the submarine corridor could address the issues.

Table 9: Early Stage Concerns for Submarine Corridor

Consideration	Potential Solutions
Submarine Cable	
Avoid hard-bottom areas, rocky substrate, or bedrock.	▪ Geophysical (geological and geotechnical) survey during route assessment. ▪ Conduct post-lay surveys to determine as-built impacts and restoration plans, and fund payments into a Hard Bottom Mitigation Fund.
Avoid slopes greater than 30 degrees.	▪ Bathymetry and sonar survey during route assessment.

Table 9: Early Stage Concerns for Submarine Corridor

Consideration	Potential Solutions
Route cable crossings of faults in the direction of the fault lines.	▪ Geophysical survey during route assessment. ▪ Study of seismic activity and history during route assessment to determine seafloor instability, seismic ground movement, and fault rupture. ▪ Provide excess slack of cable in fault areas where large displacements could occur.
Avoid suspensions or free spans of cable.	▪ Secure the cable to the seafloor through the installation of bolts or anchorage systems in the rock, although this could result in unavoidable impacts to hard bottom habitat. ▪ Geophysical survey during route assessment.
Avoid State Marine Conservation Areas.	▪ Requires specific authorization by CDFW. ▪ Conduct early CDFW staff consultation.
Avoid State Marine Reserves.	▪ Activities within a marine reserve should be avoided, as they are generally restricted to research, restoration, or monitoring. ▪ Conduct early SMR and CDFW staff consultation.
Avoid routing along length of a navigable or marked channel, and avoid areas used for anchoring.	▪ Identify anchorage areas and normal navigable routes during early-stage study. ▪ Increase burial depth and add armoring to increase protection.
Route cable or pipeline crossings as near a 90-degree perpendicular angle to the existing cable as practicable.	▪ Identify existing cables and pipelines during early stage study. ▪ Magnetometer survey during route assessment. ▪ Install a protective conduit for existing utilities or post-lay armoring.
Avoid known shipwrecks and mapped archaeological resources.	▪ Identify known wrecks, protected cultural resources, and debris during early stage study. ▪ Magnetometer survey during route assessment. ▪ Follow a treatment plan for unanticipated and unavoidable discoveries.

HVDC Converter Stations	
Site converter stations with compatible existing land uses.	▪ Choose converter station locations with adequate transportation infrastructure for 100-ton transporter capacity. ▪ Select Alamitos or Huntington Beach for northern HVDC terminal point. ▪ Select San Onofre or Encina for southern HVDC terminal point.
Coastal Landings and Underground Cable	
Site coastal landing zones and terrestrial underground cable with compatible existing land uses.	▪ Choose coastal landing to occur through an existing conduit or pipeline, such as one of the power plant cooling water intake structures, if available and well-maintained. ▪ Underground route selection should avoid creating disruptions to existing sensitive, nonindustrial land-use types.
Avoid placing HDD through permeable geologic formations.	▪ Install casings or conduits during the HDD process to seal off permeable formations.
Avoid placing underground cable through contaminated sites.	▪ Adhere to applicable site management plans or risk management plans established for purposes of subsurface remediation.

Source: Aspen Environmental, 2014

Tools for Route Selection

Recent federally sponsored review (Sharples, 2011) of the state-of-the-art for submarine power cable burial shows the wide range of interrelated considerations for route selection and the various phases of study. The route depends on:

- Considerations of cable design, installation, burial depth, and lifetime.
- Considerations of installation vessel based on water depth, geological information, permissible cable stresses, and burial depth/cable protective measures.
- Weather for installation.
- Potential cable protection from scour and navigation risk.

Refining the understanding and requirements along the route can be accomplished by a sequence of studies, data gathering, and surveys.

Desktop Study

This level of study helps to design and plan the subsequent field surveys. The range of information gathered would include:

- Bathymetric information, such as charts and surveys from harbors.
- Anchorage areas, shipping fairways, normal shipping routes, buoy areas, and others.
- Geological information, including rock outcrops and mudslide areas.
- Existing geotechnical (soils) data and information from other geological surveys.
- Information on existing cables, pipelines, and so forth.
- Meteorological and oceanographic information, including tides, currents, and wind and wave regimes.
- Information on wrecks and debris on seabed, for example, from NOAA databases including Automated Wreck and Obstruction Information System (AWOIS).
- Seismic activity maps and any records of seismic activity.
- Archeological and chemosynthetic communities that may be necessary to avoid.
- Information from USCG databases of incidents and near misses of shipping in the area, dropped equipment.
- Information on military activities including restricted military activity areas and so forth.

Route Assessment Field Survey

After desktop studies, the initial field work to determine suitability of the route includes:

- Bathymetry survey to confirm and refine the detail of information from charts.
- Sonar survey to understand the bottom and subbottom profile, potential sand waves, and information on evidence of bottom currents.
- Magnetometer survey to provide information on metal objects including debris, existing pipelines, and cables.
- Geophysical survey to provide soil type, strength, temperature, and temperature absorption capability.
- Survey of currents and surf action.

Burial Assessment Survey

After preliminary route selection and before installation, a burial assessment survey would provide input to design of armoring, confirmation of the potential burial depth, data to determine the speed with which the cable can be laid and the risk of hang-up of the burial methods and methods to facilitate the selection of installation vessels and burial equipment. This may involve running an assessment plow along without a cable present to confirm the route or using an instrumented sled to conduct final electronic surveys of the route.

Environmental Considerations

Agency Jurisdiction

Federal Agencies

Coastal waters are granted to the State of California, and federal jurisdiction of the Outer Continental Shelf (OCS) lands includes resources beyond 3 nautical miles (5.6 kilometers) from shore.

The USACE has jurisdiction over structures and work in navigable waters, and the USACE would be the likely federal lead agency in the NEPA process. The authority of the USACE stems from Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The site-specific circumstances and construction methods dictate the permitting requirements. For example, jet plowing would not generally be subject to a Section 404 permit because it would not represent a discharge of dredged or fill material. Work in navigable waters would generally be subject to the Section 10 permit requirements. Although not all trenching for installation of a submarine cable may require a Section 404 permit, the USACE Los Angeles District Engineer has the authority to specify the cable burial depth and separation distances. Typically, the USACE burial requirements would be 3 to 6 feet below the seabed and up to 15 feet buried in an anchorage area or in a channel (Sharples, 2011). Obtaining a permit from ACOE and completing the NEPA process may take about two years.

Although the Outer Continental Shelf Lands Act establishes the authority of the U.S. Department of the Interior and Bureau of Ocean Energy Management to grant rights-of-way for energy facilities through the OCS, the submarine HVDC cable would not require BOEM approval because the project would not qualify as an activity that supports development or production of energy on the OCS (30 CFR 585).

Other federal agencies that would need to be consulted during the NEPA process, which could alternatively serve as NEPA lead agency, depending on the level of interest, include the U.S. Coast Guard, Department of Energy, Department of Defense, Fish and Wildlife Service, and National Marine Fisheries Service/National Oceanic and Atmospheric Administration. Other permitting requirements are shown in Chapter 3, Regulatory Requirements for Submarine-Based Alternatives.

FERC could be involved with economic regulation of the new electric transmission infrastructure, but FERC would not conduct environmental review for this project.

The study area does not include any waters that are within a National Park or a National Monument located on the OCS or in National Marine Sanctuaries or National Wildlife Refuges located on the OCS.

State Agencies

Either the California Coastal Commission or the California State Lands Commission would be likely to take the role of lead agency in the CEQA process. The State Lands Commission has jurisdiction to permit or establish a lease for facilities within the state's tidal and submerged coastal lands from the mean high tide line to 3 nautical miles offshore. Development activities within 1,000 yards of the mean high tide are generally subject to the Coastal Act and would also require a CDP from the California Coastal Commission. Completing the CEQA process through either lead agency may take about two years.

Other state or local agencies could serve as CEQA lead agency, depending on specific development proposals. For example, a municipal utility district may serve as a lead agency if it has a partnership or ownership interest with the development team. Alternatively, the CPUC may serve as lead agency if the developer seeks a CPCN for CPUC rate recovery or to obtain eminent domain authority. Other permitting requirements are shown in Section 4.2.

State Marine Protected Areas

No federally protected marine sanctuaries are within the study area between Long Beach and San Diego. The following National Wildlife Refuges occur nearby but outside the corridor:

- Seal Beach NWR (onshore).
- San Diego Bay NWR (near Chula Vista).
- Tijuana Slough NWR (south of the study area).

The following state-managed marine protected areas (State Marine Reserves and State Marine Conservation Areas) occur along the corridor:

- Crystal Cove SMCA, north of Laguna Beach.
- Laguna Beach SMR and Laguna Beach SMCA (No-Take) – extends to State Water Jurisdiction.
- Dana Point SMCA.
- Swami's SMCA, near San Elijo Lagoon, San Diego County – extends to State Water Jurisdiction.
- South La Jolla SMCA and South La Jolla SMR – extends to State Water Jurisdiction.

Installing the cable near the shoreline may require specific authorization by the CDFW for establishing a new nonconsumptive use or commercial activity potentially within a marine protected area. An SMCA generally allows certain commercial purposes as long as the CDFW determines the activity would not compromise protection of the resource. An SMR is more restrictive because activities in these areas are generally restricted to research, restoration, or monitoring for resource protection.

- Early surveys of habitat and cultural resources including hard substrate would be necessary to establish the potential for take within the marine protected areas.
- CDFW staff consultation would clarify the potential for take.
- Routing through an SMR should be avoided.

Marine Biology and Coastal Habitat

Marine Habitat and Wildlife

The cable-laying vessel, cable-trenching equipment, and excavation of an HDD containment area would have direct contact impacts to marine benthic species, incidental contact with fish, and limited or unlikely contact with marine mammals. Ship presence, noise, and vessel wakes could temporarily disturb sea birds, including migratory birds and colonies. Activities would need to adhere to seasonal work windows established by resource agencies and to avoid areas designated as EFH.

Hard-Bottom Areas

Cable-laying could damage hard-bottom habitats and rock substrate. Vessels anchoring near shore for construction of coastal landings for the cable system may damage the seafloor. Similarly, if the route of the submarine cable system must traverse steep slopes or across canyons, the cable may need to be secured to avoid suspensions or free-spans. Securing the cable to the seafloor could result in unavoidable impacts to hard bottom habitat due to the installation of bolts or cable anchorage systems in the rock. Detailed mapping may be available in the areas of existing oil and gas resources licensed by BOEM in San Pedro Bay, but project-specific bathymetry and sonar surveys would likely be necessary to assess the benthic habitats along the full length of the power cable route. Natural kelp beds would need to be avoided, as well as one known artificial rock reef. Offshore near the San Clemente pier, SCE installed an artificial rock reef called the Wheeler North Reef for improving giant kelp habitat in the area.

Turbidity and Suspension of Contaminants

Turbidity would impact benthic or slow moving species and, to a lesser extent, fish and marine mammals. Seafloor disturbance could cause suspension of low-level contaminated sediments that may bio-accumulate in species within the food chain.

Underwater Noise

Underwater noise levels from ship and equipment could impact fish and mammals (avoidance of work vicinity, possible disruption of communications, migration, and feeding behaviors), and potentially disrupt benthic species behaviors, including filter feeding and foraging. Noise levels near the plowing or trenching activities could be considered to be harassment to marine mammals and fish by the National Marine Fisheries Services.

Heat Dissipation

The power cable would dissipate heat, and this dissipation could affect the marine environment, especially for areas where cable could not be buried. Operation of the cable in the marine environment could increase water temperatures immediately near the sediment surface, generally for the water within about 4 inches of the seafloor above the cable. If hard-bottom areas cannot be avoided, the cable bundle could lie on the ocean floor. In some areas this unburied cable would be covered by concrete mattresses or protective sleeves. In other areas the cable could be exposed. Marine species could come in contact with the exposed cable or the protective covering. The 2007 environmental study for the Port Angeles–Juan de Fuca 550 MW underwater DC cable[4] found that the cable surface would be about 140°F (60°C), and water temperatures over the sediment covering the cable could increase by about 1.8°F (1°C). Species could be injured or startled if they settled on the unburied cable. Unburied cable would not be in one continuous length. This means that creating a migration barrier would be unlikely.

Potential Solutions

- Conduct appropriate presiting surveys (bathymetry and bottom profile) to identify and characterize potentially sensitive seafloor habitats and geological information related to natural rock outcrops.

- Adhere to seasonal work windows established by resource agencies and avoid areas designated as EFH.

- Avoid locating facilities near known sensitive seafloor habitats, such as kelp reefs, coral reefs, hard-bottom areas, and chemosynthetic communities.

- Avoid hard-bottom habitats, including seagrass communities and kelp beds and restore any damage to these communities (Bureau of Ocean Energy Management, 2007).

- Vessels should travel reduced speeds when assemblages of cetaceans are observed and maintain a reasonable distance from whales, small cetaceans, and sea turtles (Bureau of Ocean Energy Management, 2007).

- Minimize potential vessel impacts to marine mammals and sea turtles by requiring project-related vessels to follow the NMFS Regional Viewing Guidelines while in transit. Operators should be required to undergo training on applicable vessel guidelines (Bureau of Ocean Energy Management, 2007).

- Minimize construction activities in areas containing anadromous fish, during migration periods (Bureau of Ocean Energy Management, 2007).

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4. http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EIS-0378-FEIS-2007.pdf

- Minimize disruption and disturbance to marine life from sound emissions during construction (Bureau of Ocean Energy Management, 2007).

- If hard-bottom cable installation is not avoidable, post-lay surveys via a remotely-operated-vehicle (ROV) may be necessary to determine as-built impacts and restoration plans for hard-bottom habitats and rock substrate.

- If hard-bottom cable installation is not avoidable, postlay surveys may be necessary to determine the scope of payments into a Hard Bottom Mitigation Fund, subject to oversight by the California Coastal Commission.

- Minimize turbidity during construction (Bureau of Ocean Energy Management, 2007).

- Minimize impacts to wetlands by maintaining buffers around wetlands, implementing erosion and sediment control, and maintaining natural surface drainage patterns (Bureau of Ocean Energy Management, 2007).

- Minimize potential conflicts with commercial and recreational mariners and fishing interests.

- Use submarine cables that have proper electrical shielding to reduce electromagnetic fields and bury the cables in the seafloor, where practicable (Bureau of Ocean Energy Management, 2007).

- Implement an invasive marine species control plan for controlling ballast water of construction vessels that originate outside Southern California.

Geologic, Geotechnical, and Seismic Hazards

On the continental shelf, the most likely geologic hazards would be scouring, irregular topography, faulting, and the effects of tsunamis occurring anywhere in the Pacific Basin. The study area includes a portion of the continental shelf in a physiographic region known as the California Continental Borderland (Bureau of Ocean Energy Management, 2007). The continental shelf is fairly narrow in this region and typically occurs within five miles from shore. In the vicinity of Newport Beach, Laguna Beach, and Dana Point, the edge of the shelf is only one to two miles offshore.

Topography, Water Depth, and Slopes

The seafloor within the corridor of study remains relatively shallow at a depth of less than 150 feet for most locations very near shore or within one-half to three-quarters mile. Generally following the state-federal water boundary three miles from shore, a steep wall of the continental shelf drops an additional 1,000 to 1,500 feet. Within 10 miles from shore, depths up to 2,600 feet are encountered. Although some submarine power cables have been successfully installed at depths of up to 5,000 feet (National Renewable Energy Laboratory, 2011), this study anticipates that the cable design would dictate avoiding water depths greater than 3,000 feet.

Major canyons would be encountered offshore near the historical Newport Pier, at the Santa Ana River, and at the La Jolla Canyon.

Crossing the underwater canyons and steep offshore walls may leave portions of the cable suspended, exposed, or in free-span, which would increase risks of damage and entanglements.

Potential Solutions

- Routing near the shoreline (within one-half to three-quarters mile) would generally avoid steep offshore walls, but this would increase exposure of the cable to wave energy and the scouring action of ocean currents.

- Secure the cable to the seafloor through the installation of bolts or anchorage systems in the rock, although this could result in unavoidable impacts to hard bottom habitat.

- At Newport Canyon, hydroplow or jet cable installation should be investigated near the shore (roughly 200 feet offshore), where depths less than 100 feet would be encountered. However, this would increase potential impacts to the coastal zone, near-shore habitat and potentially to the historical Newport Pier, which would increase the need for cable protection from anchor dragging and fishing gear.

- Burial of the submarine cables along the steep offshore walls at La Jolla Canyon may not be feasible and could leave portions suspended.

Cable anchorage may be necessary for direct laid cable on slopes greater than 30 degrees, and slopes of 45 degrees should be avoided to the greatest extent possible as these areas would require more involved anchorages and pose additional risks to the cable.

Cable burial along the steep walls of the shelf or submarine canyons, portions of the cable may be exposed to unacceptably high risk of damage or entanglements by remaining suspended, exposed, or in free-span.

Subsurface Geology, Scouring Action, and Seafloor Instability

Installing the cable within the hard bottom, rocky substrate, or bedrock would be problematic and would need to be avoided for minimizing impacts to biological resources. For hard bottom conditions, a plow would not be usable, and a rock saw or excavator would need to be used to create a shallow trench in the bedrock before laying a duct. Then the duct would need to be pinned to the floor of the trench before placing the cable (Sharples, 2011).

Vigorous tidal circulation and storm waves have an important effect on the transport of sediments on the surface of the continental shelf. Episodic sediment movement caused by ocean currents and waves can undermine offshore structures and lead to failure. The energy of currents and waves also poses a risk to submarine cables (Bureau of Ocean Energy Management, 2007). Introducing hard scour-protection structures should generally be avoided because the structure can induce increased erosion over time.

Potential Solutions

- Conduct seafloor surveys in the early phases of a project to ensure that the project is sited appropriately to avoid or minimize potential impacts associated with seafloor instability or other hazards (Bureau of Ocean Energy Management, 2007).

- Conduct appropriate presiting surveys to identify and characterize potentially sensitive topographic features (Bureau of Ocean Energy Management, 2007).

- Hazards posed by scouring to underwater cables could be mitigated by building the cable system with sufficient excess slack to reduce the risk of breakage due to increased tension caused by irregular topography or seafloor displacement as a result of mass movement or faulting (Bureau of Ocean Energy Management, 2007).

- Where burial of the cable in sediment is not possible, secure the cable to the seafloor through the installation of bolts or anchorage systems in the rock, although this could result in unavoidable impacts to hard bottom habitat.

- Surveying the cable route every one to two years during the life of the project should verify that the cable has remained buried consistent with an agency-approved cable burial plan. The survey may be conducted with an ROV equipped with video and still cameras. If a survey shows that any segment of the cable is no longer buried consistent with the cable burial plan, repairs would be needed to rebury those cable segments.

Cable burial in shallow areas of vigorous scouring due to tidal circulation and storm waves may warrant an unacceptably high level of maintenance or protective repairs.

Seismic Hazards

The undersea transmission cable system would be especially vulnerable to earthquake-induced displacement and slope failure, including slumping and mudslides. Known faults through Southern California traverse the terrestrial and submarine areas of study. Notably, the Newport-Inglewood fault that is parallel to and along the Orange County coastline is a feature capable of causing roughly 3 to 10 feet of surface rupture offshore. Crossing a fault at 90 degrees may not be optimal for minimizing the effects of displacement of the cable system during a fault rupture (Sharples, 2011).

Tsunami effects are primarily a concern in the shallow water of coastal areas where the bottom causes the tsunami wave height to increase, which increases scour. Increasing the burial depth may protect the cable from the scour of the tsunami wave (Sharples, 2011).

See also the section "Technical Considerations" below.

Potential Solutions

- The cable route and coastal landing locations would need to be determined through geologic and geotechnical evaluation of the formations.

- Seafloor mapping and study of seismic activity conducted during the early phases of project development would help establish an appropriate route to avoid or minimize potential impacts and the hazards associated with seafloor instability, seismic ground movement, and fault rupture.

- Avoid direct fault areas where a large displacements could occur when selecting the submarine cable route.

- Hazards posed by fault rupture could be mitigated by laying the cable in the direction of the fault line, not crossing at 90 degrees, and by building the cable system with sufficient excess slack to reduce the risk of breakage as a result of faulting.

- The cable system should include a submarine earthquake monitor and a detailed earthquake emergency repair plan.

- The cable system specifications may include improved tensile strengths and deformation capabilities through the design of the submarine cable armoring.

Previous study of this issue (Sharples, 2011) reveals that for extreme earthquakes where ground upheaval is significant, there are no reasonable mitigations that can completely avoid damage. For smaller quakes where ground displacement is an issue, the mitigation of laying excess cable parallel to the direction of the fault line can minimize the probability of damage.

Submarine Archaeology and Known Obstacles

Coastal areas are usually especially sensitive due to a long history of human settlement resulting in a high density of historical and prehistoric buried resources, including archeological resources or human remains. Shipwrecks are often in known locations and, therefore, could be avoided, but many would be unknown and may be identified during cable routing studies. Other resources would include prehistoric sites covered by water and sediment. Highly degraded or deteriorated cultural resources, including shipwrecks, may exist undetected buried within unconsolidated sediments, which could be damaged or destroyed during cable burial.

Route selection would be conducted in a manner to avoid areas of known cultural resources. Shipwrecks would need to be avoided as protected resources under the Abandoned Shipwreck Act and Sunken Military Craft Act. Early stage study helps to identify known wrecks and debris on seabed, for example, from NOAA databases; however, other wooden or metallic debris on the seafloor or in the sediment can obstruct cable installation. All reports that consolidate the information on cultural resources or potential resources would need to be reviewed by the State Historic Preservation Office during the agency consultation process.

Potential Solutions

- Conduct side scan sonar and magnetometer tows using 30-m (100-ft) line spacing in areas where there is a high potential for shipwrecks.

- Develop and implement a worker cultural resources training program for educating construction crews on standards for resource avoidance and handling of unanticipated discoveries.
- Before route selection, a qualified marine archaeologist would analyze available side scan sonar and magnetometer data and prepare a report for agency review and approval.
- Avoid known and potential shipwreck locations.
- Follow a treatment plan for unanticipated and unavoidable discoveries of cultural resources.

Air Pollutant Emissions and Air Quality Attainment

Vessels used for construction could temporarily cause emissions exceeding local thresholds for ozone precursors or particulate matter. Construction, installation, or maintenance in federal waters would be subject to a determination of applicability of the General Conformity Rule for air quality impacts in the South Coast ozone and PM2.5 federal nonattainment area or in the San Diego ozone nonattainment area.

Potential Solutions

- Minimize emissions from construction and maintenance activities by maintaining all construction equipment properly in accordance with manufacturer's specifications, and ensure that equipment is checked by a certified visible emissions evaluator.
- Offroad construction diesel engines should be registered under the California Air Resources Board (ARB) Statewide Portable Equipment Registration Program or meet at a minimum the Tier 2 California Emission Standards for Off-Road Compression-Ignition Engines, as specified in CCR Title 13, Chapter 9, Sec. 2423(b)(1).
- All marine commercial harbor craft, except gasoline-powered small craft, should meet at a minimum the Tier 2 Marine Engine Emission Standards (CCR Title 17, Sec. 93118.5).

Marine Vessel Traffic and Military Use Areas

Submarine cables, especially telecommunications, are prone to damage from fishing gear or ship anchor dragging. Power cables that are buried and armored are less susceptible to damage. Additional discussion of protection to avoid cable damage appears under the section below, "Technical Considerations."

The study area falls outside and to the east of the Port of Long Beach area. However, recreational mariners, fishermen, and military activities are common in the corridor. Navy Fleet and Marine Corps amphibious training occurs nearly every day along the Southern California coastline to the San Diego Bay. The level of activity varies from unit-level training to full-scale Carrier/Expeditionary Strike Group operations and certification (Bureau of Ocean Energy

Management, 2007). Although power cable construction and maintenance would involve small-scale commercial vessel activity within offshore military areas, coordination with the appropriate military authorities will be necessary.

Potential Solutions

- Site facilities to avoid unreasonable interference with ports, marinas, and USCG-designated traffic separation schemes.
- Coordinate with the USCG Vessel Traffic Service, Los Angeles-Long Beach, to establish a vessel safety zone for construction and maintenance so that USCG can provide information for the appropriate notices to mariners for cable-laying work.
- Department of Defense consultation and coordination would be necessary to identify the stipulations necessary to avoid or eliminate potential conflicts with military use.
- Cable corridors landing at or near San Onofre would require a license from the U.S. Marine Corps Base Camp Pendleton, which has discretion over any proposal that may disrupt military activities. Following approval by Camp Pendleton, cable construction and maintenance could become part of the Marine Corps' operations.

HVDC Converter Stations

The HVDC converter stations require sufficient space (from 5 to 8 acres), seismic protection, and transportation infrastructure allowing construction access by large equipment (Chapter 3, section "High-Voltage Submarine Transmission"). The converter stations would introduce an additional new industrial land use to the two endpoints. The converter station transformers, two per station, would be the largest pieces of equipment at about 100 tons each. To avoid traffic impacts, these transformers could require transport at night from the barge landing via truck trailer to the site (Navigant Consulting, Inc., 2011).

Potential Solutions:

- Select converter station locations with adequate transportation infrastructure for 100-ton transporter capacity.
- Select converter station locations to avoid conflicts with sensitive, nonindustrial land-use types (for example, residential, recreational, hospitals, schools) that may be incompatible with the aesthetics and noise of the industrial-type converter station facilities, including the switchgear, a large array of cooling fans, and standby power generators.

Coastal Landings

Coastal landings of the cables may be installed using either a direct lay approach or horizontal directional drilling (HDD). The direct lay approach requires a soil or sandy bottom that allows the cables to be installed using conventional excavation methods such as jetting or trenching. (See Chapter 3, section "High-Voltage Submarine Transmission.")

Potential Solutions:

To avoid impacts caused by direct burial of the cable across a beach or sandy bottom, shore landings could occur through one of two optional approaches:

- Pulling the cable to the cable-laying vessel through an existing conduit or pipeline, such as one of the power plant cooling water intake structures, if available and well-maintained.

- Using an HDD to install a pipe as a conduit to create a landing for the cable from the cable-laying vessel.

HDD construction methods require a work area on shore of roughly one to two acres for pipe laydown, drilling pads, and cable-pulling equipment. This work area can be set back from the shore area as necessary, but the setback is limited by the 2,500-foot cable-pulling distance. Installing the HDD in near-surface geological formations could result in an accidental bedrock or soil fracture, during which drilling fluids or cuttings could be released into the ocean.

Potential Solutions:

- HDD work areas should be sited to avoid potential conflicts with sensitive onshore land-use types.

- Steps would need to be taken to avoid accidental release of drilling fluids or cuttings during the HDD process due to bedrock or soil fracture.

- Drilling could be slowed if a loss of drilling mud volume or pressure is detected. If a fracture occurs, increasing the viscosity of the drilling mud may be able to seal the fractures and stabilize the bore hole.

- Casings or conduits could be installed during the HDD process to seal off permeable formations.

Terrestrial Underground Cable

Ground Disturbance

Construction of underground HVDC duct banks could require continuous trenching, along with excavation of rock, blasting, and stockpiling and removal of spoils. Underground construction and trenching would involve new ground disturbance and construction-related impacts (traffic, air quality and dust, and noise). There is also a potential to encounter contaminated soils and cultural resources and to impact biological resources as a result of the ground disturbance.

Construction and Repair Time

Maintenance and restoration time in the event of an outage of submarine or underground HVDC cables would be difficult and could result in longer outages and repair times when compared to an overhead AC system. Accessing underground components and vaults could require intensive traffic control. In addition, duct bank repair could require rock excavation, traffic control, and possible roadway closure.

EMF and Static Discharge

Operation of the transmission line would produce electric and magnetic fields (EMF). The electric field strength, measured in volts per meter (V/m), would be reduced by shielding or by burial of the line, which would effectively eliminate the potential for exposure to the electric field. Unlike the electric field, the magnetic field, measured in milligauss (mG), would not be reduced by intervening objects. Field levels fall off with distance from the source; however, locations immediately along the cable would be exposed to increased magnetic fields due to the cable. A typical DC circuit employs two conductors per circuit. Another environmental consequence of this configuration is static discharge in the area around the converter terminals. See Appendix C for additional information on EMF due to HVDC transmission systems.

Potential Solutions:

- Implement typical best practices for protection of natural and cultural resources during trenching or cut-and-cover activities necessary for installation of on-land electric transmission and linear infrastructure.

- Route selection should avoid creating disruptions to existing sensitive, non-industrial land-use types (for example, residential, recreational, hospitals, and schools).

- Coordinate with local authorities and agencies to minimize conflicts with existing transportation systems and underground utility systems.

- Avoid contaminated sites and, where unavoidable, adhere to applicable site management plans or risk management plans established for subsurface remediation.

Technical Considerations

Technical Challenges of Submarine HVDC

The range of technical factors to be evaluated in assessing the feasibility of a HVDC submarine transmission interconnection falls into two broad categories; constraints related to electric transmission system operation and physical challenges related to installation, maintenance, and upkeep of the HVDC submarine cable system.

System Operation

Electric system modeling of the interconnected transmission system, including the HVDC converter stations and submarine link, will establish necessary parameters to determine the AC portion of the system filtering and protection, as well as converter type and harmonic conditioning for the DC portion of the power system. A major component of the system modeling will be to determine the communication and control requirements for an HVDC interconnection. Cable system sizing would also be determined based on this modeling.

Development of the electric system requirements for an HVDC transmission interconnection, including submarine cable components, does not represent a technical limitation as has been demonstrated by the significant range of HVDC submarine systems that have been developed and installed worldwide. (See Chapter 3, "High-Voltage Submarine Transmission.")

Installation and Maintenance Challenges

The primary physical challenges that need to be considered include the maximum depth of the cable installation, the subsea topography and bottom materials, as well as other external threats to the cable integrity. The integrity of submarine cables can be impacted by both natural phenomenon as well as human activity.

Maximum cable-laying depth is dictated primarily by the strength of the submarine cable itself in terms of its ability to withstand the tensile stresses from the length of cable suspended between the laying ship and the seafloor. A review of installations to date indicates it is feasible to place power cables in water depths of 3,000 feet.

The topography along the route of a submarine cable needs to be evaluated in terms of slopes to be traversed. There are a couple of concerns related to sloping topography. For cables laid across steep slopes, a concern is that gravitational forces pulling the cable downslope that may cause cable movement, resulting in excessive longitudinal or torsional stresses after placement. Limiting the steepness of slopes traversed, burying, or anchoring the cables can mitigate slope concerns.

Another slope-related concern is the potential for submarine landslides or sediment movement that would stress or damage the cable. This concern is accentuated in seismically active areas. Evaluating the stability of the seafloor and the cable route selection process helps to identify the most appropriate mitigation for this issue. However, if it is not feasible for cable routing to avoid areas exhibiting evidence of historical earth movement, the topography and geologic hazards may pose an unacceptably high risk of damaging a submarine cable.

Hard substrate or exposed rock outcroppings along the route of a submarine cable are also of concern. These conditions can result in significant discontinuities that could lead to the cable being suspended above the sea bottom or the cable may rest upon hard or sharp points. Under these conditions the cable may experience excessive and cyclical bending stresses. If the cable is suspended in notable water currents, the currents may induce vibrations that lead to cable damage and failure.

Submarine cables are also susceptible to damage from human activities. This damage can occur from physical contact due to ship anchor dragging or fishing operations. Again, route selection to avoid areas with seafloor disturbing activities is the best mitigation for avoiding cable damage. Cable routing can be accomplished in areas with ship traffic or fishing activities as there are several options that can be considered for protecting and armoring cables from physical intrusion.

Cable and Pipeline Crossings

No major underwater telecommunication cables would be crossed in the corridor of study. Other power cables may be present for oil and gas operations in San Pedro Bay although none appear in BOEM databases.

Pipelines to or from the BOEM oil and gas platforms in the San Pedro Bay would be crossed by the project, if Alamitos is selected as a termination point. Selecting Huntington Beach as a termination point may allow the project to avoid crossing existing pipelines to oil and gas platforms.

Potential Solution:

- Cable and pipeline crossings, if necessary, would need to occur as near a 90-degree perpendicular angle to the existing cable or pipeline as practicable, and crossings could require installation in a protective conduit or postlay armoring by a remotely operated vehicle (ROV).

Burial and Protection of the Submarine Cable

Reliability of the system depends on its protection, and the power cable should be expected to experience occasional faults due to outside damage. During 15 years of study by CIGRE, 49 faults were reported for 7,000 circuit-kilometers (4,350 circuit-miles) of submarine power cables, resulting in a fault rate of 0.8 faults per year per 1,000 circuit-miles (National Renewable Energy Laboratory, 2011). The most common risks of damage to submarine cables are from fishing gear (52 percent), anchors (18 percent), and suspensions (5 percent). Earthquakes caused relatively few of the reported faults (3 percent) (National Renewable Energy Laboratory, 2011).

Techniques are available to armor and protect the cable, and assessing the effectiveness of the techniques can be accomplished through the use of a "burial protection index" (Sharples, 2011).

Potential Solutions:

- Burial within seafloor between 1 to 5 meters reduces the risk of damage.
- Periodically during project operation, for all buried portions of the cables, the owner would need to ensure that adequate coverage has been maintained to avoid interference with fishing gear/activity (Bureau of Ocean Energy Management, 2007).
- The USACOE would generally prohibit installing a buried cable along the length of a marked channel, and areas known to be used for vessel anchoring would need to be avoided. Outside of known vessel anchoring areas, burial alone would not completely avoid the risk of an anchor strike, and a high risk of an anchor strike would violate a primary underwriting standard for cable insurance (Navigant Consulting, Inc., 2011).

Other Mechanical and Electrical Considerations

There are no standard designs for submarine cable systems. Water depths and routing details may dictate cable strength requirements, and the cable-laying vessel equipment and layout of the vessel and installation equipment should also be considered in cable design (Sharples, 2011).

Cable specifications would need to be established to address the following details:

- Cable strength
- Bending radius
- Thermal requirements
- Water penetration
- Fault-protection, lightning protection
- Splicing
- Repair procedures
- Quality control

Other Installation and Maintenance Considerations

- Limited global availability of cable-installation vessels
- Quantity, mass, and transport of cable
- Availability of mechanical plow or jet plow equipment
- Need for postlay burial in sediment or postlay cable protection and armoring through the use of ROV.

CHAPTER 5: Submarine Transmission Route Alternatives

Alternative 1: Submarine HVDC Cable

ALTERNATIVE 1

Submarine High-Voltage Direct Current Cable – connecting SCE and SDG&E system

a. Build converters at Alamitos or Huntington Beach switchyard.

b. Connect Alamitos East and Alamitos West 230 kV buses together (this may require upgrading 230 kV circuit breakers to withstand higher fault duty at Alamitos Substation).

c. Build converters at the following terminating point at one of the following potential sites (four options).

   i. San Onofre 230 kV switchyard or vicinity location near SONGS.

   ii. Encina 230 kV switchyard.

   iii. Terminating at the existing Penasquitos Substation.

   iv. Terminating at South Bay, Old Town, or Silvergate

d. Common upgrades to the above item (c):

   i. Converter station at Encina 230 kV switchyard.

   ii. Install dynamic reactive supports at the following locations:

      - 700 MVAR to be connected to San Onofre 230 kV switchyard.
      - 500 MVAR at Alamitos East 230 kV switchyard (this could be part of the converter's dynamic reactive support capability).
      - 300 MVAR at Alamitos West 230 kV switchyard.
      - 300 MVAR at Del Amo 230 kV Substation.
      - Retain existing Huntington Beach dynamic reactive supports for Units 3 and 4 (if these two are not repowered by AES due to lack of PPA).
      - Install a 225 MVAR SVC at Penasquitos Substation (for options that terminate the submarine cable at Encina or Penasquitos; if connecting at Penasquitos, this could be part of the dynamic reactive support of the converter).

e. Potential future upgrade to San Onofre–San Luis Rey 230 kV #1 line (under 1.c.i above) for terminating submarine cable at San Onofre 230 kV switchyard.

f. Upgrade Encina Tap–San Luis Rey 230 kV line (TL 23011A) from 2x1033 ACSR to 2x1033 ACSS to gain more emergency rating; ACSS conductors could be strung on the same tower without requiring additional rights-of-way. This is required for Option 1.c.ii above (i.e., terminating at Encina 230 kV switchyard).

g. Lay XLPE undersea cable connecting L.A. Basin to San Diego areas (that is, Alamitos to termination points under 1.c.).

Description of Submarine Options

Submarine options involve establishing a new HVDC transmission line to connect the service territories of SCE and SDG&E inside the Los Angeles Basin and San Diego local capacity areas. Each submarine option includes establishing new transmission line interconnections at one northern and one southern terminating point at existing SCE and SDG&E switchyards, respectively. Each submarine HVDC option would also include two new converter stations near the existing SCE and SDG&E switchyards, coastal landings for the cable, and laying the new cable offshore.

In terms of evaluating potential constraints, the primary considerations for this alternative are:

- Siting the HVDC converter stations with compatible existing land uses.
- Siting the cable system coastal landing zones and terrestrial underground cable with compatible existing land uses.
- Routing the cable to avoid slopes greater than 30 degrees.
- Routing the cable crossings of faults in the direction of the fault lines.
- Routing the cable to avoid State Marine Conservation Areas and State Marine Reserves.

Many other routing considerations must also be balanced, such as avoiding impacts to hard-bottom benthic habitats and avoiding mapped archaeological resources, but proper route selection and design should be able to address these issues.

Figure 22 shows the underwater topography along the submarine corridors, and Figure 23 shows the slopes of the topography. Figure 24 shows known faults in the study area. Appendix E (Detailed Submarine Corridor Maps) contains six higher-resolution maps for each of these figures.

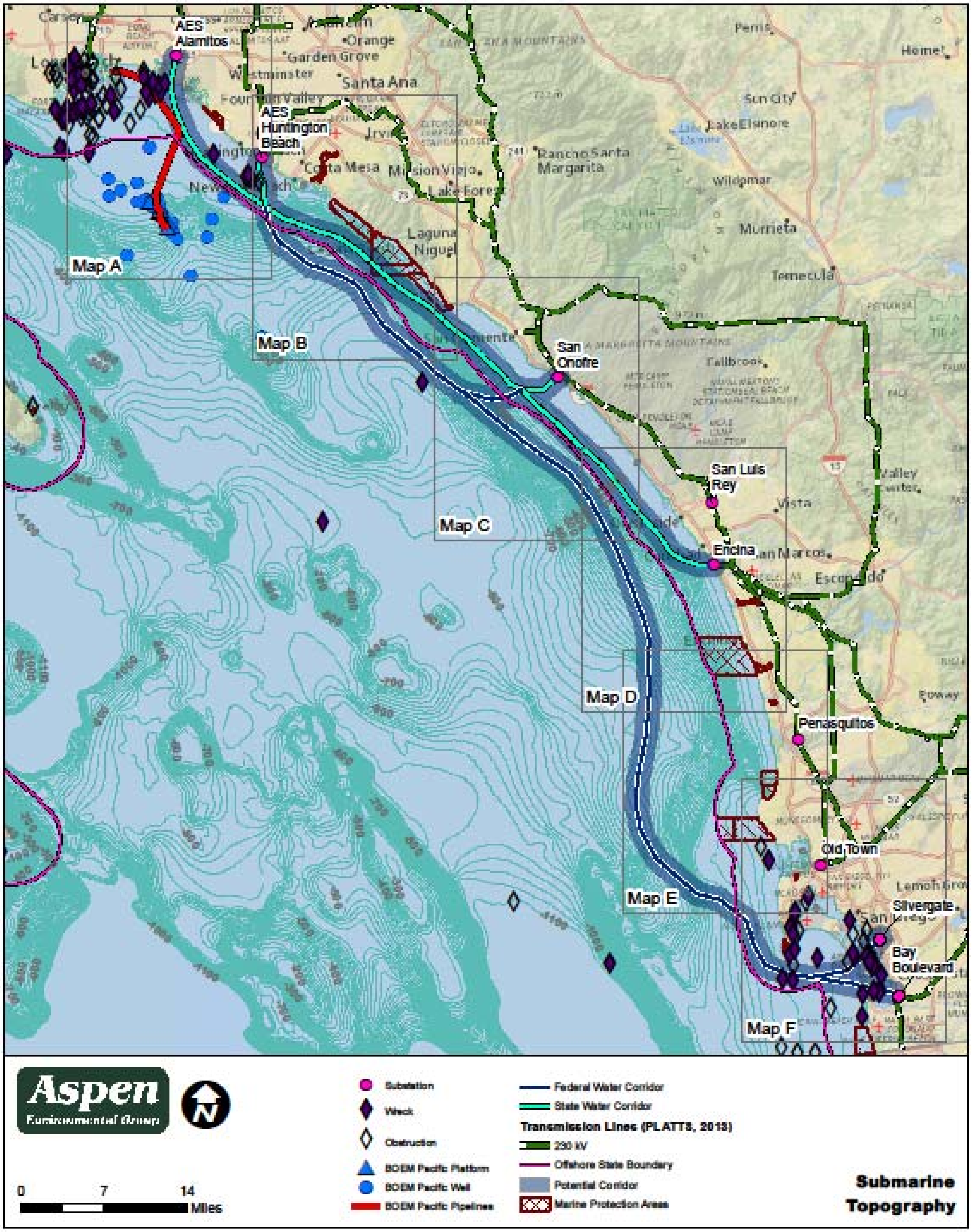
HVDC Converter Station Locations and Coastal Landings

New terminating points for interconnection would be established for the new submarine HVDC transmission line at two of the switchyards/substations listed in Table 10. The northern terminating point would either by at Alamitos or Huntington Beach, and the southern terminating point would be at one of the six southern locations listed in Table 10.

Table 10: Possible Terminating Points for New Submarine HVDC Transmission Line

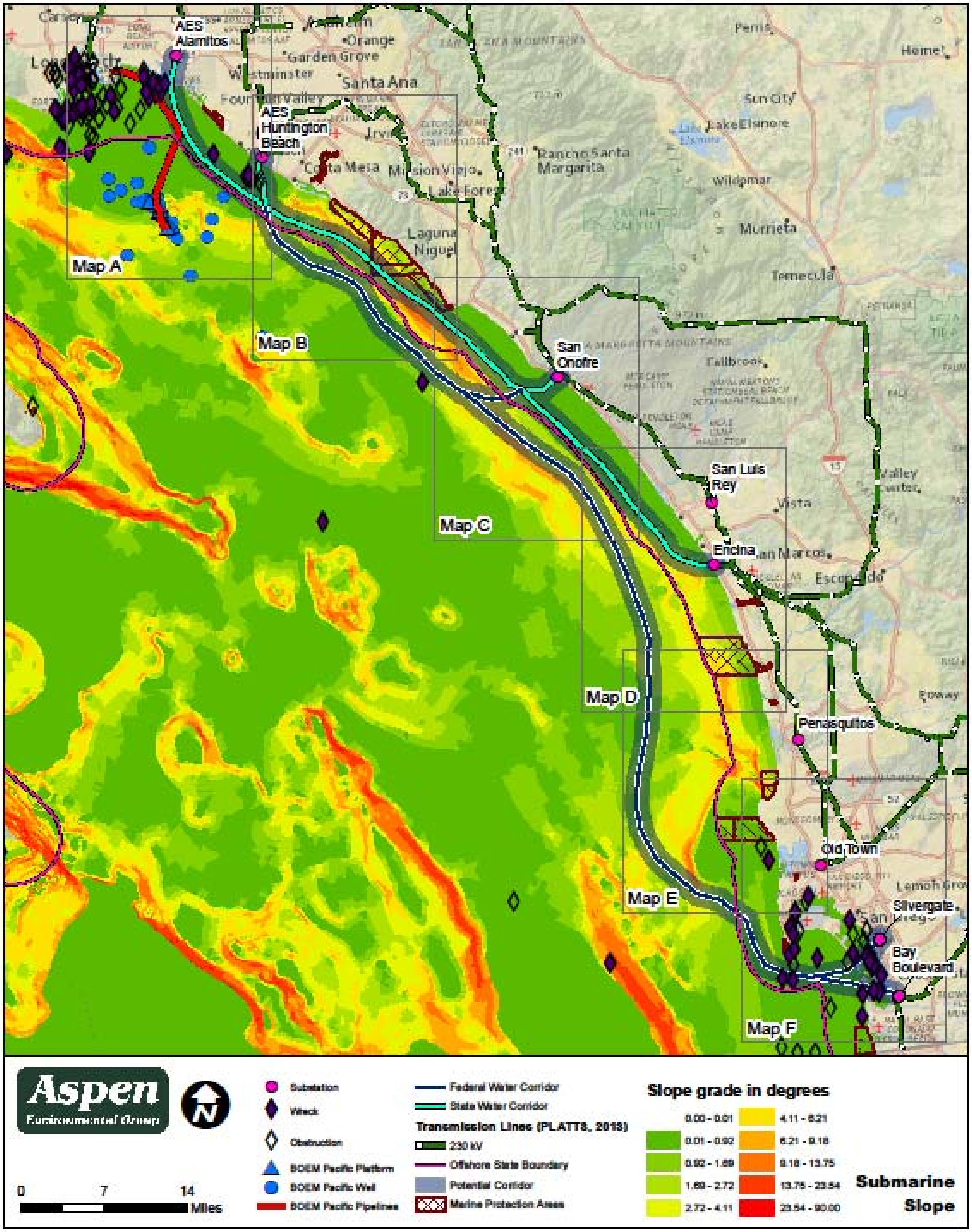
Northern Substations	Jurisdiction, Location	Constraints
North 1. Alamitos	City of Long Beach City of Seal Beach	Dense coastal development. Potential conflicts with commercial and recreational mariners. Channelized and navigable waterways.
North 2. Huntington Beach	City of Huntington Beach	Coastal landing would require long HDD or beach traverse through Huntington Beach State Park. Site planned for redevelopment.
Southern Substations	**Jurisdiction, Location**	**Constraints**
South 1. San Onofre	Marine Corps Base Camp Pendleton	Requires ROW on Camp Pendleton.
South 1 Option: Japanese Mesa or SONGS Mesa	Marine Corps Base Camp Pendleton	Requires ROW on Camp Pendleton.
South 2. Encina or Cannon	City of Carlsbad	Site planned for redevelopment.
South 3. Pensaquitos	City of San Diego	Incompatible surrounding existing land uses. Not viable: no suitable coastal landing site.
South 4. South Bay or Bay Boulevard	U.S. Department of Defense, San Diego Bay City of Chula Vista	Requires routing cable in navigable waterways of San Diego Bay or crossing Coronado Island near or through Silver Strand State Beach.
South 5. Old Town	U.S. Department of Defense, San Diego Bay City of San Diego	Incompatible surrounding existing land uses. Not viable: no suitable coastal landing site.
South 6. Silvergate	U.S. Department of Defense, San Diego Bay City of San Diego	Requires routing cable in navigable waterways of San Diego Bay or crossing Coronado Island near or through Silver Strand State Beach.

Figure 22: Submarine Topography



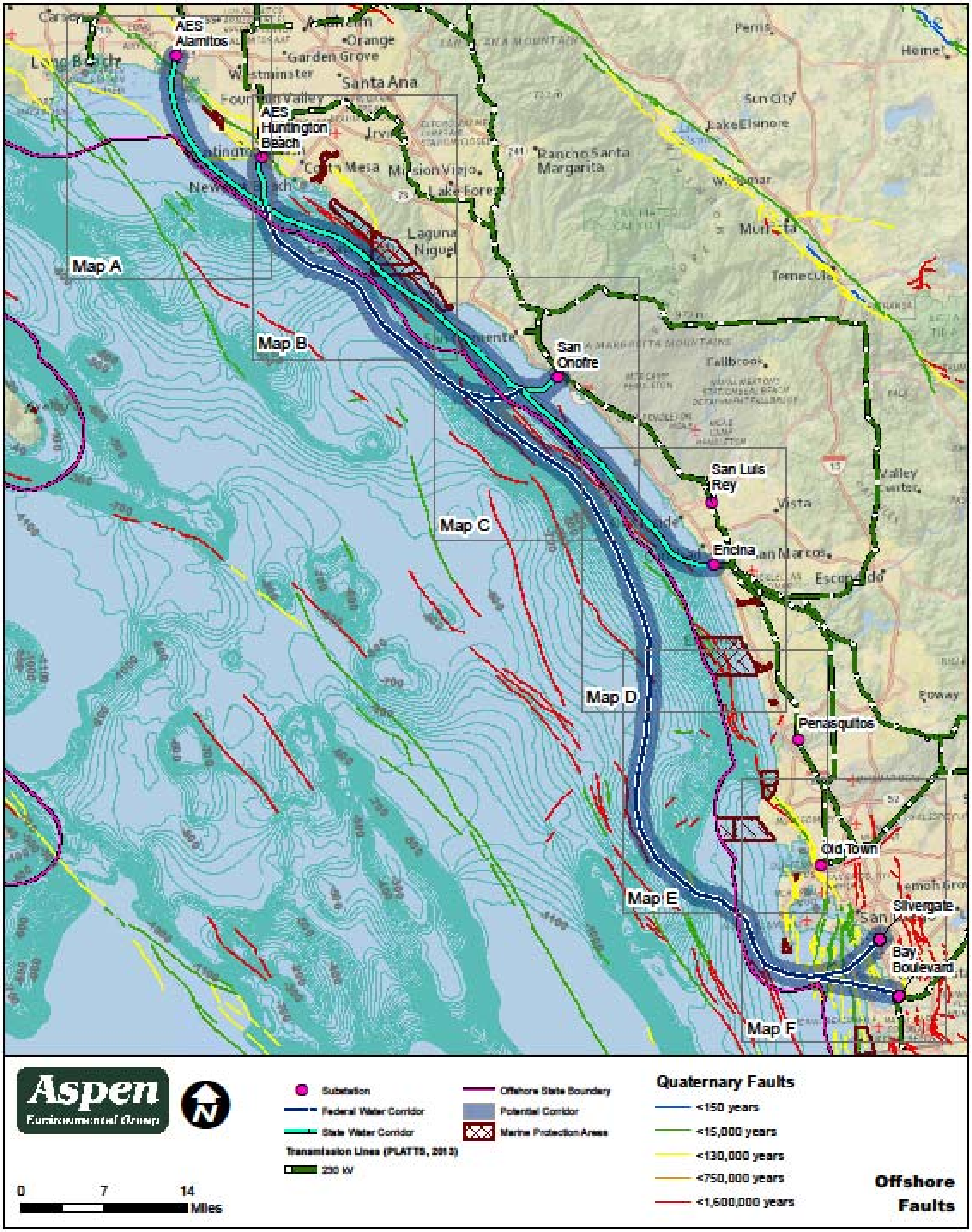
Source: Aspen Environmental, 2014

Figure 23: Submarine Slope



Source: Aspen Environmental, 2014

Figure 24: Offshore Faults



Source: Aspen Environmental, 2014

Submarine Corridor Descriptions

Figure 22 shows the potential submarine transmission corridors identified in this analysis based on the following goals:

- Avoid slopes greater than 30 degrees.
- Route cable crossings of faults in the direction of the fault lines.
- Avoid State Marine Conservation Areas and State Marine Reserves.
- Avoid known shipwrecks and mapped archaeological resources.

Federal Water Corridor

The Federal Water Corridor, a corridor far enough offshore to be under federal jurisdiction, would allow the cable system to avoid the Laguna Beach marine conservation areas and would allow the greatest flexibility in the route selection process in avoiding steep slopes or canyon crossings.

For interconnection points south of Encina, routing through federal coastal water would allow the cable to bypass other State Marine Conservation Areas, Swami's SMCA, and South La Jolla SMCA and SMR.

The maximum water depth along the Federal Water Corridor is about 2,000 feet (600 meters).

State Water Corridor

The State Water Corridor, a corridor within California state jurisdiction, leaves little flexibility for the route selection process in avoiding steep slopes or canyon crossings. For the route to avoid traversing steep slopes, the route may be forced to cross the Laguna Beach marine conservation areas. The corridor shown in this analysis minimizes the crossing of the Laguna Beach conservation areas, although this increases the likelihood of forcing the route to traverse steep slopes. To remain within state waters, the cable may need to be secured to the seafloor to avoid suspensions or free-spans, which could increase benthic habitat impacts.

Interconnection points south of Encina are not considered to be viable with a State Water Corridor because routing through state coastal water would force the cable to cross the Swami's SMCA and South La Jolla SMCA and SMR.

The maximum water depth along the State Water Corridor is about 1,000 feet (300 meters).

Supporting Analysis of Interconnection Locations

Alamitos (North 1)

The Alamitos Generating Station (AGS) is at 690 North Studebaker Road on the eastern side of Long Beach in Los Angeles County. AGS includes six conventional steam turbine units with a total generating capacity of 1,950 MW (California Ocean Protective Council, 2008). The AGS facility covers 120 acres of a 230-acre industrial site along the west back of the San Gabriel River, 2 miles northeast of the entrance to Alamitos Bay and the Long Beach Marina (California Ocean

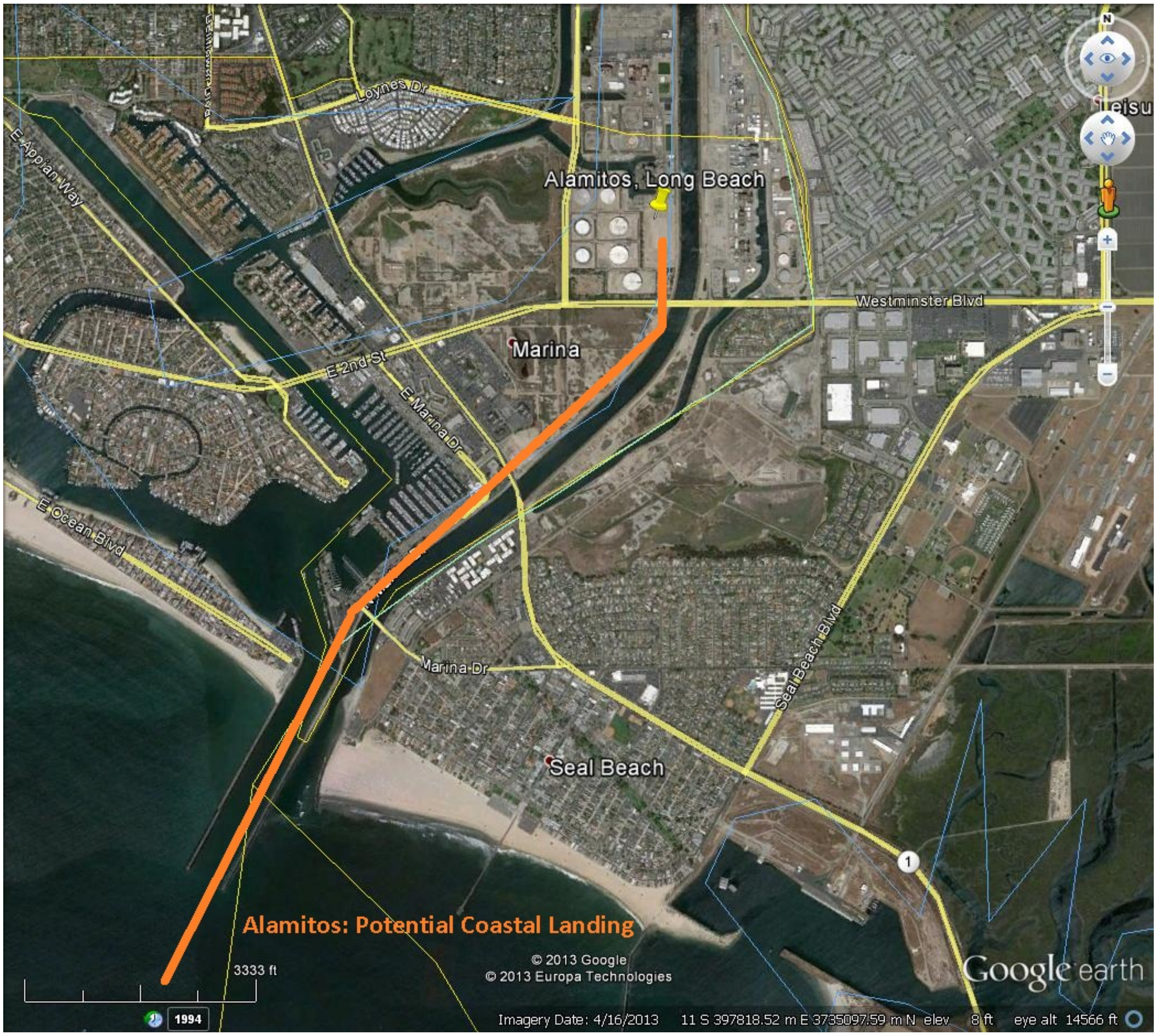
Protective Council, 2008). The switchyard is in the northern portion of the site near East 7th Street.

The AGS site is bounded by East 7th Street (Highway 22) to the north, the San Gabriel River to the east, Westminster Avenue to the south, and North Studebaker Road and the Los Cerritos Channel to the west. The city of Seal Beach is adjacent to the eastern edge of the facility across the San Gabriel River. The Los Angeles Department of Water and Power Haynes Generating Station is directly opposite AGS on the east bank of the San Gabriel River.

Land Use: The land use in the vicinity of the Alamitos Generating Station includes power generation, open space, and residential. The immediate area of the generating station is zoned for planned development (PD-1) as part of the Southeast Area Development and Improvement Plan (SEADIP), Subarea 19, by the City of Long Beach and residential low density (RLD) and residential high density (RHD) by the City of Seal Beach. The land use at the generating station is mixed uses (7). Subarea 19 is fully developed by the existing permitted industrial uses, that is, Alamitos and adjacent power generation stations (City of Long Beach, 1999). Rosie the Riveter Charter High School is located on the AGS site.

Jurisdiction/Plans*:* City of Long Beach General Plan, Southeast Area Development and Improvement Plan, City of Seal Beach General Plan. The site is not in the California Coastal Commission’s designated coastal zone.

Figure 25: Alamitos: Potential Coastal Landing



Source: Obtained from Google Earth, 2014

Site Analysis for Alamitos

Figure 25 shows the potential Alamitos landing. The switchyard is adjacent to the San Gabriel River and two miles northeast of the entrance to Alamitos Bay and the Long Beach Marina. There are open space, industrial, and residential land uses between the site and the Queensway Bay. In 2008, the site was evaluated for conversion to closed-cycle wet cooling (California Ocean Protective Council, 2008). The evaluation determined that there would not be space for wet cooling towers if land owned by Pacific Energy could not be secured for use.

Huntington Beach (North 2)]

The existing Huntington Beach Generating Station (HBGS) is at 21730 Newland Street, just north of the intersection of Pacific Coast Highway (U.S. Highway 1) and Newland Street. In

2012, AES Southland, LLC submitted an application to the Energy Commission to demolish the HBGS and replace it with the Huntington Beach Energy Project (HBEP). The HBEP would be air-cooled, which would eliminate the need for large quantities of once-through cooling seawater currently used by the HBGS. HBEP would be a natural gas-fired, combined-cycle, 939 MW electrical generating facility consisting of two independently operating, combined-cycle gas turbine power blocks. Huntington Beach is in Orange County. An optional endpoint in this area would be the SCE Ellis Substation, located about three miles northeast of the power plant, near the intersection of Garfield Avenue and Ward Street, also in Huntington Beach.

Land Use

The HBGS/HBEP site covers 28.6 acres in a largely industrial area of Huntington Beach. The area is designated as Public (P) in the Huntington Beach General Plan; this designation allows for development of public utilities. The HBGS/HBEP site is zoned public-semi-public (PS) and is included in the Coastal Zone Overlay District (CZ), and the Oil Production Overlay District (O). The areas surrounding the site include the following land uses:

- **North:** Between Edison Drive and the Huntington Beach Channel, there are an animal hospital and auto wrecking and recycling centers. Beyond the Huntington Beach Channel there are mini-storage facilities, warehouses, and then residential neighborhoods, including parks and schools.
- **South:** The Wetlands and Wildlife Care Center is adjacent to the existing HBGS site on a narrow strip of land between the HBGS boundary and Pacific Coast Highway. Huntington Beach State Park and the Pacific Ocean are across Pacific Coast Highway from the site.
- **East:** The Huntington Beach Channel runs along the eastern boundary of the HBGS/HBEP site. The Huntington Beach Wetland Preserve/Magnolia Marsh Restoration Project Area is adjacent to the southeast HBGS boundary and southwest of the Huntington Beach Channel. There is another tank farm (Plains All American Tank Farm) to the east of the Channel and the Ascon/Nesi Landfill is to the northeast (within the Magnolia Pacific Specific Plan Area).
- **West:** The Huntington-By-The-Sea Mobile Home and RV Park and Cabrillo Mobile Home Park are across Newland Street to the west. There is a partially completed new subdivision, Pacific Shores, to the northwest.

Jurisdiction/Plans

City of Huntington Beach General Plan, Huntington Beach Zoning and Subdivision Ordinance.

Figure 26: Huntington Beach: Potential Coastal Landing

Source: Obtained from Google Earth, 2014

Site Analysis for Huntington Beach

Figure 26 shows the potential Huntington Beach landing. The southwest boundary of the HBGS/HBEP site is about 1,200 feet from the Pacific Ocean. This site may be able to provide a landing point, possibly using retired once-through cooling facilities once the HBGS is closed. In addition, there may be space on the reconfigured HBEP site for a converter station. Coastal landing would require a long HDD (more than 2,000 feet) or beach traverse through Huntington Beach State Park.

San Onofre (South 1)

The San Onofre Nuclear Generating Station (SONGS) site is in northwestern San Diego County, two miles south of San Clemente. It is just south of I-5 and the Pacific Coast Highway along the coast. The SONGS site is under the jurisdiction of the MCBCP. The switchyard is in the northern portion of the site near Pacific Coast Highway. Offshore and north of SONGS, near the San Clemente pier, SCE installed an artificial rock reef for improving giant kelp habitat in the area, called the Wheeler North Reef.

SCE announced plans to permanently retire SONGS on June 7, 2013. Within two years of shutdown, SCE must submit a detailed decommissioning plan, including activities and schedules, cost estimates, and potential environmental impacts, to the Nuclear Regulatory Commission and to state officials. The final closure date for the SONGS has not been determined, but SCE is required to complete decommissioning within 60 years.

Land Use. The SONGS site is characterized by industrial land uses, such as office structures, warehouses, paved equipment years, and paved parking lots. The site is also surrounded by designated open space and recreational areas managed by California State Department of Parks and Recreation and MCBCP.

Jurisdiction/Plans. MCBCP (DOD), San Onofre State Beach (California State Department of Parks and Recreation), U.S. Marine Corps Base Camp Pendleton *Integrated Natural Resource Management Plan* (2001), *San Onofre State Beach Revised General Plan* (1984).

Japanese Mesa or SONGS Mesa (South 1 Option)

The existing SDG&E Japanese Mesa 69 kV (also known as SONGS Mesa) substation on Camp Pendleton is south of the San Onofre Gate and east of I-5, within Area 51 of the base. Area 51 is used by the Pendleton's Heavy Equipment Facilities Maintenance Department. Japanese Mesa substation occupies a roughly 0.3-acre site within a 3-acre parcel situated immediately south and east of land used by the Marines for bulk materials storage (sand/gravel) and other low-density activities. Southeast of the substation is an approximately 70-acre area through which power lines from the SONGS switchyard pass before diverging north and south to SCE and SDG&E substations. About 30 acres of this area appear sufficiently flat to be graded to accommodate new electricity facilities such as switchyards and substations. Subject to Department of Defense approval, it appears feasible to replace substation and switchyard facilities at SONGS with new facilities at this location. This move would eliminate high-voltage lines crossing over I-5 and consolidate facilities closer to the existing north-south transmission corridor on Camp Pendleton. The area also has the potential for construction of a substation that would be an alternative to using the Talega Substation as a hub for various transmission line interconnection alternatives.

Land within the base includes breeding habitat for birds such as the western snowy plover and California gnatcatcher. Rare mammals on base include the Pacific pocket mouse and Stephens' kangaroo rat. Based on Pendleton's Integrated *Natural Resources Management Plan*, the area around Japanese Mesa includes California gnatcatcher habitat (U.S. Marine Corps Base Camp Pendleton, 2012). Presence of these birds during nesting season potentially would restrict construction activities for that part of the year. Also, mitigation may be required if habitat is taken.

Site Analysis for San Onofre. Figure 27 shows the potential San Onofre landing. The SONGS site is within 100 feet of the ocean. Based on aerial review it may be able to provide a landing point and space for a converter station. To avoid colocation of the cable system with the decommissioning activities at SONGS, the Japanese Mesa or SONGS Mesa option would be preferred.

Figure 27: San Onofre: Potential Coastal Landing

Source: Obtained from Google Earth, 2014

Encina or Cannon (South 2)

The Encina Power Plant and the SDG&E Cannon Substation are in Carlsbad in northern San Diego County. In 2012, the Energy Commission approved NRG's application to construct the Carlsbad Energy Center Project (CECP) on the Encina Power Plant site.[5] The 23-acre CECP is planned for the northeast section of the 95-acre Encina Power Plant site (currently occupied by a tank farm). The SDG&E Cannon Substation is located immediately south of the CECP site. The Encina Power Plant/CECP site is north of Cannon Road and west of I-5, roughly 1,500 feet from the shoreline. An option to this endpoint would be the SDG&E San Luis Rey Substation near Highway 76 in Oceanside, although this site is farther from the coast and closer to residential areas.

Land Use. The CECP is site surrounded by a variety of industrial and commercial land uses including:

- **North:** Agua Hedionda Lagoon to the north and northeast.
- **South:** Cannon Boulevard and single family residences south side of Cannon Boulevard.
- **East:** I-5 to the east, with Car Country Park south and adjacent to west side of I-5 (private greenbelt).
- **West:** Carlsbad Boulevard (Community Scenic Corridor) to the west and Carlsbad State Beach west of Carlsbad Boulevard; single-family residences to the southwest (west of Carlsbad Boulevard).

The Encina Power Plant site is designated public utilities (PU) under the city's general plan. There is designated open space to the north and south. There are also residential low-medium density, travel/recreational commercial, and planned industrial designations to the south.

Jurisdiction/Plans. Encina Specific Plan (SP 144) covers 680 acres of Encina Power Plant and adjacent beach and lagoon. Carlsbad General Plan, Carlsbad Zoning Ordinance, Encina Specific Plan, Encina Power Station Precise Development Plan (PDP 00-02), Carlsbad Local Coastal Program/Agua Hedionda Land Use Plan (1982), North County Multiple Habitat Conservation Plan (MHCP) and the Carlsbad Habitat Management Plan (HMP) for Natural Communities, South Carlsbad Coastal Redevelopment Project Area Plan. The City of Carlsbad has a certified Local Coastal Program, but the proposed CECP is within the Coastal Commission's retained jurisdiction.

Site Analysis for Encina. Figure 28 shows the potential Encina landing. The site is in an industrial area that borders the Agua Hedionda Lagoon. The site is relatively close to the shore (~1,500 feet), and based on aerial review, there may be adequate space for a landing point and converter station.

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5 According to the City of Carlsbad, it is not clear when the CECP would be built. http://news.carlsbadca.gov/proposed-power-plant

Figure 28: Encina: Potential Coastal Landing

Source: Obtained from Google Earth, 2014

Penasquitos [South 3]

The Penasquitos Substation is in San Diego near the intersection of Carmel Mountain Road and East Ocean Air Drive.

Land Use. The land use designations surrounding the substation are commercial and office, parks and recreation/open space, public facilities and utilities, and residential. Torrey Hills Park is to the west, and the Torrey Corner Shopping Center is to the northeast.

Jurisdiction/Plans. City of San Diego, City of San Diego General Plan.

Site Analysis for Penasquitos. Figure 29 shows the surroundings for Penasquitos. The site is surrounded by open space, recreational, commercial, and residential land uses, and it is more than 2 miles from the shoreline. Based on aerial review this site does not appear feasible for a coastal landing point or a converter station.

Figure 29: Peñsaquitos: Surrounding Land Uses

Source: Obtained from Google Earth, 2014

South Bay or Bay Boulevard (South 4)

The existing South Bay Substation is in Chula Vista in southwestern San Diego County. In October 2013, the CPUC voted to allow SDG&E to develop the South Bay Substation Relocation Project. This project involves demolition of the existing South Bay Substation (near Bay Boulevard and L Street) and the construction of the Bay Boulevard Substation 0.5 miles to the south on the site of a former liquefied natural gas (LNG) plant. The Bay Boulevard Substation site would be 2 miles within Chula Vista, 7 miles southeast of downtown San Diego.

Land Use. Both the South Bay Substation site and the future approved Bay Boulevard Substation site are adjacent to industrial and commercial uses and designated open space. According to the draft Port Master Plan amendment, the proposed substation site is designated as Industrial Business Park, and land uses surrounding the substation site include habitat replacement to the immediate east, park/plaza to the north, and open space to the east. North of the site, there is industrial land associated with previous LNG facility. To the west there are salt crystallizer ponds associated with Western Salt Works (commercial salt producer). To the south there are industrial and office uses, and to the east there are an SDG&E utility corridor/easement, San Diego and Arizona Eastern Railway tracks, and commercial and industrial uses east of Bay Boulevard. The Bay Boulevard substation site is adjacent to the boundary of San Diego Bay National Wildlife Refuge.

Jurisdiction/Plans. Bayfront coastal area of the City of Chula Vista Coastal Zone, lands under the jurisdiction of the Unified Port District of San Diego and under the jurisdiction of the city, the city's LCP Land Use Plan area (Figure D.10-2a [Bayfront Jurisdictional Boundaries]), California Coastal Act Policy, Chula Vista Bayfront Master Plan, Unified Port District of San Diego – Port Master Plan, Chula Vista Local Coastal Program – Land Use Plan, Bayfront Specific Plan, City of Chula Vista General Plan, Chula Vista Bayfront Master Plan (CVBMP).

Site Analysis for South Bay. Figure 30 shows the potential South Bay landing. The Bay Boulevard site is roughly 0.4 mile from the bay across the existing salt works. Fourteen acres of the former LNG site would not be developed for the relocated substation, which may leave room for a converter station. Access to San Diego Bay may require routing the cable system across Coronado Island near or through Silver Strand State Beach.

Figure 30: South Bay: Potential Coastal Landing

Source: Obtained from Google Earth, 2014

Old Town (South 5)

The Old Town Substation is in San Diego at 5525 Gaines Street.

Land Use. The Old Town Substation site is bordered by four city streets: Gaines Street to the south, Benicia Street to the east, Azusa Street to the west, and Riley Street to the north. The San Diego County Animal Services Department is across Azusa Street to the west. There are homes across Riley Street to the north, commercial areas to the south, and residential areas to the west.

Jurisdiction/Plans. City of San Diego, City of San Diego General Plan.

Site Analysis for Old Town. Figure 31 shows the surroundings for Old Town. This substation site is 3 miles (through largely residential areas) from the nearest inlet to the ocean near Sea World Drive. There is an approximately 1-acre, apparently vacant, lot south of the substation, but otherwise space is constrained by adjacent residential and commercial development. Based on aerial review, this site is unlikely to provide a feasible coastal landing point or space for a converter station.

Figure 31: Old Town: Surrounding Land Uses

Source: Obtained from Google Earth, 2014

Silvergate (South 6)

The SDG&E Silvergate Substation is located at Harbor Drive and Sampson Street in the Barrio Logan community in San Diego. The site vicinity is entirely paved and developed. The site is surrounded by industrial development to the northwest, Harbor Drive to the northeast, Sampson Street to the southeast, and East Belt Street to the southwest. There are homes 500 feet to the north. The harbor is roughly 700 feet southwest of the substation site. The Naval Station San Diego, National Steel and Shipbuilding Company, and other military-associated facilities are in the project vicinity.

Land Use. The substation site is designated as industrial land in the San Diego County General Plan. There are areas designated for multiple uses across Harbor Way.

Jurisdiction/Plans. City of San Diego General Plan, San Diego Unified Port District, Barrio Logan Community Plan and Local Coastal Program, Barrio Logan Planned District Ordinance.

Site Analysis for Silvergate. Figure 32 shows the potential Silvergate landing. The Silvergate Substation is separated from the San Diego Bay by about 700 feet of industrial development. There may be some vacant industrial sites in the vicinity that could be used for siting a converter station. Access to the San Diego Bay may require routing the cable system across Coronado Island near or through Silver Strand State Beach.

Figure 32: Silvergate: Potential Coastal Landing

Source: Obtained from Google Earth, 2014

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ACRONYMS

ABDSP	Anza-Borrego Desert State Park
AC	alternating current
ACEC	Area of Critical Environmental Concern
AGS	Alamitos Generating Station
ARB	California Air Resources Board
ARPA	Archaeological Resources Protection Act
AWOIS	Automated Wreck and Obstruction Information System
BLM	U.S. Bureau of Land Management
BNSF	Burlington Northern Santa Fe
BOEM	Bureau of Ocean Energy Management
BPA	Bonneville Power Administration
Cal FIRE	California Department of Forestry and Fire Protection
California ISO	California Independent System Operator
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDP	coastal development permits
CECP	Carlsbad Energy Center Project
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFGC	California Fish and Game Code
CFR	Code of Federal Regulations
CIGRE	Council on Large Electric Systems
CNF	Cleveland National Forest
CPCN	Certificate of Public Convenience and Necessity
CPUC	California Public Utilities Commission
CSC	Current Source Converters
CSLC	California State Lands Commission
CVBMP	Chula Vista Bayfront Master Plan
CWA	Clean Water Act
CZ	Coastal Zone Overlay District
CZMA	Coastal Zone Management Act
DC	direct current
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DTSC	Department of Toxic Substances Control
EFH	essential fish habitat
EIR	environmental impact report
EIS	environmental impact statement
EMF	electric and magnetic fields

ESA	Endangered Species Act
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
FLMPA	Federal Land Management Policy Act
HBEP	Huntington Beach Energy Project
HBGS	Huntington Beach Generating Station
HCP	Habitat Conservation Plans
HDD	horizontal directional drilling
HECO	Hawaiian Electric Co.
HIREP	Hawaii Inter-Island Renewable Energy Program
HMP	Habitat Management Plan
HVAC	high-voltage alternating current
HVDC	high-voltage direct current
ICAPCD	Imperial County Air Pollution Control District
IHA	Incidental Harassment Authorization
IID	Imperial Irrigation District
kV	kilovolt
LADWP	Los Angeles Department of Water and Power
LCC	line-commutated converters
LCP	Local Coastal Programs
LEAPS	Lake Elsinore Advanced Pumped Storage
LNG	liquefied natural gas
LOA	Letter of Authorization
MBTA	Migratory Bird Treaty Act
mG	milligauss
MCB	Marine Corps Base
MCBCP	Marine Corps Base Camp Pendleton
Merc	mercury
MHCP	Multiple Habitat Conservation Plan
MI	mass-impregnated
MMAs	Marine Managed Area
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Areas
MRI	magnetic resonance imaging
MWD	Metropolitan Water District
MVA	million volt-amperes
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge and Elimination System
NREL	National Renewable Energy Laboratory

NWP	Nationwide Permit Program
O	Oil Production Overlay District
OCRM	Ocean and Coastal Resource Management
OCS	Outer Continental Shelf
OH	overhead
P	public
PDP	precise development plan
PEA	proponent's environmental assessment
PPA	power purchase agreement
PRC	Public Resources Code
PU	Public Utilities
RCHCA	Riverside County Habitat Conservancy Agency
RHD	residential high density
RLD	residential low density
ROV	remotely operated vehicle
ROW	right-of-way
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SBNF	San Bernardino National Forest
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison Company
SCFF	self-contained fluid–filled
SCR	Selective Catalytic Reduction
SDG&E	San Diego Gas & Electric
SDAPCD	San Diego Air Pollution Control District
SEADIP	Southeast Area Development and Improvement Plan
SEIS	supplemental environmental impact statement
SMCA	State Marine Conservation Areas
SMR	State Marine Reserves
SOCRE	South Orange County Reliability Enhancement
SONGS	San Onofre Nuclear Generating Station
SP	specific plan
SR	State Route
SUP	special use permit
SVC	Static VAR Compensator, where VAR means reactive volt-amperes
SWPL	Southwest Powerlink
SWPPP	Storm Water Pollution Prevention Plan
TBC	Trans Bay Cable LLC
TE/VS	Talega-Escondido/Valley-Serrano Interconnect
Thy	thyristor
TNHC	The Nevada Hydro Company
Tra	transistor
TRTP	Tehachapi Renewable Transmission Project

TSP	tubular steel pole
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VAR	volt ampere reactive
VID	Vista Irrigation District
V/m	volt per meter
VSC	Voltage Source Converters
WDR	waste discharge requirement
WQC	water quality certifications
WSA	wilderness study area
XLPE	cross-linked polyethylene

APPENDICES