total linear length of underground 345-kV cable in the TNA screening analyses ranged from 4 to 44 miles.

Because the Council directed the ROC Group to determine the maximum linear miles of underground that are technologically feasible, the studies began by focusing on segments 3 and 4 (East Devon to Singer, and Singer to Norwalk). While the siting process generally addresses "linear miles," technological feasibility is affected by "circuit miles."[3] Therefore, the ROC Group began its investigation with the locations where the fewest circuits are required, with the intent of then moving on as the system's tolerances would allow. Because the Project segments west of East Devon require only two circuits, while the Project segments east of East Devon require three circuits, maximizing linear length of underground cable logically starts with the portion of the Project between East Devon and Norwalk.

As discussed in this report, the ROC Group has made the following key determinations in meeting the goal of maximizing the amount of underground cable that is technologically feasible:

(1) The construction and operation of Alternatives A and B in the Companies' October 2003 Application to the Council are technologically feasible, and the ROC Group would support the construction and operation of either of these configurations. In the list of studies undertaken by the ROC Group, the Alternative A route was studied in Case 2. Alternative A as studied includes the use of 13.3 linear miles (26.6 circuit miles) of underground cross-linked polyethylene ("XLPE") cable rather than high pressure fluid-filled ("HPFF") cable as had originally been proposed. Alternative B includes the use of 4.2 linear miles[4] (8.4 circuit miles) of underground XLPE cable.

(2) The Companies' proposed route (with 24 linear miles of underground cable) as set forth in the Companies' October 8, 2003 Application to the Council, is

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[3] "Circuit miles" is the product of the number of 3-phase circuits between two points times the distance between the two points.

[4] These 4.2 miles would be located in the same path – 2.1 miles from Seaview Transition Station to Singer Substation and 2.1 miles back from Singer to Seaview.

technologically feasible, and the ROC Group supports its construction and operation, provided that:

- XLPE cable is used rather than HPFF cable as had originally been proposed;
- replacement of approximately 1,200 surge arresters and upgrades of other equipment are completed at about half of CL&P's transmission substations and all of the UI transmission substations to improve the capability of the equipment to withstand TOVs; and
- more extensive changes are made to remedy local area problems (Rocky River Substation).

In the list of studies undertaken by the ROC Group, this route and technical configuration was studied as Case 5. It includes 24 linear miles (48 circuit miles) of underground cable.

Case 5 will meet the reliability objectives of the original Phase I and Phase II projects as defined in the Regional Transmission Expansion Plan ("RTEP"). While this configuration (Case 5) is more difficult to construct and operate and carries more risk than Case 2, the ROC Group supports the Case 5 configuration as that which is the maximum technologically feasible use of underground cable. Given what ISO and the Companies have learned about the impact that installing underground cable would have on the already weak system in SWCT (as discussed further below), from the standpoint of electric system design, ISO and the Companies would prefer a transmission design that contains more overhead transmission. Notwithstanding that preference, and in light of the Council's directive, Case 5 can meet necessary reliability, operability and planning requirements.

(3) The potential for TOVs on the electric system that would exceed the withstand capability of system elements limits the use of underground cable. An expanded SWCT system could not be considered reliable if TOVs exceeding the withstand capability of any of its elements were likely to occur under contingency conditions. The capacitance associated with underground cables increases the potential for TOVs. The ROC Group has looked carefully at the magnitude of TOVs in a number of cases, with varying combinations of overhead and underground transmission lines and varying cable and electrical equipment technologies (such as synchronous condensers and C-Type filters) and under varying operating scenarios. The linear length of underground cable in the TNA screening analyses ranged from 4 to 44 linear miles. Upon reviewing the TNA results, and considering the volatility of the system transient response and load composition variations, as well as various possible generator, capacitor, and reactor dispatches, the ROC Group has determined that the maximum length of underground cable that is technologically feasible for the Project is the 24 linear miles (48 circuit miles) of underground XLPE cable in Case 5. In the judgment of the ROC group, the addition of more

ROC Report Errata Page – Figure 1 Reformatted to Print Correctly
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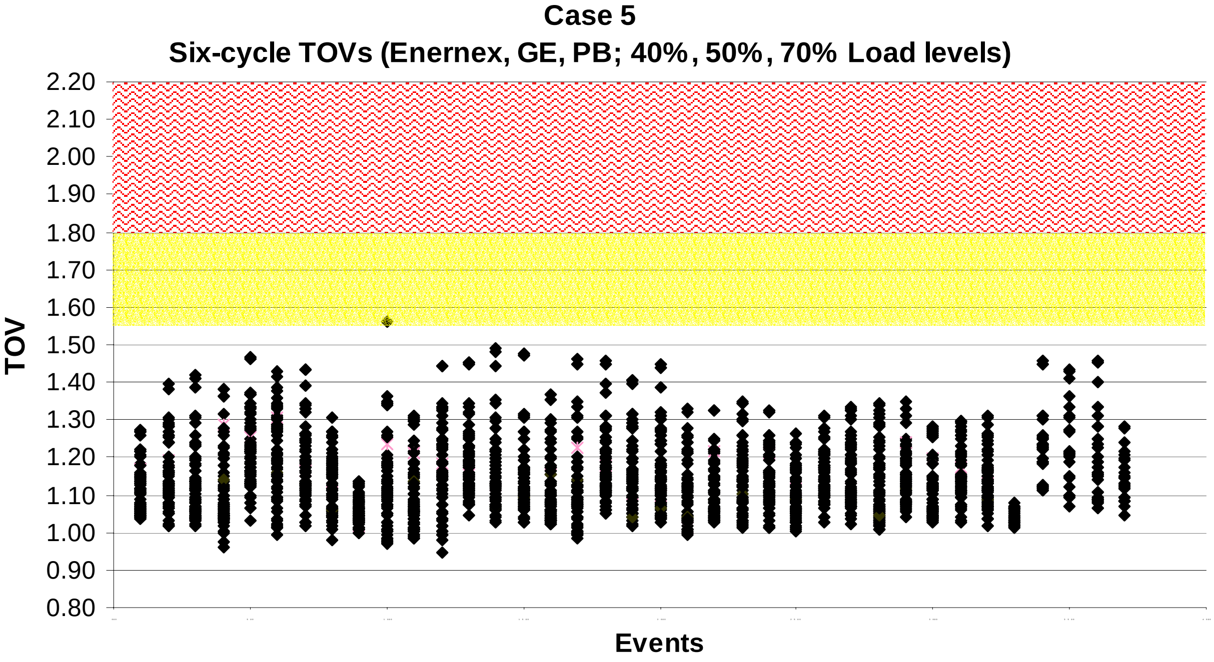
Figure 1



These results, along with the other TNA results, have been reviewed with the ROC Group consultants.

After further analysis and testing of the results, the ROC Group has determined that Case 5 is technologically feasible, provided that the equipment upgrades assumed in Table 1 (the TOV limit table) are made. Thus, in order to maximize the use of underground cable for this configuration to work, CL&P and UI will be required to replace surge arresters on the 115-kV system within and immediate to SWCT, install higher rated replacement equipment and higher rated 345-kV equipment including lightning arresters and potentially, circuit breakers. While making changes to the overhead transmission system in order to enable underground transmission may not be required by P.A. 04-246, the ROC Group has endeavored to mitigate the risks of Case 5 in order to render the case technologically feasible.

arrester can successfully withstand after a series of discharge tests. The Duty Cycle test procedure is defined in IEEE Standard C62.11. For the purpose of this discussion, the remaining arrester rating parameters will be discussed in terms of MCOV in order to directly compare the arrester rating with the nominal system phase to ground voltage.

At MCOV the arrester current is less than a few milliamperes. As the voltage across the arrester is increased to between 20% and 30% above the MCOV, the arrester resistance decreases and the arrester starts to conduct some current and absorb some thermal energy from the power system. This conduction process occurs quickly and the arrester may "turn on" and "turn off" in a fraction of a microsecond. For lightning and switching overvoltages, arresters may conduct and absorb all the energy from a particular waveshape in much less than one 60 Hz power frequency cycle (16.7 milliseconds).

In the case of a temporary overvoltage, the arrester will absorb energy from the system at each positive and negative voltage wave peak until the TOV decays to a level approaching the MCOV rating. It is this repeated operation of the arrester (twice every 60 Hz period) over an extended duration that will often cause a surge arrester to fail.

Manufacturers' data (from ABB – "EXLIM P") for arresters commonly used on the NU and UI transmission system indicate the arresters may fail if the following TOVs are exceeded:

Table 2 – Typical (Existing) Southwest Connecticut Surge Arrester Temporary Overvoltage Limits

	2 cycles	6 cycles	30 cycles	1 second
115 kV (70kV MCOV)	1.69	**1.65**	1.59	1.57
345 kV (209 kV MCOV)	1.62	1.58	1.52	1.50

The energy handling capability of an arrester depends on the amount of metal oxide material within the arrester. A higher voltage arrester will have more standard 76 mm disks stacked in series to withstand the applied voltage. A higher voltage arrester is capable of absorbing more energy than a lower voltage arrester of the same type. A higher voltage arrester also withstands a higher voltage before it starts to conduct and absorb energy from the power system. For these two reasons, an acceptable engineering practice when arrester energy limits are a concern, is to increase the specified arrester's MCOV. In certain