Modeling the Effect of a Water Tree inside Tape Shield and Concentric Neutral Cables

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Introduction: A water tree forms in the insulation of underground cables and is one of the main reasons for cable failures [1]. A water tree grows from a imperfection in the insulation/shield interface, which causes the electric field to increase. This causes the insulation to break down and form microfractures. Which fill with moisture and increase the electric field, thus continuing dielectric breakdown of the insulation. The water tree shape is very thin and long Figure 1 (a) and can be represented as an ellipsoid in COMSOL shown in Figure 1 (b). A water tree has a linear change in the electrical conductivity by 10^{10} [2] and relative permittivity by 3 [3] of the insulation at that location shown in Figure 1 (c, d).

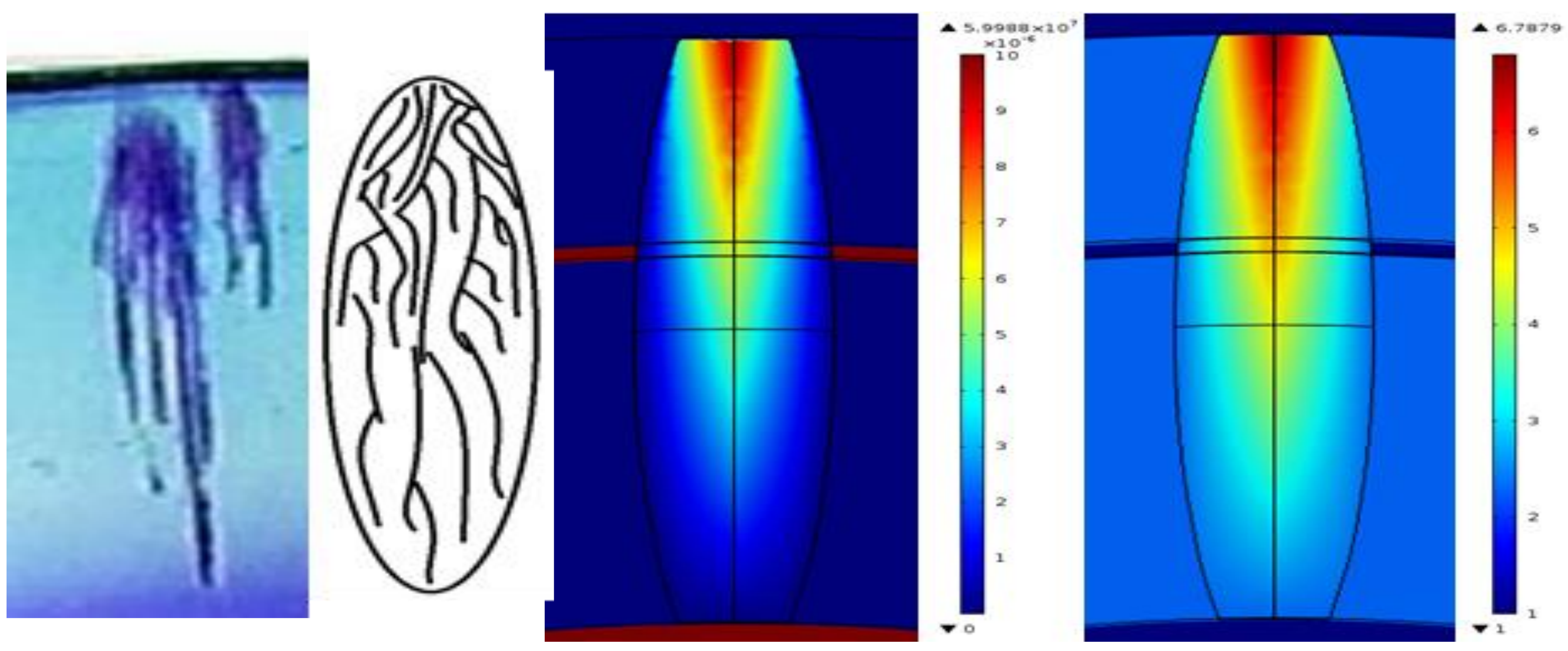

Figure 1. (a) Water Tree in insulation. (b) Effective water tree shape. (c) Electrical conductivity of water tree. (d) Relative permittivity of water tree

Water Trees: Since the water tree acts as a conductor the electric field inside the water tree was zero therefore, the electric potential was constant. At the tip of the water tree the electric field was the greatest and the electric field was perpendicular with the water tree surface. Water trees grown 70 % and 100% through the insulation in both cables are shown in Figures 2-5.

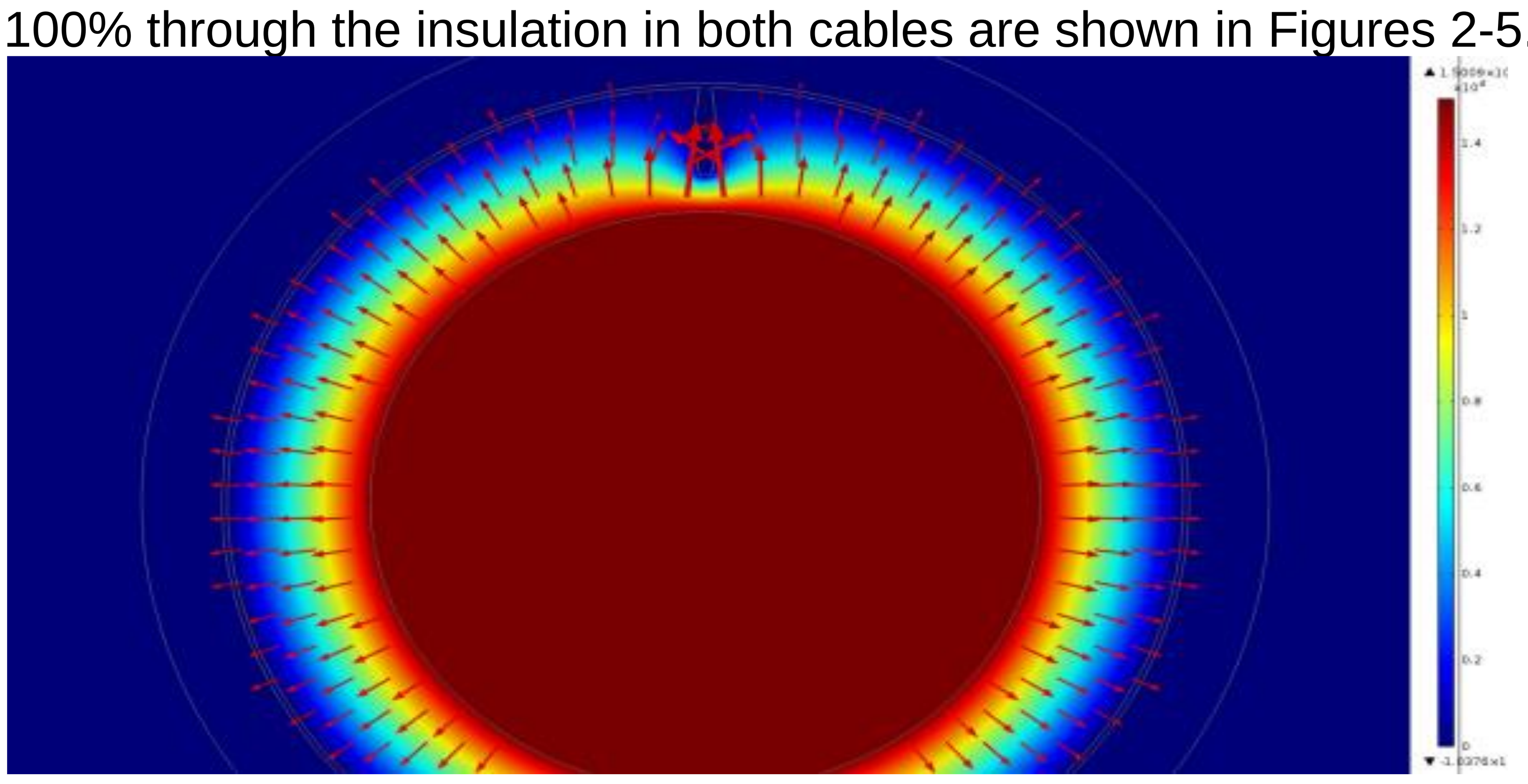

Figure 2. Water tree 70% across insulation in tape shield cable

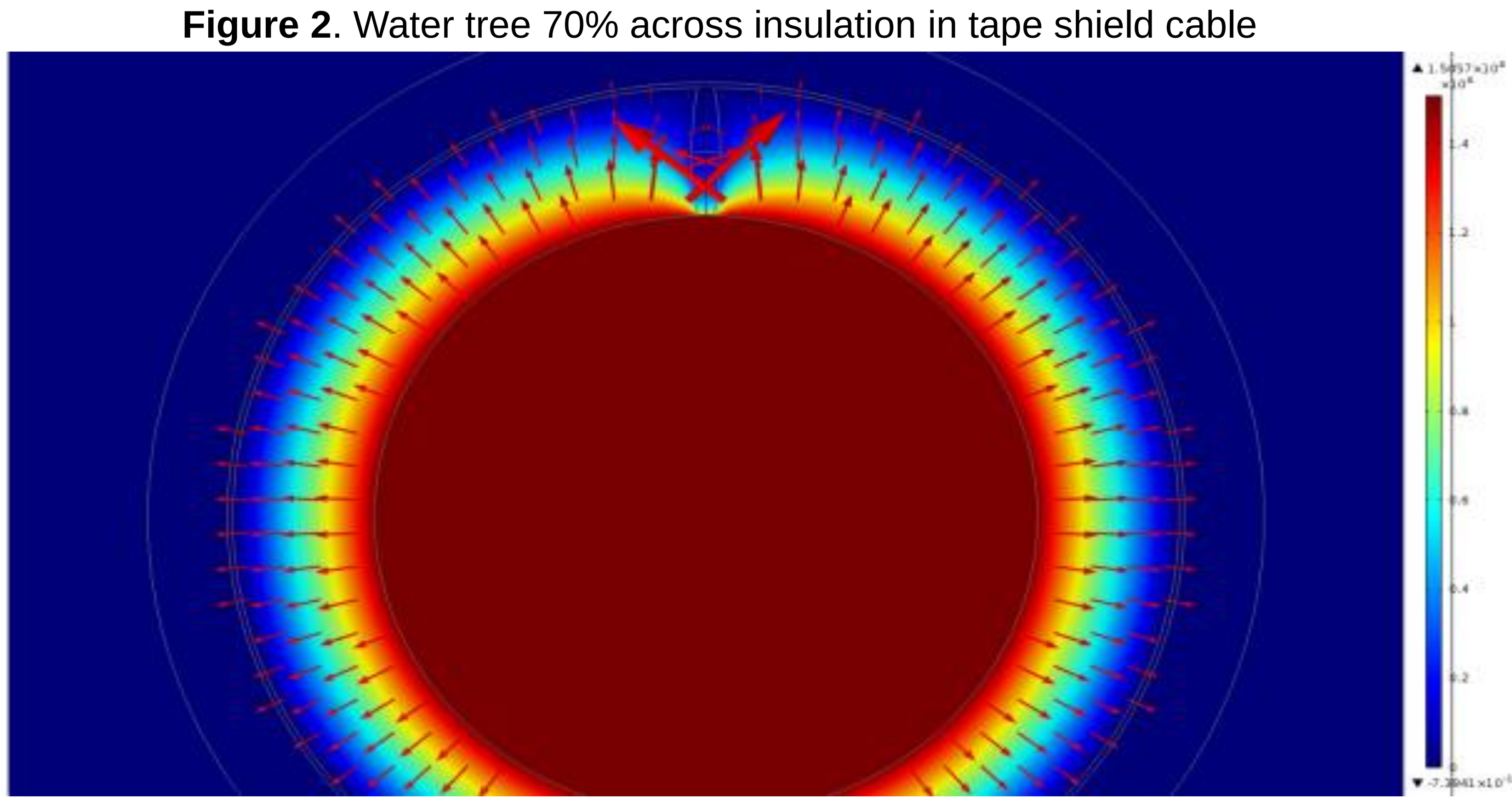

Figure 3. Water tree 100% across insulation in tape shield cable

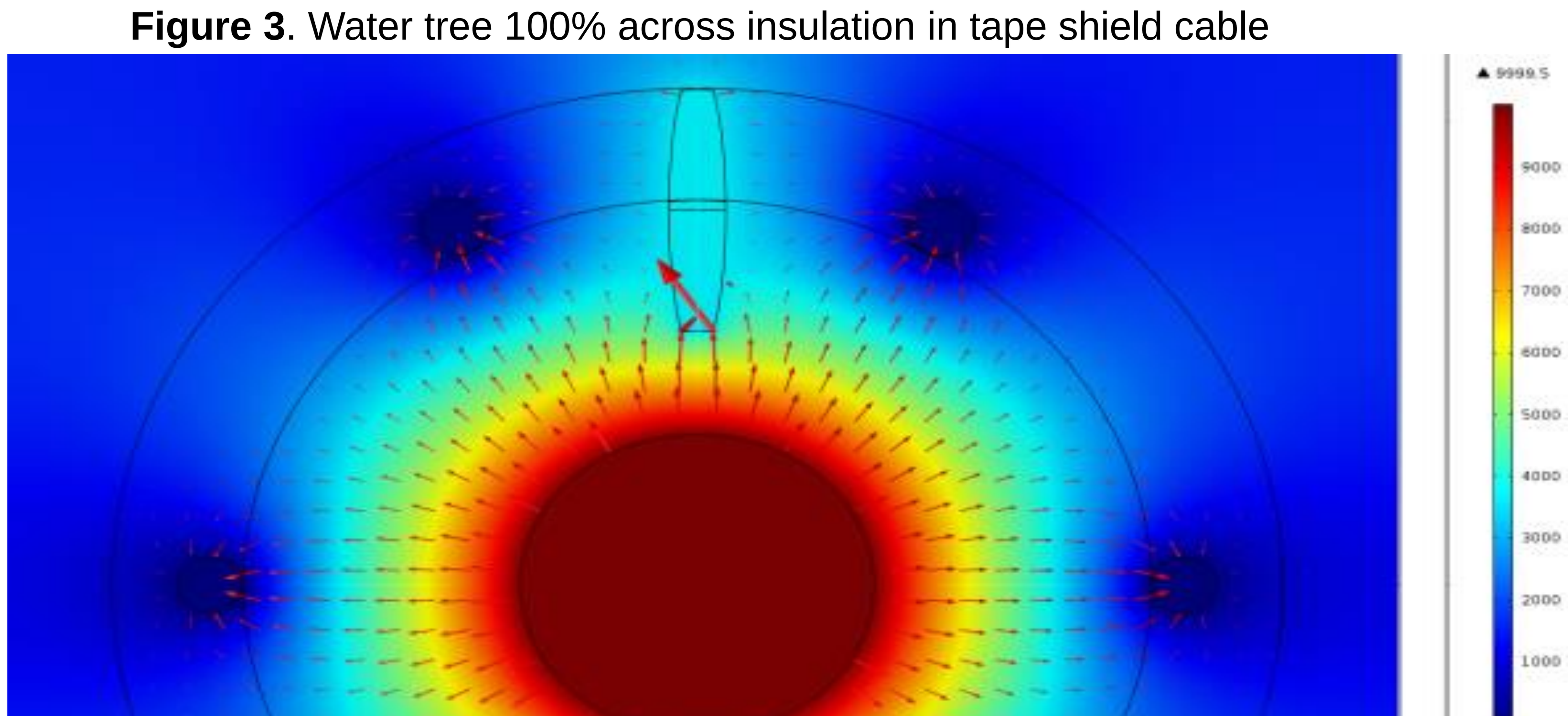

Figure 4. Water tree 70% across insulation in concentric neutral cable

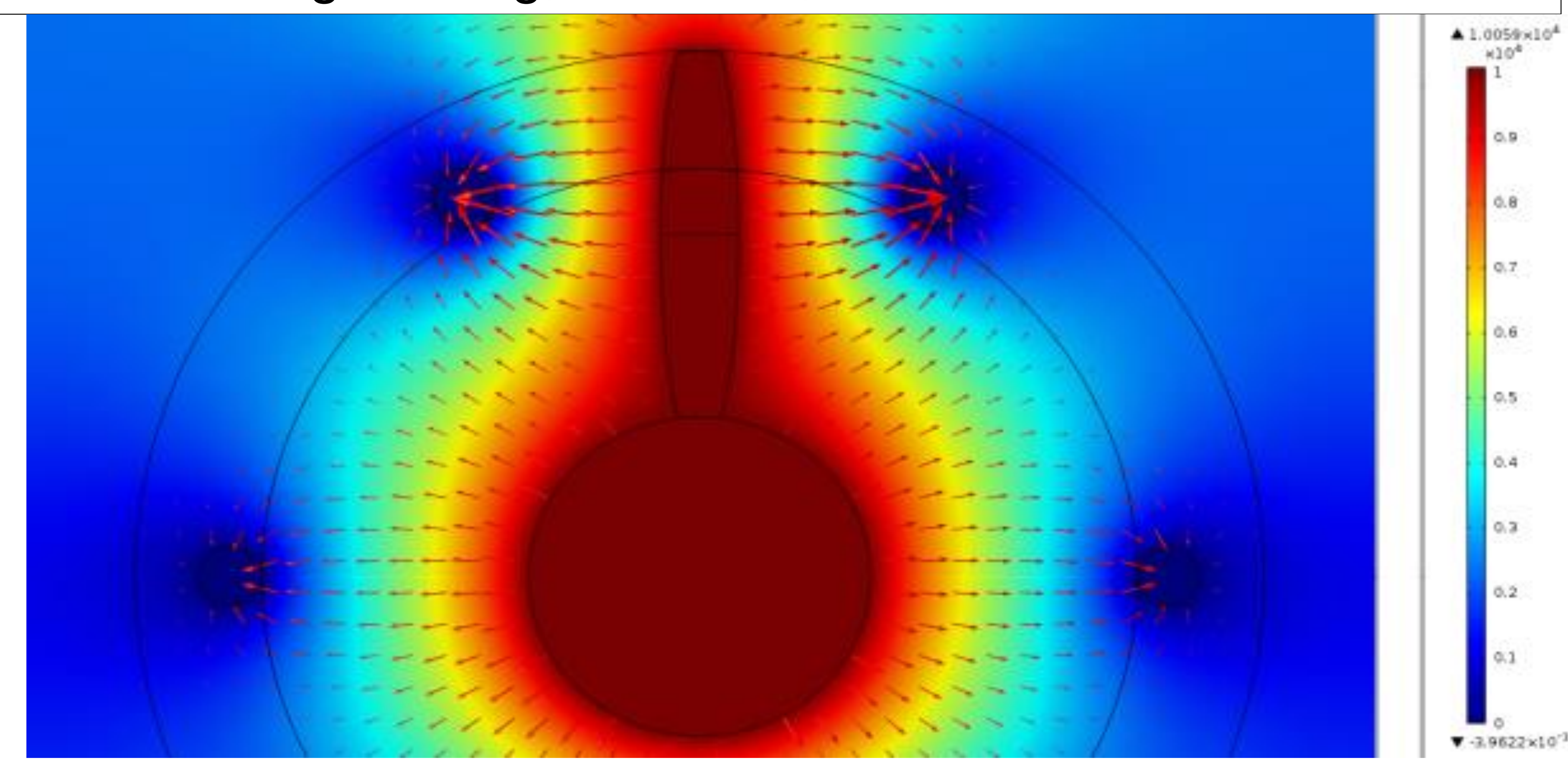

Figure 5. Water tree 100% across insulation in concentric neutral cable

Lumped Parameters: The capacitance had an exponential shape as the water tree grew across the insulation. This is because the water tree is a conductor and as it grows it is the same as bringing two parallel plate conductors together Figure 6. The resistance was constant until the water tree touched the conductor. This is because there is no path for resistive current to flow until the water tree touches the conductor Figure 7.

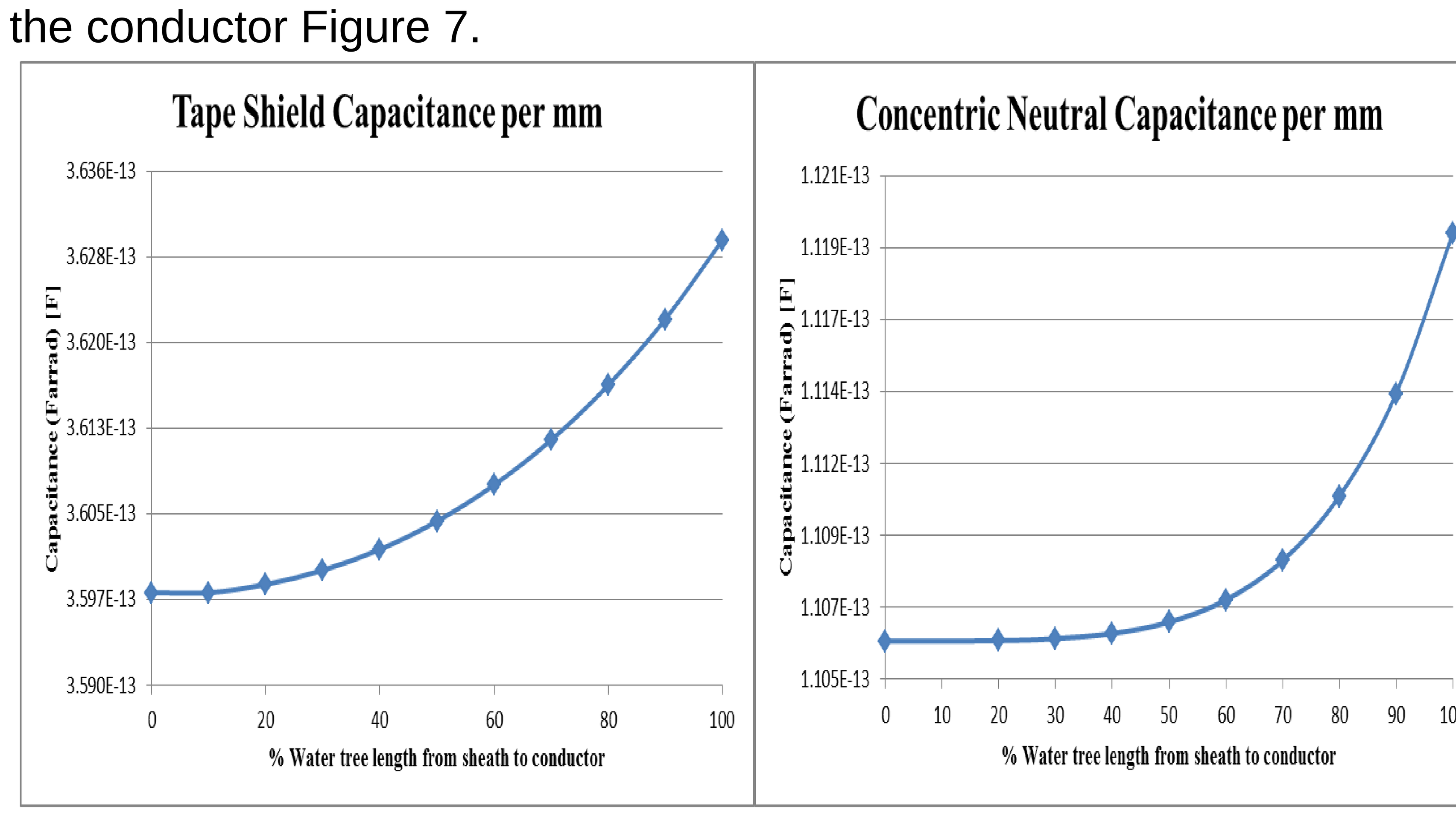

Figure 6. Capacitance as water tree grows across the insulation for (a) tape shield and (b) concentric neutral cables

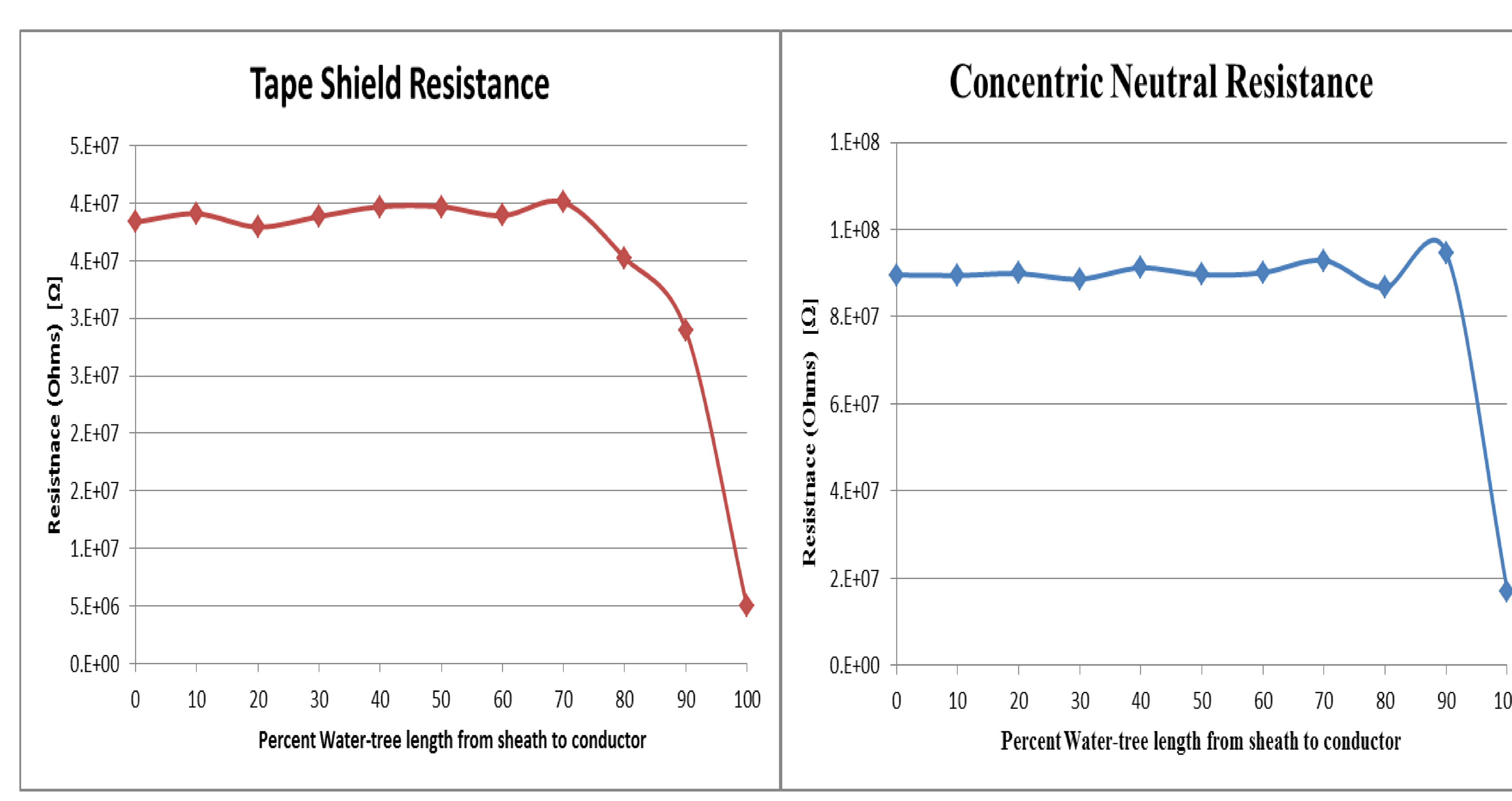

Figure 7. Resistance as water tree grows across the insulation for (a) tape shield and (b_ concentric neutral cables

Conclusions: The increase in the electric field at the tip of the water tree allows for visualization of what was already known about water trees. Also, the lumped parameters of water tree will allow for future simulation in PSCAD for continued research.

References:

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