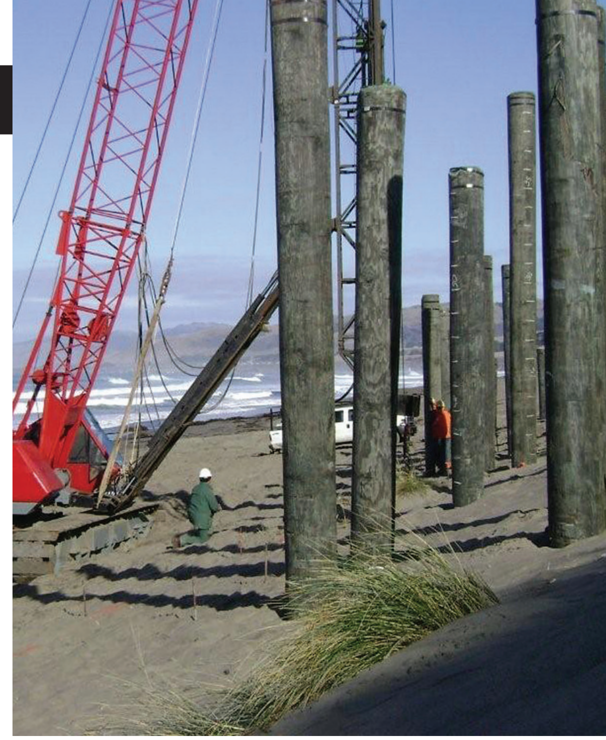
*Conclusions and Summary Brief*



### Environmental Life Cycle Assessment of

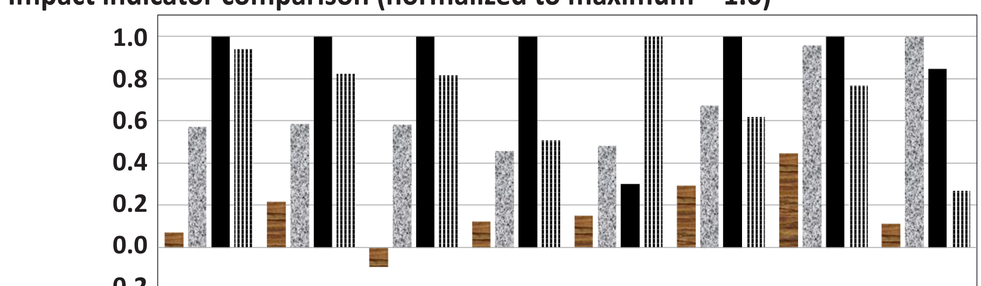
# Ammoniacal Copper Zinc Arsenate-Treated Marine Piles with Comparisons to Reinforced Concrete, Galvanized Steel, and Plastic Marine Piles

Arxada commissioned AquAeTer, Inc., an independent consulting firm, to prepare a quantitative evaluation of the environ-mental impacts associated with the national production, use, and disposition of ammoniacal copper zinc arsenate (ACZA)-treated wood, concrete, galvanized steel, and plastic marine piles using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The comparative results demonstrate:

- **Less Energy & Resource Use:** ACZA-treated wood marine piles require less total energy, less fossil fuel, and less water than concrete, galvanized steel, and plastic marine piles.
- **Lower Environmental Impacts:** ACZA-treated wood marine piles have lower environmental impacts than concrete, steel, and plastic marine piles in all six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, ecotoxicity, and eutrophication-causing emissions.
- **Decreases Greenhouse Gas Levels:** Use of ACZA-treated wood marine piles lowers greenhouse gas levels in the atmosphere whereas concrete, galvanized steel, and plastic marine piles increase greenhouse gas levels in the atmosphere.
- **Offsets Fossil Fuel Use:** Reuse of ACZA-treated wood marine piles for energy recovery in permitted facilities with appropriate emission controls will further reduce greenhouse gas levels in the atmosphere, by offsetting the use of fossil fuel energy.

Impact indicator values were normalized to better support comparisons between products and to understand the quantitative significance of indicators. Product normalization sets the cradle-to-grave life cycle value of maximum impact to 1.0, and all other values are a fraction of 1.0. The normalized results are provided in Figure 1.

**Figure 1.**
**Impact indicator comparison (normalized to maximum = 1.0)**




| | Fossil Fuel Use | Greenhouse Gas | Net GHG | Acid Rain | Water Use | Smog | Eutrophication | Ecotoxitcity |
|---|---|---|---|---|---|---|---|---|
| ACZA-treated pile | 0.072 | 0.22 | -0.09 | 0.12 | 0.15 | 0.29 | 0.45 | 0.11 |
| Concrete pile | 0.57 | 0.58 | 0.58 | 0.46 | 0.48 | 0.67 | 0.96 | 1.0 |
| Steel pile | 1.0 | 1.0 | 1.0 | 1.0 | 0.30 | 1.0 | 1.0 | 0.84 |
| Plastic pile | 0.94 | 0.82 | 0.81 | 0.50 | 1.0 | 0.62 | 0.77 | 0.27 |

## Scope

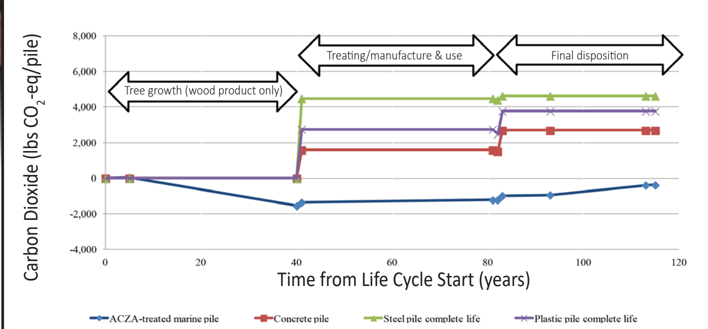
The scope of this study includes:

- A life cycle inventory of ACZA-treated wood, reinforced concrete, galvanized steel, and plastic marine piles, modified from a life cycle inventory of CCA-treated marine piles done for the Treated Wood Council.
- Calculation and comparison of life cycle impact assessment indicators: anthropogenic greenhouse gas, net greenhouse gas, acid rain, smog, ecotoxicity, and waterborne eutrophication impacts potentially resulting from life cycle air emissions.
- Calculation of energy, fossil fuel, and water use.


©Arch Wood Protection, Inc. (2015)

| Impact Category | Units | ACZA-treated pile | Concrete pile | Galvanized steel pile | Plastic pile |
|---|---|---|---|---|---|
| Energy Use | | | | | |
| Energy input from technosphere | MMBTU | 1.3 | 4.6 | 7.4 | 3.8 |
| Energy Input from nature | MMBTU | 0.87 | 8.9 | 17 | 18 |
| Biomass energy | MMBTU | 0.62 | 0.086 | 0.29 | 0.073 |
| Impact indicators | | | | | |
| Anthropogenic GHG emissions | Ib-$CO_2$-eq | 855 | 2,671 | 4,566 | 3,756 |
| Net GHG emissions | Ib-$CO_2$-eq | -369 | 2,691 | 4,636 | 3,774 |
| Acid rain air emissions | Ib-H+ mole-eq | 173 | 743 | 1,627 | 822 |
| Smog potential | g NOx/m | 1.4 | 3.6 | 5.4 | 3.3 |
| Ecotoxicity air emissions | Ib-2,4-D-eq | 1.9 | 19 | 16 | 5.1 |
| Eutrophication air emissions | Ib-N-eq | 0.087 | 0.22 | 0.23 | 0.17 |
| Resource use | | | | | |
| Fossil fuel use | MMBTU | 1.4 | 13 | 22 | 21 |
| Water use | gal | 71 | 267 | 167 | 556 |

**Table 1. Environmental performance (per pile)**




*Note: Net carbon less than zero is a reduction of greenhouse gas levels in the atmosphere because of the product's manufacture, use and disposal. Net carbon greater than zero is an increase of greenhouse gas levels in the atmosphere.*

**Figure 3. Carbon balance for marine pile products (per pile)**

## Environmental Performance

The assessment phase of the LCA uses the inventory results to calculate total energy use, impact indicators of interest, and resource use. For environmental indicators, USEPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI)[1] is used to assess anthropogenic and net greenhouse gas, acid rain, smog potential, ecotoxicity, and eutrophication impacts potentially resulting from air emissions. The categorized energy use, resource use, and impact indicators provide general, but quantifiable, indications of environmental performance. The results of this impact assessment are used for comparison of all marine pile products as shown in Table 1.

Treated wood piles result in releases that could impact highly localized marine ecological toxicity. The potential for such releases depends on numerous factors, including water flow or circulation rates, ambient levels of metals, and the number of piles in a row parallel to flow or current. A modeling tool, such as the peer-reviewed and National Oceanic and Atmospheric Administration (NOAA) Fisheries-recognized Preservative Risk Assessment Model, provides a tool to evaluate potential marine ecotoxicity for specific projects in which treated marine piles are being considered.

Wood products begin their life cycles removing carbon from the atmosphere (as carbon dioxide) and atmospheric carbon removal continues as trees grow during their approximate 40-year growth cycle, providing an initial life cycle carbon credit. Approximately half the mass of dry wood fiber is carbon. Transportation and treating operations are the primary sources of carbon emissions in the manufacture of ACZA-treated wood marine piles.

Non-wood marine pile products begin their life cycle with the extraction of resources, such as limestone or silica sand or carbon-sequestered resources such as oil and coal, and require energy to convert resources into manufactured products.

Minimal life cycle impacts result from the service life stage of either wood or non-wood products. Following the service life stage, ACZA-treated wood piles are recycled for secondary uses or disposed in landfills. Energy recovery from ACZA-treated wood marine piles is evaluated in sensitivity analysis, but not as a likely disposition scenario. Non-wood material piles are recycled, disposed in landfills, or recycled for energy. The carbon balance of each marine pile product, through the life cycle stages, is shown in Figure 3.

## Quality Criteria

This study was done as an extension of work performed by the Treated Wood Council and is not intended as a standalone LCA. The study includes most elements required for an LCA meeting the International Organization for Standardization (ISO) guidelines as defined in standards ISO/DIS 14040 "Environmental Management – Life Cycle Assessment – Principles and Framework" and ISO/DIS 14044 "Environmental Management – Life Cycle Assessment – Requirements and Guidelines". However, there was no external peer review of the ACZA components of this LCA.

## Additional Information

This study is further detailed in a Life Cycle Assessment Report completed in May 2014 and is available from Arxada at 1200 Bluegrass Lakes Parkway, Alpharetta, GA 30004. Additional information is also available at WolmanizedWood.com.
This study is based on data collection and analysis done as part of an LCA on CCA-treated marine piles. A manuscript of the CCA-treated marine piles findings was published in the peer-reviewed Journal of Marine Environmental Engineering and is available at http://www.oldcitypublishing.com/JMEE/JMEEcontents/JMEEv9n3issuecontents.html.

[1] Bare, J., Norris, G., Pennington, D., & McKone, T. (2003). TRACI–The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. Journal of Industrial Ecology, 6(3-4), 49-78