

Conclusions and Summary Report:

Environmental Life Cycle Assessment of Ammoniacal Copper Zinc Arsenate-Treated Wood Marine Piles with Comparisons to Reinforced Concrete, Galvanized Steel, and Plastic Marine Piles

Prepared by: AquAeTer, Inc.

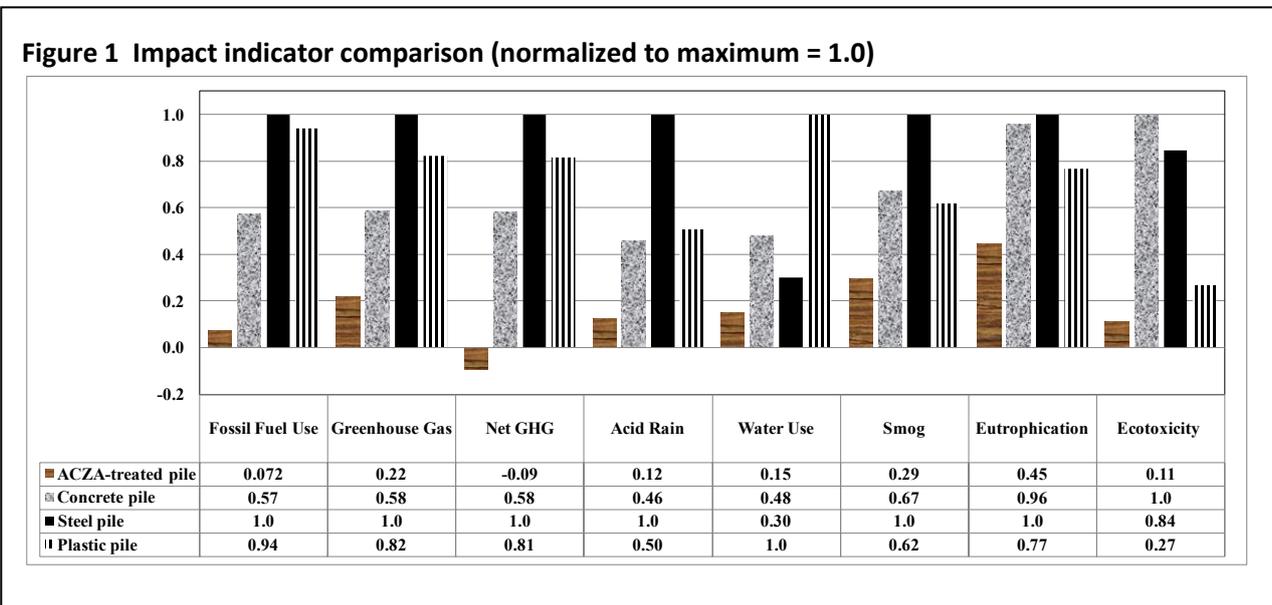
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Conclusions and Summary Report

Arch Wood Protection, Inc. commissioned AquAeTer, Inc., an independent consulting firm, to prepare a quantitative evaluation of the environmental 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.

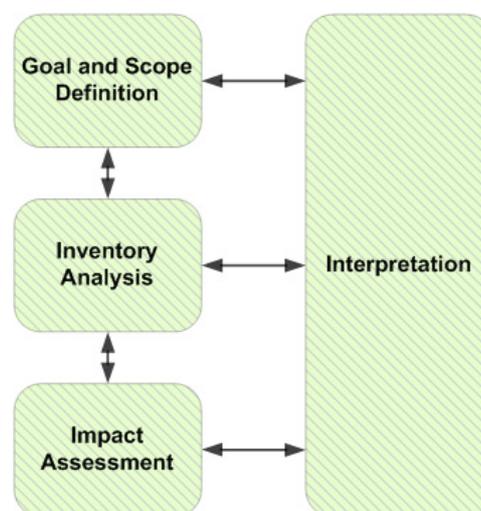
Goal and Scope

The goal of this study is to provide a comprehensive, scientifically-based, fair, and accurate understanding of environmental burdens associated with the manufacture, use, and disposition of ACZA-treated wood marine piles using LCA methodologies. 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.

Quality criteria

This study was done as an extension of work performed by the Treated Wood Council and is not intended as a stand-alone 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.



Manufacturer Information

ACZA is listed in the American Wood Protection Association (AWPA) Standard P5 for Waterborne Preservatives. ACZA can be used to treat numerous species of wood, however its ability to penetrate makes it particularly useful in the treatment of coastal Douglas fir.

The LCA for ACZA-treated wood marine piles is based on Arch Wood Protection-provided inventory data. Arch Wood Protection supplies the ACZA preservative to wood treating companies treating piles in accordance with appropriate AWPA standards.



The LCAs for reinforced concrete, galvanized steel, and plastic marine piles represent general product categories, manufactured with different designs and material contents. These LCAs were prepared using secondary data sources and provide a basis for general comparison of products.

Product Description and Functional Unit

For collection of LCA inventory inputs and outputs and comparative purposes, a 40-foot pile was chosen as a baseline product.

Scope: cradle-to-grave

Functional unit: one 40-foot marine pile (wood product has a mid-point diameter of approximately 11.5 inches).

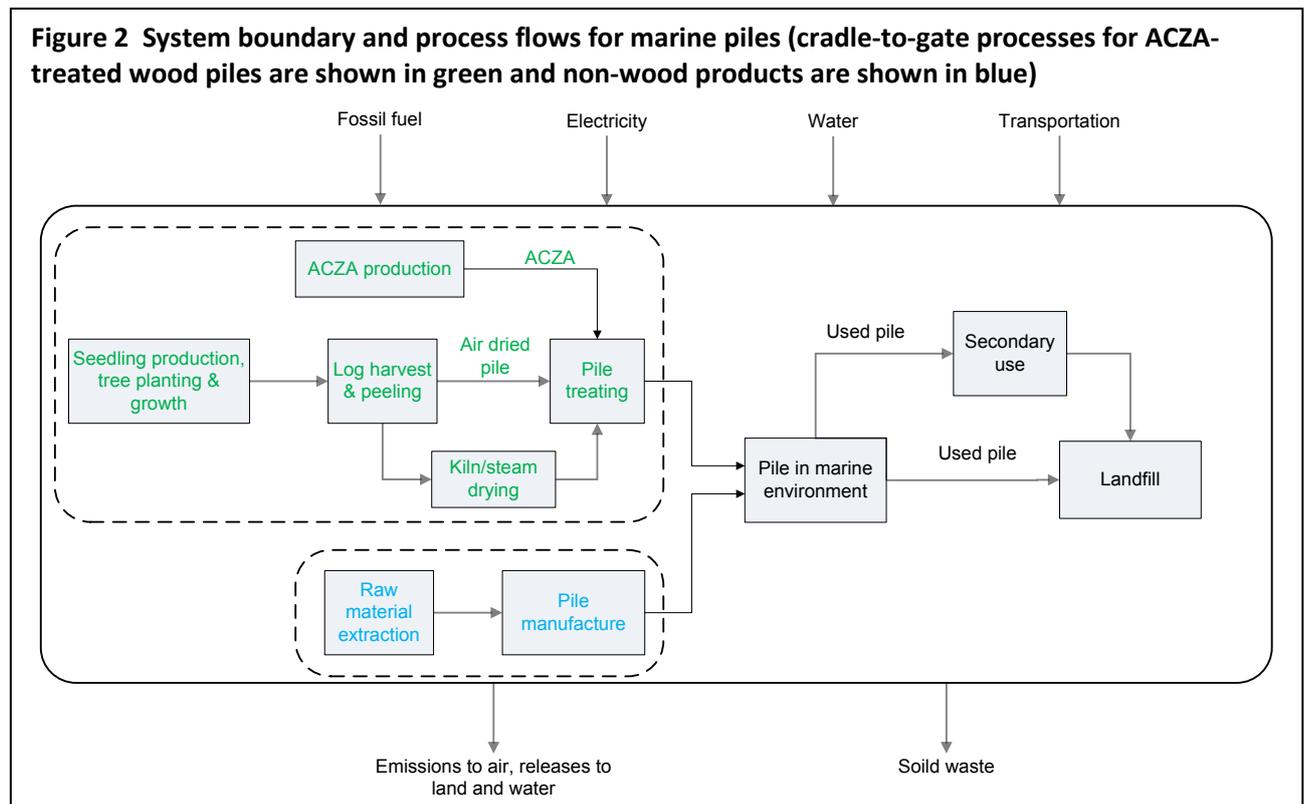
Service life: 40 years

System boundary: from the extraction of the raw materials through processing, transport, primary service life, reuse, and disposal of the product.

Geographic boundary: U.S.

Life Cycle Inventory

The system boundaries include all the production steps from extraction of raw materials from the earth (cradle) through to final disposition after its service life (grave). Figure 2 illustrates the system boundaries and process flow for both wood and non-wood marine piles assessed in this study.



The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the marine pile. For each stage of the product life cycle, inputs of energy and raw materials, outputs of products, co-products and waste, and environmental releases to air, water, and soil are determined.

The length of time a marine pile remains in marine service is dependent upon a number of factors. Often, piles are removed from service before the end of their useful service life, such as for marine upgrades. Assumptions used in this LCA for disposition of marine piles after service life include:

- ACZA-treated wood piles are recycled for secondary use or disposed in a solid waste landfill
- Reinforced concrete piles are disposed in a solid waste landfill
- Steel piles are recycled
- Plastic piles are recycled or disposed in solid waste landfills

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.

Table 1 Environmental performance (per pile)

Impact category	Units	ACZA-treated wood 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	lb-CO ₂ -eq	855	2,671	4,566	3,756
Net GHG emissions	lb-CO ₂ -eq	-369	2,691	4,636	3,774
Acid rain air emissions	lb-H ⁺ mole-eq	173	743	1,627	822
Smog potential	g NO _x / m	1.4	3.6	5.4	3.3
Ecotoxicity air emissions	lb-2,4-D-eq	1.9	19	16	5.1
Eutrophication air emissions	lb-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

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.

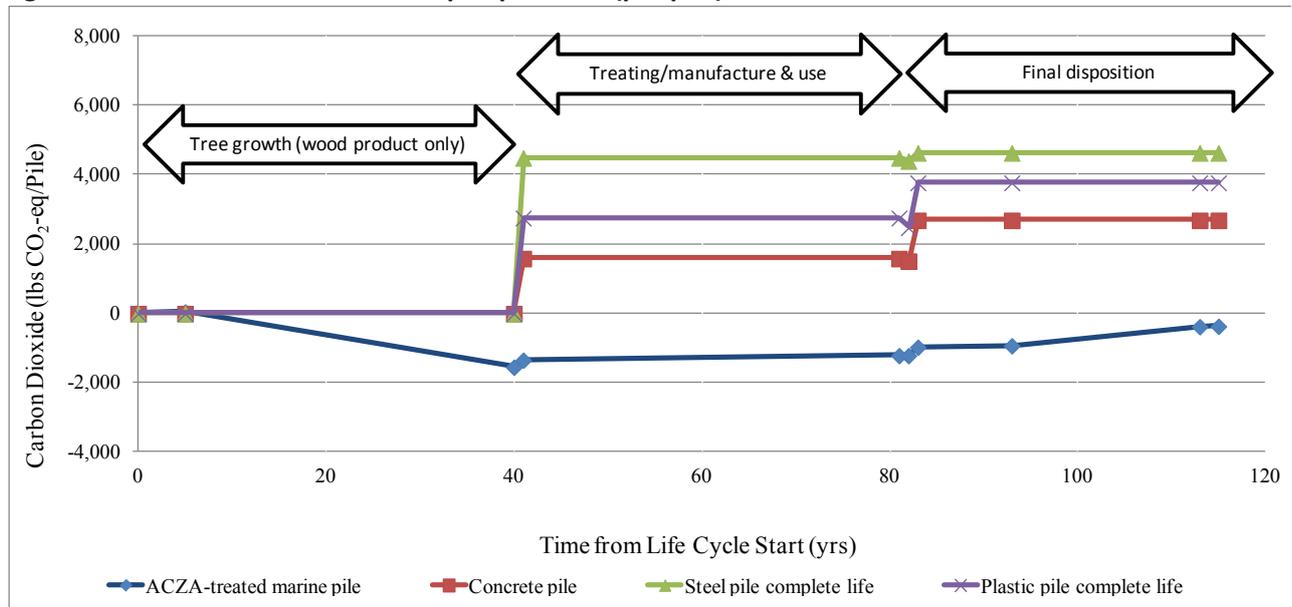
¹ Bare, J., Norris, G., Pennington, D., & McKone, T. (2003). TRACI—The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. *Journal of Industrial Ecology*, 6(3-4), 49-78

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

Figure 3 Carbon balance for marine pile products (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.

shown in Figure 3.

Additional Information

This study is further detailed in a Life Cycle Assessment Report completed in May 2014 and is available from Arch Wood Protection at 360 Interstate north Parkway, Suite 450, Atlanta, GA 30339. Additional information is also available at www.chemonite.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>.