WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Eugene Wasserman <eugene@ecwassociates.com> Mon, Dec 1, 2014 at 5:24 PM
To: WFWOComments@fws.gov

Tim Romanski
U.S Fish and Wildlife Service

The North Seattle Industrial Association requests an comment extension til January 15, 2015.

The North Seattle Industrial Association represents maritime/industrial business and property owners along the Lake Washington Ship Canal including Lake Union, Salmon Bay, Interbay. Many of them would be impacted in a major way by this plan.

We just found out about this plan last week. The plan is very extensive and would have impacts on the many varied businesses that we represent.

We therefore request this extension.

Thanks.

Eugene Wasserman
206 440-2660
eugene@ecwassociates.com
President, North Seattle Industrial Association

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS- Comment Attached

1 message

Shaun Hubbard <islandersforsafeshipping@gmail.com> Mon, Dec 1, 2014 at 5:52 PM
To: WFWOComments@fws.gov
Cc: Shaun Hubbard <islandersforsafeshipping@gmail.com>

Mr. Tim Romanski
U.S. Fish and Wildlife Service

Mr. Scott Anderson
NOAA Fisheries

Dear Mr. Romanski and Mr. Anderson,

Please see the attached files (in two formats, pdf and Word document) containing my comments regarding the Washington Department of Natural Resources' Aquatic Lands Habitat Conservation Plan Draft Environmental Impact Statement.

Thank you.

Sincerely,
Ms. Shaun Hubbard
San Juan Islanders for Safe Shipping

2 attachments

SJIFSS_Comment_WDNR_HCP_DEIS_Dec2014.pdf
125K

SJIFSS_Comment_WDNR_HCP_DEIS_Dec2014.docx
192K

San Juan Islanders for Safe Shipping
PO BOX 805 • FRIDAY HARBOR WA 98250

December 1, 2014

Mr. Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Mr. Scott Anderson
NOAA Fisheries
510 Desmond Drive SE, Suite 103
Lacey, Washington 98503

Submitted via e-mail, to WFWOComments@fws.gov

RE: Washington Department of Natural Resources' Aquatic Lands Habitat Conservation Plan Draft Environmental Impact Statement

Dear Mr. Romanski and Mr. Anderson,

Thank you for this opportunity to comment on the Draft Environmental Impact Statement (DEIS) to analyze impacts of issuance by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service of two incidental take permits under Section 10 of the Endangered Species Act for implementation of the Washington Department of Natural Resources' (WDNR) Aquatic Lands Habitat Conservation Plan (HCP).

I am writing to you as a member of San Juan Islanders for Safe Shipping, a group of citizens of San Juan County who are concerned about the likely adverse impacts to our economy and our environment from the transport of fossil fuels through the Salish Sea.

• I support Alternative 2 (Proposed Action) in the DEIS with the caveat that the elephant in the room be addressed – namely, the numerous new and expanding terminal projects proposed for the export of crude oil and coal via vessel through the waters of the state – including the projected increase in vessel traffic whether or not these projects are permitted.

• In order to comply with the Endangered Species Act of 1973 (ESA, 16 USC 1531 *et seq*.) both the final EIS and the WDNR Aquatic Lands HCP must include and address the interrelated effects of oil spill risk, vessel strike risk, and vessel traffic noise (including underwater vessel noise).

• Both the WDNR Aquatic Lands HCP and the final EIS need to address the existing and future proposed new and expanding terminal projects and the correlation between increased vessel

traffic and increased **oil spill risk, vessel strike risk, and vessel traffic noise (including underwater vessel noise)** – as highlighted below – and the corresponding impacts on the proposed covered species and aquatic ecosystems and fisheries.

Oil Spill Risk: Address the fact that the new and expanding terminal projects and the increased vessel traffic would have a corresponding increased risk of oil spills. Provide data and analysis of the various types of products transported by vessel (including propulsion fuel) and the varying impacts these products would have, when spilled, on the proposed covered species and aquatic ecosystems and fisheries. Provide data and analysis of oil spill cleanup operations and the impacts they would have on the proposed covered species and aquatic ecosystems and fisheries, including dispersant use and in situ burning.

Vessel Strike Risk: Include information and data on vessel strikes in the final EIS and WDNR Aquatic Lands HCP. List evidence of collisions between vessels and cetaceans that result in cetacean injury or death, acknowledging that these incidences may be more frequent than documented and that current levels of vessel strikes may be above the legal limits set by the United States and therefore pose a significant conservation threat.

Vessel Traffic Noise: In the final EIS and WDNR Aquatic Lands HCP, include data showing the correlation between increased marine traffic and the increase in underwater vessel noise impacts on Southern Resident Killer Whales as well as other proposed covered species and aquatic ecosystems and fisheries. This data needs to include impacts from vessel noise associated with existing and future proposed new and expanding terminal projects that could be affected by HCP implementation, and, further, the vessel noise impacts to the proposed covered species and aquatic ecosystems and fisheries.

• Please review and reconsider the species that were judged to have little or no overlap with state-owned aquatic lands or with the land uses that could be affected by HCP implementation. The information on these species may change in the final EIS and WDNR Aquatic Lands HCP with the inclusion of data that relates to increases in vessel traffic and the corresponding increases in oil spill risk, vessel strike risk, and vessel traffic noise.

Thank you for your attention to these comments.

Sincerely,

Ms. Shaun Hubbard
Member, San Juan Islanders for Safe Shipping

Jones, LouEllyn <louellyn_jones@fws.gov>

Fwd: Extension on DNR

1 message

Romanski, Tim <tim_romanski@fws.gov> Tue, Dec 2, 2014 at 12:46 PM
To: LouEllyn Jones <louellyn_jones@fws.gov>

Keep this as a comment

Tim Romanski
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Branch Manager of Conservation and Hydropower Planning
510 Desmond Drive SE, Lacey, WA 98503
360.753.5823 (phone) 360.753.9518 (fax)

-------- Forwarded message --------
From: **Charlie Costanzo** <ccostanzo@vesselalliance.com>
Date: Tue, Dec 2, 2014 at 6:11 AM
Subject: RE: Extension on DNR
To: "PALAZZI, DAVID (DNR)" <DAVID.PALAZZI@dnr.wa.gov>
Cc: "Romanski, Tim" <tim_romanski@fws.gov>, "AMIOTTE, LALENA (DNR)" <Lalena.Amiotte@dnr.wa.gov>, "scott.anderson@noaa.gov" <scott.anderson@noaa.gov>, "steve.sewell@commerce.wa.gov" <steve.sewell@commerce.wa.gov>

Hi David –

Thanks so much for this! Very helpful.

I suppose what I'd really like to know is which members of AWO are aquatic lands leaseholders. I was contacted recently by both Vigor Industrial Shipyard on Harbor Island and Foss Shipyard on the Ballard Canal. They claim to not have had notice and I didn't know about the HCP until last week either. A quick review of the very lengthy document led me to believe that the HCP is fairly extensive and significant but what I really need to assess is the degree to which my members will be impacted. Also, some of them may be sublessees through various ports. I just don't know and that's my concern.

Do you have a list of the stakeholders who were mailed notices? That would be a tremendously helpful place to start. For the moment, I need to merely assess the scope of possibly impacted towing vessel operators and shipyard owners among our membership.

- Charlie

Charles P. Costanzo

Vice President – Pacific Region

The American Waterways Operators

5315 22nd Ave. NW

Seattle, WA 98107

www.americanwaterways.com

(206) 257-4723 (Office)

(203) 980-3051 (Mobile)

(866) 954-8481 (Fax)

From: PALAZZI, DAVID (DNR) [mailto:DAVID.PALAZZI@dnr.wa.gov]
Sent: Monday, December 01, 2014 4:59 PM
To: Charlie Costanzo
Cc: Romanski, Tim; AMIOTTE, LALENA (DNR); scott.anderson@noaa.gov
Subject: RE: Extension on DNR

Mr. Castanzo,

In response to your questions below; those members of the American Waterway Operators that have an aquatic land lease from DNR were mailed a postcard in early September announcing the availability of the draft HCP and EIS for review.

Outreach has been a major component of the development of the HCP over the last 10 plus years and continues today. This includes, but is not limited to the following:

· Scoping public meetings and informational meetings throughout the state in 2006.

· Newsletters in 2005, 2006 and 2007 to provide updates on our progress.

· Ongoing outreach to our tenants on DNR stewardship as our tenants leases are expiring or when improvements are proposed.

· Ongoing communication with federal, state and local governments regulators.

· Ongoing communications with the boating industry, dock builders, engineering firms, materials manufacturers, DNR tenants and members of the public that have reached out to us regarding the HCP.

- Provide DNR web page with up-to-date information and materials on the HCP.

We are available to discuss the draft HCP with you. Please feel free to contact me if you would like to arrange a time to speak with us. dp

David Palazzi

DNR-Aquatics Program

Planning Program Manager

360-902-1069

david.palazzi@dnr.wa.gov

-------- Forwarded message --------
From: **Charlie Costanzo** <ccostanzo@vesselalliance.com>
Date: Tue, Nov 25, 2014 at 3:51 PM
Subject: Extension on DNR
To: "tim_romanski@fws.gov" <tim_romanski@fws.gov>, "lalena.amiotte@dnr.wa.gov" <lalena.amiotte@dnr.wa.gov>, "scott.anderson@noaa.gov" <scott.anderson@noaa.gov>
Cc: "steve.sewell@commerce.wa.gov" <steve.sewell@commerce.wa.gov>

Hi Tim, Lalena and Scott –

I'm writing to request an extension of the comment deadline for the Washington Department of Natural Resources Habitat Conservation Plan. The American Waterways Operators is the national trade association for the tugboat, towboat and barge industry and many of our members lease state aquatic lands for moorage and shore-side facilities. We believe that the HCP may heavily impact our business but, to my knowledge, we have not been solicited for feedback. The scope and duration of the HCP seem quite extensive and it would be helpful to have additional time to review the impacts to tugboat and barge operators.

In light of our request, can you tell me if any commercial vessel operators or shipyard operators have been involved in stakeholder outreach? I am surprised that such a far-reaching initiative as the HCP went unnoticed and I'm trying to get a sense of how stakeholder outreach was conducted.

Please let me know if an extension is possible and please keep me on any mailing list for updates on the program. Thank you!

- Charlie

Charles P. Costanzo

Vice President – Pacific Region

The American Waterways Operators

5315 22nd Ave. NW

Seattle, WA 98107

www.americanwaterways.com

(206) 257-4723 (Office)

(203) 980-3051 (Mobile)

(866) 954-8481 (Fax)

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Gregory Lyle <lyle.gregory@gmail.com> Tue, Dec 2, 2014 at 1:05 PM
To: WFWOComments@fws.gov

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Scott Anderson
NOAA Fisheries
510 Desmond Drive SE, Suite 103
Lacey, Washington 98503

Gentlemen,

Please find our comments on the Washington Department of Natural Resources' Proposed Aquatic Lands Habitat Conservation Plan.

Gregory Lyle
President
Ballard Mill Properties, LLC
425-455-4543
lyle.gregory@gmail.com

USFWS HCP Comments 12-2-14.pdf
845K

BALLARD MILL PROPERTIES, LLC
4733 Shilshole Avenue NW,
Seattle, Washington 98107

December 2, 2014

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Re: **WDNR Aquatic Lands HCP DEIS**

Dear Mr. Romanski:

Our company leases 168,246 sq. ft. of aquatic land in the Salmon Bay area of Seattle from the Washington State Department of Natural Resources (DNR) for an annual cost of approximately $60,000. There are four distinct uses on this leased property:

1. Recreational marina
2. Yacht repair sheds
3. Vessel haul-out for adjacent boatyard
4. Wharf for ocean going vessels

We support efforts at habitat conservation, but we believe the proposed Washington Department of Natural Resources' Aquatic Lands Habitat Conservation Plan (HCP) requires a few modifications and some further research. We will discuss these modifications as they relate to our exiting uses on DNR property, since real-world examples provide useful insight.

<u>Implementation schedule for structural requirements for existing uses</u> (pg. 5-9)

The timeframe for implementation of standards required by the HCP is proposed to be based on:

- The age of the facility and life expectancy of the existing structure and materials.
- The priority of replacement based on an assessment of current environmental impacts (that is, items with high negative impact on the environment must be replaced as soon as possible, while replacement of items with minor impact may wait until later in the lease term.)

- The length of the lease term. (Required implementation of all conservation measures identified in the agreement by the end of the term or by the end of year 20 in the case of a lessee who seeks a term of 20 years or more).

Even though these criteria for implementation allow flexibility, the actual proposed implementation standards for certain items require replacement or removal at the end of the lease term, irrespective of useful life and cost-benefit. Replacement of structures at the end of their useful lives is a reasonable standard for implementation, but to require replacement at the end of a lease term without regard to useful life imposes economic burdens that bear no reasonable relationship to the stated goals.

For instance, our DNR leases are in hold-over status. As such the HCP would require *immediate* replacement (due to treated timbers and piles) of a wharf for ocean going vessels, floating docks for 133 slips, 5 yacht repair sheds, marine travelift piers, 143 pilings and 12 dolphins, at a cost of millions of dollars, despite substantial remaining useful life. It is a certainty that the large wharf would not be rebuilt due to lack of economic return (and the many jobs associated with it lost), and this lease abandoned.

Docks, piers, and wharves – light transmissibility (pgs. 5-11, 5-13)

Our facility has two elevated docks in the littoral area used by a marine Travelift that removes vessels up to 100 tons from the water to an adjacent boat yard. The elevated docks are each approximately 5' wide, and constructed to carry an extraordinary load on the large wheels of the Travelift. The proposed HCP would require that these docks be grated to 100% of their surface area, which is not feasible. In addition, the support timbers underneath the decking are virtually solid, such that grating would provide little if any additional light transmissibility to the water. The HCP should be modified to exempt from grating requirements docks that are "designed and used exclusively for vessel haul-out machinery".

This standard also proposes that "Floats less than 1.5 meters (5 feet) in width must have unobstructed grating over at least 30 percent of their surface *if it is determined to be required by engineering design*" (italics added). What does the italicized clause mean?

We have numerous floating concrete finger piers between vessels. Their narrow width makes the incorporation of grating problematic since a minimum amount of floatation is required. Perhaps the italicized clause is meant to allow no grating.

In addition to engineering issues, to obtain necessary floatation the floats would need to be much deeper in the water than a non-grated float, which could create worse compliance under the HCP than narrow non-grated floats. Floats under 5' in width should not have a grating requirement.

Covered moorage, covered watercraft lifts, and boathouses (pg. 5-15)

This standard could require the immediate removal of five yacht repair sheds installed in 2004 in a process requiring the following permits:

- City of Seattle – Shoreline Management Plan
- Washington Department of Fish and Wildlife for HPA
- Corps of Engineers for Section 10 Permit
- US Fish & Wildlife Service and National Marine Fisheries Service for Endangered Species Act Consultation

The proposed HCP gives no consideration to this prior review, and does not allow the sheds to operate for their useful life. Some consideration must be given to prior standards and review, and allow them to be used for their expected life. These sheds were required to be located with a 20' setback from shore for habitat protection, and percent of light transmissible materials required at the time.

In addition, the proposed HCP would not allow sidewalls on the yacht repair sheds, when protection from the elements during repair is a primary purpose of the structure.

The issue here is not the standard, but rather its applicability at the end of existing lease term, which would be immediate rather than at the end of the useful life of the structures.

Treated wood (pg. 5-29)

We have no issue with the replacement of treated wood pilings and wharves as they need replacement. This is in fact our current procedure. In order to balance cost versus benefit, however, the implementation standards should not call for what could be an arbitrary replacement schedule in a lease, but rather a standard requiring removal "*upon replacement, functional end of useful life, or cessation of use*."

Although we generally use steel pilings for replacements, there are instances where a piling must be replaced in exactly the same place in order to anchor existing floating docks. In such an instance, capping an otherwise functional treated pile below the waterline with a steel pile may provide much less environmental degradation than the complete removal of a treated pile. The HCP should allow for the "underwater capping of a treated pile with a steel jacketed pile when the pile must be installed at the same location as the existing pile due to the demands of existing structures."

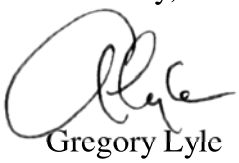
Milfoil issues

Most of our DNR lease area has become choked with Eurasian Milfoil, so must so that this past summer boats could not leave their moorages until the Milfoil was removed. The Draft Environmental Impact Statement does not address the issue of Milfoil. Is additional light transmission actually harmful to protected species in such a Milfoil choked environment? Do non-grated docks actually provide migration paths not otherwise available?

There should be answers to these questions before adopting HCP standards regarding light transmissibility in fresh water. Since this is a fresh water only issue, it suggests that *Alternative 3 – HCP for Marine Areas Only* should be adopted at this time.

Please feel free to contact me directly at lyle.gregory@gmail.com or 425-455-4543 regarding my comments on the draft HCP.

Sincerely,



Gregory Lyle
President

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Will Yates <yatesw@ludd.com> Tue, Dec 2, 2014 at 10:19 AM
To: "WFWOComments@fws.gov" <WFWOComments@fws.gov>

In the attachment is a copy of the letter from the Puget Sound Shipbuilder's Association.

Will Yates

Lake Union Drydock Co

Safety/Environmental/WC Supervisor

Direct # 206-225-2179

Cell # 425-931-5975

Fax # 206-225-2188

Lake Union Drydock Company
Craftsmanship Since 1918

This e-mail message is intended only for the use of the individual or entity to which it is addressed and may contain information that is privileged, confidential or exempt from disclosure under applicable law. If you are not the intended recipient, any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this communication in error, please notify us immediately by reply e-mail or telephone and delete or destroy all copies of the original message.

DNR REQUEST.pdf
44K

PUGET SOUND SHIPBUILDER'S ASSOCIATION

Al Rainsberger
President
1151 Fairview Ave N.
Seattle, WA 98109
(206) 281-3842

Kyle McCleary
Treasurer
P.O. Box 13368
Des Moines, WA 98198
(206) 767-4880

12/2/2014

Tim Romanski - USFWS
Washington Fish and Wildlife Office 510
Desmond Drive SE, Suite 102
Lacey, WA 98503-1263
BY EMAIL AT: WFWOComments@fws.gov

SUBJECT: REQUEST FOR EXTENSION OF THE PUBLIC COMMENT PERIOD ON THE DEPARTMENT OF NATURAL RESOURCES AQUATIC LAND HABITAT CONSERVATION PLAN

Dear Mr. Romanski:

On behalf of the Puget Sound Shipbuilders Association (PSSA) I am writing to you to request additional time to comment on the Washington State Department of Natural Resources (DNR) Aquatic Land Habitat Conservation Plan (HCP). PSSA respects the effort that DNR has put forth to prepare the HCP. We are working with our member shipyards to prepare thoughtful comments on this important document. This complex plan is sure to have lasting impact on both the future of Washington's nearshore habitat as well as the built environment surrounding these aquatic lands. This review is of particular importance to our industry, as our work requires proximity to navigable waters, and many existing sites contain nearshore buildings, overwater structural features, bank armoring, and other structures essential to our businesses that will be impacted by facets of the HCP. There are several elements of the proposed HCP that directly affect the way that we will be able to do business, and seem to have potentially significant impacts to both worker health and safety and shipyard business viability.

The HCP is a very large and complex document, that many of our members are just now becoming aware of. In consideration of the long-lasting and immense implications of this plan, PSSA hereby requests that the comment period for the draft HCP be extended by an additional 90 days in order to provide sufficient time for our membership to assess the full impact of the proposed changes and to provide meaningful feedback on the implementability, economic, and other ramifications of the standards, conservation measures, and programmatic measures contained within the HCP.

Thank you for your time.

Sincerely,

Will Yates
Vice President
Puget Sound Shipbuilders Association

Commercial Marine
CONSTRUCTION COMPANY

U.S. FISH & WILDL... OFFICE
DEC 05 2014

December 3, 2014

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Re: WDNR Aquatic Lands HCP DEIS

Dear Mr. Romanski:

Our company was founded in 1950 and has two DNR aquatic leases. One location, on Lake Union has floating docks for pleasure boats and the second location is on the ship canal with piers to accommodate large vessels from various Alaska fisheries.

After reading chapter 5 of the HCP Draft, I am unable to understand how our company could comply with the proposed requirements without undergoing a major dock re-build or replacement. At our Lake Union marina, our floating docks were rebuilt 20 years ago. The pilings were not replaced and some are almost 50 years old. These docks need floatation as they are not supported by the pilings. The retrograde application of grating to these docks would negate their ability to float. The piers at our ship canal location are fixed to the pilings. Our dock builder advises us that the commercial grade grating material available will not span the stringers. Our docks are kept in excellent condition, and while almost 50 years old we expect them to last another 50 years.

Rebuilding our docks would certainly be a financial hardship for our company. The HCP DEIS mentions compensatory mitigation would be applied individually in chapter 5.2, but does not further explain this concept.

I am very disappointed at the lack of outreach to the Leasees during the preparation of the HCP DEIS. I would like to request an extension of the comment period to at least January 30, 2015.

Thank you for your consideration,

Suzanne Dills

Suzanne Dills, President
Commercial Marine Construction
206 779 3654

Letter also mailed

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Margaret Freeman <fmmargaret@qwestoffice.net> Wed, Dec 3, 2014 at 11:38 AM
To: WFWOComments@fws.gov

Dear Mr. Romanski,

Attached please find the comment letter from Fremont Boat Co., Inc. in response to the Washington Department of Natural Resources Draft HCP EIS.

Thank you for the opportunity to reply. We look forward to the next step.

Best,

Margie Freeman

Vice President

206-632-0152

FB HCP reply 11-14.docx
22K

FREMONT BOAT CO., INC.
1059 N. NORTHLAKE WAY
SEATTLE, WA 98103
206-632-0152

December 3, 2014

Via email: WFWOComments@fws.gov
Re: WDNR Aquatic Lands HCP DEIS

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE
Suite 102
Lacey, WA 98503

Dear Mr. Romanski:

The following is our comment letter regarding the Draft Washington DNR, August, 2014, Aquatic Lands Habitat Conservation Plan.

Background:
We are writing to you from the perspective of a property owner of submerged land in north Lake Union who also leases Washington Department of Natural Resources (DNR) aquatic lands.

Fremont Boat Co., Inc. is a marina got its start in 1916, obtained its present family ownership in 1928 and moved next door to its current location in 1938.
Our docks are created from non-preserved boom logs (Douglas-fir, Cedar and Spruce) which we expect to last at least a good 200 more years. The stringers and cross-pieces are ACZA treated as are the 2x20' (12" wide) planks that are cut to the varying width of the docks. Additional flotation, as needed, is provided by food grade plastic barrels.
These floating docks are held in place by non-treated piling ranging from single piling to 4-pile dolphins. The nearshore water depth is such that no groundings occur from either floats, ramps or boats.
A recent property condition report shows minor cosmetic repair required in the next repair cycle in one or two small areas of the planking. In other words, everything from the logs up is in excellent shape.

There are no nearshore buildings on DNR land and one two-stall covered boat shed in 40' of water; all other slips are open.
However, the north shore of our DNR leased land is bulkheaded by the City of Seattle in order to hold the N. Northlake Way road in position.

Comments/Questions:
GRATING: [5-11.4]

1. Implementing a 100 percent unobstructed grating on the nearshore 'boardwalk' with a below surface makeup of non-preserved material is in itself a fairly large undertaking for the present construction of 20' long planks.
   This is an area that is used for loading and unloading as well as support of fairly heavy loads and thus would require significant changes in spans to support commercial grade plastic grates – or other materials.
   The EIS's economic statement doesn't come close to what would be required for infrastructure to make these changes.
2. Requiring a 50 percent unobstructed grating for our floating docks seems unlikely to produce any noticeable shading difference as the grating would still rest on top of huge, closely spaced logs. Is there any site specific leeway that acknowledges that a goal cannot be reached without having to pay unknown mitigation costs?
3. It may have been missed, but page 5-20, 5.2.2 is the only reference to mitigation we found – how is this cost determined and where are the funds applied?
4. Should this alternative material requirement be enforced, the plan would require more than just replacement of the planks – again making the economic impact study fall short in its conclusions.
   We are more than a little disappointed that in the 1,500 + pages that we have read so far, only 12 pages speak to how this affects one of the industries for which the Lake Washington Ship Canal was created.
5. It would appear that the 50 percent rule for dock grating may create, in our situation, a patchwork of materials used. If that is the case, we have yet to reach an understanding about how something as basic as a cleat will be attached, never mind the attendant utility arrangements.

6. It is unclear from the results of various studies whether predator fish congregate under docks and around vertical structures during spawning or during foraging.
   Likewise, we have been made aware of two studies that cancel one another in answering where salmon fry hide during migration – or if some ever hide at all.
   The answers to these should be irrefutable before requiring the considerable infrastructure changes that are being called for.
   It would not be the first time that large amounts of time and money have been spent on a solution only to find in a few years that it was not a solution at all.
7. It seems that, to a great extent, the schedule for the changes over to grating on docks is tied to the length of the DNR lease. Again, this is an economic factor not being fully addressed. Consider that it may not be possible to afford the changes from the income stream in an eight to twelve year span without having bank funding. This may create a situation where funding is not available for a shorter term lease – thus creating a Catch 22. A longer lease term should be available for those wanting to continue to rent submerged land from DNR.
8. We removed a nearshore boatshed in the last five years which allowed more light to reach the substrate. We have a few lily pads, but mostly the space is being choked with milfoil. How do we address invasive plants that will nurture the species we are attempting to protect?

SHADING: 5-11.4

1. Minimization of shading is the reason for requiring the grating on docks. It somehow goes hand in hand as well with the requirement for reduction of artificial lighting at night. In our end of Lake Union the water depths become deep very quickly. If fry or smolt salmon require vegetation or rocks to hide, they won't find that environment in huge quantities near our shoreline and not any at all farther out where sunlight is a factor. So, please help us understand why in 20-40' depths, any shading is of significance and to what species.

ARTIFICIAL LIGHTING: 5-20

1. We believe that we are close to reaching this standard, given the limitations imposed by other Federal agencies; however we admit to being confused. Would you point us in the direction of the study or

studies that differentiate between the need to create more daytime natural light and the need to create shade from artificial light at night?

TREATED WOOD: 5-29

1. To be honest, we have not finished reading all the studies done on leachates from treated lumber. The Best Management Practices (BMP's) from the American Wood Protection Association indicate that intense pressure and kiln drying create a product with minimal leaching after a matter of weeks and near zero when not submerged for the remainder of its life.
2. We are not in a marine environment that affects foraging fish nor in a river where it can be argued that salmon eggs may be laid. While this is not to say that what we expose Lake Union to is not important – it is; what we are trying to tie together is the benefit to the species we are trying to protect with what is being required of our business. This would have the biggest impact on us financially affecting 60% of our slips, we have not received hard numbers yet due to the short time frame we've had.

PILING: 5-29

1. It appears that none of the piling on the DNR lands we lease – except for that used on the City-owned bulkhead – have been creosoted, or otherwise, treated. However, in listening to others who have studied the subject, there is controversy in the value of removing treated piling for a number of reasons.
   a. Some scientific studies indicate that after a period of time, which in all likelihood includes any treated piling in the Lake Union area, algae creates a barrier to any leachates. This would indicate that a sleeve or piling cap to a level of 8' or so below the water surface may be a solution. The cap prevents disturbances to the piling from vessels.
   b. Studies also indicate that disturbance to the sediment and water column when removing a treated piling may to some extent negate the benefits.
2. The costs for removing and replacing treated piling are directly tied to how many are involved. Again, the economic study falls short in

piecing together how critical the removal is, the length of time of the lease and any extrapolation for a business decision.

OUTREACH:

1. We have known that the HCP was a 'study' being conducted since 2003 or so.
2. There were rumors over the years that the 'study' was getting closer to being a plan.
3. So, it would seem a good ten years went by without anyone indicating that this 'study' was becoming a solid plan. And now we find ourselves reading around 1,000 pages of a draft; 500 pages of an EIS, various appendices and trying to make sense of countless references and studies all in 90 days or less.
4. We are also aware that others are asking for an extension to the comment period to January 15, 2015. If that can be done we know it would be of assistance to many businesses that did not receive a presentation until November 5th. However, given the enormous amount of data, requesting an additional 90 days seems much more likely to yield feedback for a plan that will span 50 years.
5. Further than that, we believe that an outreach from both the Federal agencies involved and the DNR is in order during the entire next year.

Thank you for the opportunity to respond to the draft, we sincerely hope that you take our questions and comments as an opportunity to explore ways to save both endangered species and the economic engine in which we play a small part.

Sincerely,

Margaret Freeman
Vice President

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Margaret Freeman <fmmargaret@qwestoffice.net> Wed, Dec 3, 2014 at 7:49 PM
To: WFWOComments@fws.gov

Dear Mr. Romanski,

Attached, please find comments from the Lake Union Association with regard to the HCP from Washington DNR.

We look forward to the next step.

Best,

Margaret Freeman

President

Lake Union Association

206-632-0152

LUA WDNR HCP Reply 12-14.docx
16K

LAKE UNION ASSOCIATION
1059 N.NORTHLAKE WAY
SEATTLE, WA 98103
206-632-0152

Via email: WFWOComments@fws.gov.

December 3, 2014

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, WA 98503

Re: **WDNR Aquatic Lands HCP DEIS**

Dear Mr. Romanski:

The Lake Union Association (LUA) is an organization formed in 1964 representing the property owners surrounding the Lake from the Locks to Webster Point. Most have leases with the Washington State Department of Natural Resources (DNR).

TIMEFRAME FOR PUBLIC COMMENT:

LUA had a presentation from DNR on November 5, 2014 that summarized the process, the draft EIS and the standards that may be required. The next week the presenters were kind enough to drop off copies of the draft Plan that included the disc containing the EIS.
Needless to say, this gave a scant amount of time to recognize the ramifications of the plan to our members, their businesses or their tenants. Therefore we would ask for:

1. **Extension of the comment period for an additional 90 days.**
2. **Continued outreach from Federal and State agencies until the second draft is published.**
3. **Expansion of the Economic Study portion of the EIS.**

REMAINING USEFUL LIFE OF STRUCTURES:

The timing schedule for meeting required standards, if a long enough lease is granted, seems to take into consideration the business perspective for building in some flexibility. What does not seem to be in place is recognizing the viability of the structure at the end of a lease. Most leases in this area have been in place for many decades and to ignore the useful life of overwater structures places an unreasonable economic burden on any business. There are many member businesses that cater to the fishing industry, moor large vessels, utilize freight docks as well as marinas of every size that have business plans calling for useful life of structures for more than 20 years.
Therefore, we would ask for:

1. **A negotiated schedule for structural replacement at the beginning and end of any lease.**
2. **The ability to span replacements for high dollar value structures over the life of the HCP's 50 year term or at the end of its useful life.**

STANDARDS FOR LIGHT TRANSMISSION:

While most of us have heard about the need for light to reach the shallow nearshore areas, the blanket requirement for 100% unobstructed grating and at least 50% for floats is troubling. In just this short time frame, we have heard from members that have heavy commercial needs for non-grated piers and narrow floats that cannot be supported with that design.
Therefore, we would ask for:

1. **Continued discussion of the goals and the supporting science regarding light transmission.**
2. **Continued discussion of the engineering capabilities and the use of the docks and piers.**

We are privileged to do business in a very unique waterway and have tried to recognize the responsibility that goes with being here. It is of paramount importance that we work on the solutions that will make the most difference to endangered species and set aside those activities with minor impacts.

While some of us have degrees in the sciences, most of us do not know if the failure of certain salmon runs in our area are due to predation, water temperature, life cycling, introduction of bass or toxins. We do know that our maritime businesses have been regulated to the point of frustration while we fail to see the runoff filtered from our bridges and roadways. We know that a great many of the structures that this document is asking to be changed have existed long before there were introductions of the Bear Creek salmon strain. We also know there has been and will continue to be a population increase.

We would like to see a win-win for both animals and businesses and that requires more communication than we have seen to date. We hope you take this shortened reply as an invitation to open those lines of communication.

Sincerely,

Margaret Freeman
President
Lake Union Association

206-632-0152

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Anne Fitelson <fitelsona@ludd.com> Wed, Dec 3, 2014 at 8:51 AM
To: "wfwocomments@fws.gov" <wfwocomments@fws.gov>

Good Morning Mr. Romanski –

Attached please find a letter concerning the WDNR Aquatic Lands HCP DEIS. Please do not hesitate to contact me should you have any questions.

Best,

Anne Fitelson

Vice President, Finance

Lake Union Drydock Company

(206) 380-8516 direct

(206) 324-0124 fax

img011.pdf
541K

LAKE UNION DRYDOCK COMPANY

1515 FAIRVIEW AVENUE EAST
SEATTLE, WASHINGTON 98102
TELEPHONE (206) 323-6400
FAX (206) 324-0124

December 3, 2014

Tim Romanski – USFWS
Washington Fish and Wildlife Office 510
Desmond Drive SE, Suite 102
Lacey, WA 98503-1263

Submitted via email at WFWOComments@fws.gov

Regarding: WDNR Aquatic Lands HCP DEIS

Dear Mr. Romanski:

Our company leases approximately 2.8 acres of state-owned aquatic lands within the Lake Union Harbor Area. Lake Union Drydock Company uses the leasehold in conjunction with its upland tax parcel and has been in operation since 1919.

I became aware of the HCP on November 25, 2014 by way of an email that was forwarded to me from someone within the maritime industry. I have been reading the draft HCP in order to try to get up to speed, but have been unable to get completely through the draft.

I acknowledge and support the conservation efforts that DNR is attempting to make with this HCP, but feel strongly that more research and discussion with DNR "tenants" needs to be had.

Lake Union Drydock Company, as with others within the maritime industry, have a duty to comply with rules and regulations commanded by OSHA. There are several items within the HCP that go counter to OSHA. Lake Union Drydock Company will find itself in the middle of a federal battle if there is no agreement between the two agencies on the topics of lighting and grating.

I urge you to extend the comment period by an additional 90 days to allow time for a complete review of the draft HCP and an opportunity for all governing federal agencies to come to agreement on how best to meet the demands of safety and habitat conservation.

Best,

Anne Fitelson

Anne Fitelson

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Skip Sahlin <Skip.Sahlin@ssamarine.com> Thu, Dec 4, 2014 at 6:05 AM
To: "WFWOComments@fws.gov" <WFWOComments@fws.gov>

Tim Romanski

U.S. Fish and Wildlife Service

510 Desmond Drive SE, Suite 102

Lacey, Washington 98503

Scott Anderson

NOAA Fisheries

510 Desmond Drive SE, Suite 103

Lacey, Washington 98503

Please find attached SSA Marine's comments on Washington State Department of Natural Resources Aquatic Lands Habitat Conservation Plan. Originals will be sent to your attention by post.

20141203 WDNR Aquatic Lands HCP DEIS SSA Marine Ltr.pdf
518K

SSAMarine
A Carrix Enterprise

1131 SW Klickitat W
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

December 3, 2014

Attention: Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

Scott Anderson
NOAA Fisheries
510 Desmond Drive SE, Suite 103
Lacey, Washington 98503

Subject: Public Comments for Washington Department of Natural Resources Aquatic Habitat Conservation Plan, Draft Environmental Impact Statement, and Implementing Agreement

Dear Mr. Anderson and Mr. Romanski:

We are writing on behalf of SSA Marine, Inc. (SSA Marine) to comment on the draft Environmental Impact Statement (DEIS) for the Aquatic Habitat Conservation Plan (HCP) proposed by the Washington Department of Natural Resources (DNR). The HCP imposes significant restrictions on potential new developments and maintenance of existing developments, and provides limited benefits on species protected under the Endangered Species Act (ESA). Due to the close relationship of the HCP and the DEIS, the comments provided in this letter apply to both the DEIS and the HCP itself.

SSA Marine's comments are organized in the following four topic area: The HCP in the context of existing environmental regulations;

- The HCP Operating Conservation Program's treatment of overwater structures with respect to macroalgae, eelgrass, forage fish, mitigation, monitoring, and economics;
- The DEIS analysis of the HCP, specifically as to its economic impact, mitigation, and effectiveness; and
- The proposed Implementation Agreement between the Agencies.

SSA Marine's specific comments are provided in *italics* within this letter.

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

1.0 PROPOSED HCP AND EXISTING ENVIRONMENTAL REGULATIONS

Section 1.4 of the DEIS provides a description of all existing local, state, and federal permitting regulations. One major concern of SSA Marine is that the HCP will add an additional burdensome and unclear regulatory hurdle for necessary maintenance and operations procedures, or for proposed new uses of property. More significantly, the proposed design guidelines under the Operating Conservation Program of the HCP are not consistent with existing regulations, and would not necessarily improve the likelihood of the continued existence of ESA-Listed species beyond that which is afforded by the rules and regulations currently in place.

> **Specific Comment:** ***We request that the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries), the U.S. Fisheries and Wildlife Service (USFWS), and DNR use this HCP process as an opportunity to unify or at least coordinate the permitting process for activities on aquatic lands, such that expectations and application requirements are consistent across multiple permitting agencies. We also request that DNR conduct a review of existing regulations and clarify how the HCP will interact with those existing regulations. Without that information, the DEIS would not adequately disclose the impacts of the proposed HCP and its alternatives.***

2.0 SPECIFIC COMMENTS ON THE HABITAT CONSERVATION PLAN TREATMENT OF OVERWATER STRUCTURES

Comments on the HCP with respect to new and existing overwater structures include the following topics:

- Limitations imposed by the HCP on new and existing overwater structures,
- Mitigation and minimization strategies, and
- Operational monitoring (site access).

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

2.1 Limitations on New and Existing Overwater Structures

The HCP proposes significant limitations on both new and existing overwater structures. This section reviews those limitations (specific to macroalgae and eelgrass marine vegetation communities), the limited potential for mitigation and minimization, and operations monitoring proposed in the HCP.

2.1.1 Macroalgae and Eelgrass Marine Vegetation Communities

Under Washington Administrative Code (WAC) 220-110-250 (3)(a) and (b), eelgrass and macroalgae vegetation communities are defined as saltwater habitats of special concern, and are currently regulated by both the Washington Department of Fish and Wildlife (WDFW) and NOAA Fisheries in habitat support for ESA-Listed species.

In administering the Hydraulic Project Approval (HPA) process, the WDFW currently requires proponents of projects to: 1) avoid affecting eelgrass and macroalgae communities, 2) minimize unavoidable impacts, and 3) mitigate for any impacts to these communities. The WDFW provides specific guidelines for conducting eelgrass surveys, and for providing adequate compensatory mitigation (WDFW 2008[1]). If the intent of the HCP is to revise the requirements already in place through Washington's Code, or adopt new one then it should go through the required rule making process to do so. If the purpose of the HCP is to implement the current WAC, then it should so state..

Appendix J of the HCP is a technical memorandum that describes the results of a technical workgroup that was convened to establish criteria for defining an eelgrass bed. The work group included DNR, USFWS, NOAA Fisheries, the University of Washington, the Northwest Indian Fisheries Commission, Point-no-Point Treaty Council, the Squaxin Island Tribe, and the shellfish aquaculture industry. WDFW was absent from the workgroup, which is of concern because WDFW has regulations on the subject that are implemented through the HPA permitting process.. Because the same structures the HCP would cover will also require a HPA; there is significant risk of conflict in the application of regulations and duplication of effort. The DEIS should consider existing regulatory requirements.

[1] WDFW. 2008. Eelgrass/Macroalgae Habitat Interim Survey Guidelines. Olympia, Washington. 6pp.

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

The standard conservation measures described in the HCP specific to macroalgae and eelgrass are both more stringent than and inconsistent with existing regulations. Analysis of macroalgae and eelgrass vegetation communities' distribution through the DNR Marine Vegetation Atlas (http://www.dnr.wa.gov/researchscience/topics/aquatichabitats/pages/aqr_nrshr_mva.aspx) shows that inclusion of kelps seagrass vegetation would eliminate the majority of the Washington shoreline from future development. This will have environmental and economic impacts that should be considered in the DEIS. Furthermore, the HCP provides minimal guidance as to the definition of "shading" or "impacting" and does not provide criteria for mitigation.

Specific Comments:

- ***We request clarification on how DNR intends to work with WDFW on regulating activities in and around eelgrass and macroalgae vegetation communities.***
- ***We recommend interagency coordination that will result in clear direction for applicants on macroalgae and eelgrass marine vegetation communities.***
- ***We request addressing the extent of macroalgae and eelgrass communities on state-owned aquatic lands, identifying real opportunities and pathways for compensatory mitigation for unavoidable impacts.***
- ***If the intent of the HCP is to revise existing regulations to completely restrict development in vegetated areas and to implement required buffers from native aquatic vegetation, we request that a formal regulatory process be initiated to make such a change and that the process be fully implemented.***

2.1.2 Forage Fish

Similar to the comment regarding macroalgae and eelgrass communities regulation, forage fish are currently managed and protected by WDFW through the HPA process. As described in the HCP, Washington's Hydraulic Code lists herring, surf smelt, and sand lance spawning habitat areas as "marine habitats of special concern," requiring a "no-net-loss" management approach (WAC 220-110). WDFW defines the protection of these species as a priority for the State, and the habitat that these species use for breeding and concentrating is

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

consequently considered a priority for protection (WDFW, 2008[2]). In addition, NOAA Fisheries typically regulates and monitors forage fish in protection of ESA-listed salmonids, thereby offering them additional protection on a case-specific basis.

The protection measures described in the HCP are generally consistent with existing regulations for new development (e.g., conducting forage fish surveys prior to construction, placement of pilings). However, page 5-38 of the HCP states that forage fish surveys must be conducted by consultants approved by DNR or agency staff. In the past, forage fish surveys have been overseen by WDFW.

> **Specific Comment:** ***We request that DNR and WDFW coordinate on adopting protocol and establishing approval criteria for scientists conducting forage fish surveys to avoid inconsistency and conflict.***

Furthermore, operational limitations could potentially decrease the efficiency of operations. There are currently no timing/work-window limitations for the operation of marine industrial facilities. WAC 220-110-271 concerns *construction* work waterward of Ordinary High Water and does not typically apply to general operations. The HCP proposes work windows for in-water operational use. The HCP does not specifically state what types of in-water use would be subject to work windows, or suggest criteria for appropriate operations of a facility.

> **Specific Comment:** ***If DNR is proposing to revise the WAC to apply timing limitations to operational use of existing or proposed facilities, we request that DNR follow the rule making or legislative process to do so. Furthermore, with this comment, we request that DNR address what specific exemptions and requirements for complying with any timing/work-window would be required.***

2.2 Mitigation and Minimization Strategies

Mitigation and minimization are major components of the Operating Conservation Program detailed in the HCP, however the HCP is deficient as currently proposed because compensatory mitigation standards are not included. ESA Section 10(a)(2)(B) requires the development of *"a mitigation program that will minimize and*

[2] WDFW. 2008. Priority Habitats and Species. Olympia, Washington. 177pp.

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

mitigate the impacts of the proposed taking to the maximum extent practicable." Section 4.2.6 of the HCP states that compensatory mitigation is a programmatic measure of the Operating Conservation Program to be negotiated with NOAA Fisheries and USFWS on a case-by-case basis, and was thus not included as a factor potentially affecting species. This reference to compensatory mitigation is consistently undefined throughout the HCP, and these standards for compensatory mitigation are identified as "a programmatic measure' to be determined is indicated in several locations throughout the HCP and the DEIS analysis.

The HCP does not provide adequate framework for compensatory mitigation of unavoidable impacts. For example, Section 5.1.3 states that *"DNR will compensate for unavoidable impacts from DNR-authorized activities by restoring and improving the overall quality of habitat that supports covered species on State-owned aquatic lands."* Section 5.2 (Operating Conservation Program of the Habitat Conservation Plan) states that DNR will require project proponents to provide compensatory mitigation for unavoidable impacts, but that the exact nature of such compensation will be determined individually for each authorization.

Specific to marine vegetation, no thresholds were articulated concerning what constitutes an impact. It is therefore not clear what level of compensatory mitigation would be acceptable to DNR to satisfy the conditions of the Incidental Take Permit (ITP), since the HCP does not address compensatory mitigation requirements.

> **Specific Comment:** ***We request that DNR coordinate and collaborate with WDFW, NOAA Fisheries, and USFWS to develop a marine and aquatic shoreline mitigation guidance that identifies mitigation scenarios, potential compensation types and standards, and that is consistent with existing regulations. The mitigation program should include a list of impacts (e.g., direct and indirect effects to marine vegetation or forage fish or water quality) and a provide mechanisms for identifying appropriate and adequate compensation actions for such impacts. Ideally, the DNR, WDFW, NOAA Fisheries, and USFWS would work together to develop mitigation framework similar to the wetland mitigation framework developed by the U.S. Army Corps of Engineers. Without such guidance, the public is unable to assess the potential effects/benefits and mitigation requirements that may be inherent in a proposed project. Wetland compensatory mitigation practice is a good example of how functions and values of a resource may be assessed up front in the development phase of a project.***

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

2.3 Operational Monitoring

The HCP includes baseline and long-term compliance monitoring, including enforcement achieved by implementing limitations and restrictions on leases. Monitoring has the opportunity to provide significant value and would help enforce accountability from lessees; however, limitations on operation access, and potential conflicts with other regulatory agencies who have expertise and existing jurisdiction need to be recognized and applied. For example, marine terminal operations result in specific safety and security requirements and most have limited access per the U.S. Department of Homeland Security requirements. Additionally, operations of marine terminals are subject to specific internal protocols, US Coast Guard, and Washington Department of Ecology regulations that must be followed to maintain the safety and integrity of the operation. DNR staff are not likely to be involved in the operations of industrial facilities or to be appropriately trained to be granted facility access.

> **Specific Comment:** ***An internal compliance monitoring and reporting program needs to be an option for any conditions attached to facility maintenance and operations associated any aquatic lands lease or project. A similar type program is currently provided by the Department of Ecology under their Stormwater program.***

3.0 SPECIFIC COMMENTS ON THE DEIS

An overarching theme in the DEIS is that DNR's HCP would not allow new uses that reduce the value and function of natural habitats, in areas with little to no development, and with high to moderate importance to the proposed covered species.

Comments on the DEIS provided in this section are focused on economic impacts, mitigation, and the potential effectiveness of implementing Alternative 2 (the identified Preferred Alternative).

3.1 Economic Impact

The economic impact and cost of implementing the HCP needs to be more fully evaluated. According to Revised Code of Washington (RCW) 79.105.030 (Aquatic lands – Management guidelines):

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

> "The management of State-owned aquatic lands shall strive to provide a balance of public benefits that includes fostering water-dependent uses and ensuring environmental protection, while also generating revenue."

According to the DEIS, overwater structures managed under Port Management Agreements would not be included in the Aquatic Lands HCP. Overwater structures subject to the requirements of the HCP would include terminal and transfer facilities, ferry terminals, boat repair facilities, fish processing plants, irrigation pumping plants, navigational aids, sand and gravel processing facilities, and petroleum refining facilities.

The DEIS states that the amount of economic activity associated with the use of aquatic lands for transport and commerce, "while substantial, is unknown." This "unknown" variable is significant, and requires additional research that would not be difficult to analyze given the data available on the value of cargo movements to and from the facilities listed in the DEIS. Without knowledge and understanding of the economic baseline, the effects of implementing the HCP cannot be understood or evaluated accurately, nor can decision-makers be adequately informed to balance the objectives stated in the DEIS. This is a serious deficiency in the EIS and would seem to indicate a bias towards a "protection only" plan without consideration for "fostering water-dependent uses" and "generating revenue".

Section 4.13.3 of the DEIS indicates that Alternative 2 would result in a reduction in the amount of aquatic areas available for private or commercial use. The loss of this available aquatic areas for private or commercial use should be evaluated for potential environmental impacts. Specifically, if marine industrial facilities cannot be built or maintained, what will happen to existing and potential future activity? Will the shipping industry be forced to use smaller vessels, will traffic be direct to rails or highways?

Furthermore, Alternative 2 would adversely affect revenue, jobs, and/or income in the aquaculture, forestry, recreation, or commerce industries. What is the economic scale of the anticipated impact? And at what cost, and for what measureable benefits? No projected costs were presented in the DEIS. The potential economic impacts to state, counties, cites, and nearshore property owners should be evaluated.

> **Specific Comment:** ***We request that a thorough economic and environmental analysis be conducted to evaluate the economic baseline and potential effects of preventing new nearshore developments***

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

and new overwater structures throughout the implementation area. We request that the analysis address the effects of the potential loss of available aquatic areas for commercial or industrial use, and how that loss will affect general transport of goods and the overall economy. We recommend addressing how US commerce may be affected and potential loss of revenue to Canadian export facilities.

3.2 Mitigation

The cumulative effects section of the DEIS states that it is unclear whether mitigation measures will be fully implemented or would achieve the intended results. This general assessment of the HCP and the proposed Operating Conservation Program is of concern because it further illustrates the lack of specifics in the HCP and potential anticipated outcomes regarding all aspects of mitigation efforts (avoidance, minimization, and compensation) that would be required of lessees to comply with DNR's HCP.

Specific Comment: ***We repeat the request that specific thresholds for what constitutes an impact, and specific mitigation measures for those impacts, be developed in detail with WDFW and other State and federal agencies that already regulate these aquatic habitats. Once that is completed the availability of other alternatives should be considered.***

3.3 Access to Industrial Facilities

Throughout the DEIS, the alternatives analysis refers to the implementation of an adaptive management and monitoring program where field audits would be conducted to assess whether the HCP Operating Conservation Program is being implemented as intended. In general, DNR could not be given safe access to marine industrial terminals. It is unlikely that such audits would be allowed to occur at random times at an operating industrial facility due to the security oversight of the Department of Homeland Security. While it may be practical for such compliance audits to be conducted for private homeowners and other private facilities, it is not practical for industrial facilities.

Specific Comment: ***We request that the HCP and DEIS be revised to incorporate language excluding industrial facilities from such monitoring. As an alternative to DNR field audits, the HCP could***

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

provide a system for self-regulation and reporting, as is currently in place for the state's stormwater program.

3.4 Effectiveness of the HCP: the Species Perspective

In the DEIS analysis of potential benefits to the protected species, Section 4.8.3 states that *"overall trends in the distribution, abundance, and condition of habitat (and subsequent listing status) for fish and aquatic invertebrate would likely be similar to those anticipated under Alternative 1"* (the no action alternative).

The DEIS provides an analysis of the effects of the preferred alternative (Alternative 2 – implementing the Aquatic Lands HCP on state-owned aquatic lands throughout Washington State) on fish, aquatic invertebrates, and aquatic invertebrates. This analysis predicts that the benefits for ESA-Listed species anticipated from the HCP are not commensurate with the expense of implementing the HCP in terms of environmental impact, State revenue and the impact on property owners.

Specific comment: ***The document contains no supporting evidence for this conclusion and we again request that a more complete environmental and economic analysis be conducted to evaluate the impacts of the HCP to evaluate whether the cost of implementing the HCP is commensurate with the potential ecological benefits gained.***

4.0 SPECIFIC COMMENTS ON THE IMPLEMENTING AGREEMENT

Our specific concern about the Implementing Agreement (IA), is that the IA presents limits on mitigation that can be required of DNR by USFWS and NOAA Fisheries, while simultaneously providing a basis for DNR to require unspecified and seemingly limitless mitigation to be provided by lessees so that DNR is in compliance with its ITP.

Specific Comment: ***We repeat the request that specific thresholds for what constitutes an impact, and specific compensatory mitigation requirements for those impacts, be developed in detail with WDFW and other State and Federal agencies that already regulate aquatic habitats.*** **Only when that mitigation is identified can the environmental and economic impacts be understood and evaluated against alternatives.**

SSAMarine
A Carrix Enterprise

1131 SW Klickitat Way
Seattle Washington
98134

800/422-3505 tel
206/623-0179 fax

SUMMARY

Section 79.105.030 of the RCW defines DNR's mission of managing State-owned aquatic lands and focuses on ensuring the sustainability of the resources managed, while balancing economic and ecological benefits. As written, the HCP offers limited additional protection of ESA-Listed species presumable at the cost of state and local economies. DNR lease applicants would be burdened with additional costs due to reporting requirements, and DNR would have additional staffing requirements to complete required documentation and compliance with the monitoring and reporting requirements associated with the HCP and ITP.

In closure, we view the development of the HCP as an opportunity for local, State, and Federal regulatory agencies to work together to develop a management structure and mitigation framework for state lands in the nearshore environment that meets all of the objectives of managing and protecting the nearshore environment while creating a state and federal regulatory structure that is logical, consistent and fair to all stakeholders.

Sincerely,

Skip Sahlin
Project Manager

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Kevin Ragon <kevin.spta@gmail.com> Wed, Dec 3, 2014 at 11:59 AM
To: WFWOComments@fws.gov

To whom it may concern:

The Timber Piling Council (TPC) is a not for profit trade association located in Starkville, MS. The TPC consist of companies that manufacture encased treated wood, treated wood, and untreated wood piling for both foundational and marine use. Our membership covers the U.S. and our goal is to promote the use of timber piling by providing sources of supply, engineering seminars, design assistance, and research efforts that better the competitive aspect of timber piles. We would like to thank you for the opportunity to comment on the WDNR Quactic Lands HCP DEIS and have attached our written statement for your review.

Thanks again for considering our statements,

Kevin

Kevin W. Ragon, PhD
Executive Director
Southern Pressure Treaters' Association
PO BOX 1784
Starkville, MS 39760
Phone: 601-405-1116
Fax: 662-205-8589
www.spta.org

Response Letter TPC.pdf
93K

Timber Piling Council
Foundation & Marine Piling

November 18, 2014

Washington State DNR
1111 Washington St. SE
Olympia, WA 98504-7027

Subject: *Draft Aquatic Lands Habitat Conservation Plan*

To Whom it May Concern;

The Timber Piling Council (TPC) is a not for profit trade association located in Starkville, MS. The TPC consist of companies that manufacture encased treated wood, treated wood, and untreated wood piling for both foundational and marine use. Our membership covers the U.S. and our goal is to promote the use of timber piling by providing sources of supply, engineering seminars, design assistance, and research efforts that better the competitive aspect of timber piles. We believe the proposed rules by the DNR should be altered to better reflect the safe use of preserved wood for in-water structures in sensitive areas.

We propose the following alternative language for Treated Wood 5-29.

Standard

Before using treated wood as part of the decking, pilings, or other components of any new in-water structures, such as floats, docks, wharves, piers, marinas, rafts, shipyards, and terminals a risk assessment shall be done to determine if any negative impacts will be caused. Treated wood may only be used for above-water structural framing and may not be used as decking or pilings or for any other uses.

During maintenance that involves replacing treated wood, the existing treated wood should be replaced with alternative materials, such as untreated wood, steel, concrete, or recycled plastic. Alternatively, the treated wood must be encased in a manner that prevents metals, hydrocarbons, and other toxins from leaching out.

Treated wood can be used for a new structure or retained at an existing structure if an encasement method approved by Washington DNR is determined to fully preclude exposure to water and sediments and potential leaching into the aquatic environment.

Intent and effects addressed

Treated wood may leach harmful chemicals into the aquatic environment, degrading water and sediment quality. Chemicals in treated wood can be absorbed or ingested by covered species and may cause biological dysfunction. Many of these chemicals can bioaccumulate in higher trophic levels through food web dynamics, impacting health and reproduction. This standard is designed to avoid and minimize impacts on water and sediment quality and on covered species and their habitats.

Implementation

All authorizations for new construction will include the prohibitions on treated wood as discussed in this section. For existing structures, the authorizing document will define a schedule for replacing treated wood and will specify acceptable replacement materials, such as untreated wood, steel, concrete, or recycled plastic, or encasement in a manner that prevents environmental contamination. Disposal of treated wood at a state authorized disposal facility—such that reuse of this material is precluded— will be required.

Thanks for your time and consideration. If you would like to have more information on technologies such as the encasement of treated wood products I would be happy to supply you with information.

Sincerely,

Kevin Ragon, Ph. D
Executive Director

Timber Piling Council
P.O. Box 1784
Starkville, MS 39760
Phone: 800-410-2070
Mobile: 601-405-1116
FAX: 662-205-8589
kevin.spta@gmail.com
http://www.timberpilingcouncil.org/

Life Cycle Assessment

Procedures and Findings
for
CCA-Treated Marine Piling

Prepared for

TREATED WOOD COUNCIL

Prepared by

AquAeTer

Preliminary Issue November 2011
Final Issue September 2012

Copyright 2012
Treated Wood Council

ADMINISTRATIVE INFORMATION

This life cycle assessment (LCA) of Chromated Copper Arsenate (CCA)-Treated Marine Piling has been prepared for:

Treated Wood Council
1111 19th St., NW, Suite 800
Washington, DC 20036

This LCA of CCA-treated marine piling has been prepared by:

AquAeTer, Inc.
7430 East Caley Avenue, Suite 310
Centennial, Colorado 80111
Primary authors: Chris A. Bolin and Stephen T. Smith

This study and report was completed on November 17, 2011. The final was issued on September 28, 2012 following Journal of Marine Environmental Engineering acceptance for publication.

ACKNOWLEDGEMENTS

This LCA study would not have been possible without the support of several key individuals and organizations. Sincere thanks are given to the following individuals and organizations for their time and contributions to this study:

Jeff Miller, President and Executive Director, Treated Wood Council, Inc. and members of the Treated Wood Council for the financial support and promotion of this project.

Participating companies and individual treating facility respondents from the treated wood industry for their time and effort in providing the data needed for this project.

James H. Clarke, PhD. Professor of the Practice, Civil and Environmental Engineering, Earth and Environmental Sciences, Vanderbilt University for his review and comments.

Paul Cooper, PhD. Professor of Wood Science and Technology. University of Toronto, Department of Forestry Science, for his review and comments.

Mary Ann Curran, PhD. Life Cycle Assessment Research Program Manager. USEPA, Office of Research and Development, for her review and comments.

Craig R. McIntyre, PhD. Independent Consultant, Wood Scientist, and Chemist to the Wood Preservation Industry, McIntyre Associates, Inc., for his review and comments.

Yurika Nishioka, PhD. Consultant, Sylvatica Life Cycle Assessment Consulting, for her review and comments.

Maureen E. Puettmann, PhD. Independent Consultant, Environmental Life Cycle Assessment, WoodLife, for her review and comments.

Copyright 2012
Treated Wood Council

TABLE OF CONTENTS

REPORT ORGANIZATION
ADMINISTRATIVE INFORMATION i
TABLE OF CONTENTS ii
INDEX OF TABLES v
INDEX OF FIGURES v
LIST OF APPENDICES vi

EXECUTIVE SUMMARY ES-1
1. INTRODUCTION 1-1
1.1 BACKGROUND 1-1
1.2 PURPOSE 1-1
1.3 STRUCTURE AND ISO CONFORMITY 1-2
1.4 DEFINITION OF THE PRODUCTS 1-2
2. GOAL AND SCOPE 2-1
3. LIFE CYCLE INVENTORY 3-1
3.1 METHODS DISCUSSION 3-1
3.1.1 Choice of Spreadsheet 3-1
3.1.2 Primary and Secondary Data 3-1
3.1.3 Format of the LCI Spreadsheets 3-2
3.1.4 Use of NREL LCI Modules 3-2
3.1.5 Inputs from Nature or from Technosphere 3-3
3.1.6 Electricity and Supporting Processes 3-3
3.1.7 Distributions 3-4
4. LIFE CYCLE INVENTORY ANALYSIS 4-1
4.1 INTRODUCTION TO CCA-TREATED MARINE PILING LIFE CYCLE INVENTORY ANALYSIS 4-1
4.2 CCA-TREATED MARINE PILING LIFE CYCLE INVENTORY 4-1
4.2.1 CCA Treated Marine Piles Introduction 4-1
4.2.2 Log Growth and Harvest Stage Prior to Wood Treatment (LC Stage 1) 4-2
4.2.3 CCA Production (LC Stage 2) 4-3
4.2.4 CCA Piling Treatment Stage (LC Stage 2) 4-6
4.2.5 CCA-Treated Piling in Marine Use - Service Life Stage (LC Stage 3) 4-11
4.2.6 Piling End-of-Life Disposition Stage (LC Stage 4) 4-12
4.2.7 CCA-Treated Marine Piling Inventory Totals 4-14
4.3 CONCRETE MARINE PILING INVENTORY 4-14
4.4 GALVANIZED STEEL MARINE PILING INVENTORY 4-16
4.5 PLASTIC MARINE PILING INVENTORY 4-19
5. IMPACT ASSESSMENT 5-1
5.1 GENERAL 5-1
5.2 IMPACT INDICATORS 5-1
5.3 IMPACT INDICATOR DEFINITION AND CLASSIFICATION 5-3
5.3.1 Greenhouse Gas (GHG) Emissions 5-3
5.3.2 Fossil Fuel Usage 5-4
5.3.3 Releases to Air Potentially Resulting in Acid Rain (Acidification) 5-4
5.3.4 Water Use 5-4

Copyright 2012
Treated Wood Council

5.3.5 Releases to Air Potentially Resulting in Ecological Toxicity 5-4
5.3.6 Releases to Air Potentially Resulting in Smog Formation 5-4
5.3.7 Releases to Air Potentially Resulting in Eutrophication 5-5
5.3.8 Impact Indicators Considered But Not Presented 5-5
5.4 TOTAL ENERGY 5-6
5.5 RELEASES TO MARINE WATERS WITH THE POTENTIAL TO IMPACT ECOLOGICAL TOXICITY 5-7
5.6 CHARACTERIZATION 5-7
5.7 NORMALIZATION 5-7
5.7.1 Product Normalization 5-7
5.7.2 National Normalization of Impact Indicators 5-8
5.8 CCA IMPACT ASSESSMENT 5-9
5.8.1 Greenhouse Gas Emissions 5-9
5.8.2 Fossil Fuel Usage 5-10
5.8.3 Emissions Potentially Resulting in Acid Rain (Acidification) 5-10
5.8.4 Water Use 5-10
5.8.5 Emissions with Potential to Form Smog 5-10
5.8.6 Emissions with Potential to Impact Eutrophication 5-10
5.8.7 Emissions with the Potential to Impact Ecotoxicity 5-11
5.9 CCA-TREATED MARINE PILES TOTAL ENERGY IMPACT 5-11
5.10 MARINE ECOTOXICITY 5-11
5.11 CONCRETE, STEEL, AND PLASTIC PILING IMPACT ASSESSMENT 5-11
5.12 DATA QUALITY ANALYSIS 5-12
5.12.1 Gravity Analysis 5-12
5.12.2 Uncertainty Discussion 5-13
5.12.3 Sensitivity Analysis 5-15
5.13 COMPARISON OF CCA-TREATED MARINE PILING TO ALTERNATIVE PILING PRODUCTS 5-18
5.13.1 Discussion 5-18
5.13.2 Fossil Fuel Usage 5-18
5.13.3 Greenhouse Gas Emissions 5-18
5.13.4 Releases to Air Potentially Resulting in Acid Rain (Acidification) 5-18
5.13.5 Water Usage 5-19
5.13.6 Releases to Air Potentially Resulting in Smog 5-19
5.13.7 Releases to Air Potentially Resulting in Eutrophication 5-19
5.13.8 Releases to Air Potentially Resulting in Ecological Toxicity 5-19
5.13.9 Comparisons Conclusion 5-19
6. INTERPRETATIONS 6-1
6.1 IDENTIFICATION OF SIGNIFICANT ISSUES 6-1
6.1.1 Precision and Confidence 6-1
6.1.2 Cradle-to-Grave Scope 6-1
6.1.3 Extended Time Frame 6-2
6.1.4 Carbon Accounting 6-2
6.1.5 Use of TRACI for Impact Indicators 6-4
6.1.6 Potential Marine Ecotoxicity 6-5
6.1.7 Human Health Indicators 6-6

Copyright 2012
Treated Wood Council

6.1.8 U.S. Average Electricity 6-7
6.1.9 Recycling Issues 6-7
6.1.10 Recycle and Disposal Assumptions 6-7
6.1.11 Wood Combustion Impacts 6-7
6.1.12 Water Use 6-8
6.1.13 Comparative Analysis 6-8
6.2 EVALUATION 6-8
6.2.1 Completeness Check 6-8
6.2.2 Sensitivity Check 6-9
6.2.3 Consistency Check 6-9
6.3 CONCLUSIONS, LIMITATIONS, AND ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES 6-9
6.3.1 Conclusions 6-9
6.3.2 Limitations 6-11
6.3.3 Environmental Improvement Opportunities 6-12
7. CRITICAL REVIEW 7-1
7.1 INTERNAL REVIEW 7-1
7.2 INDEPENDENT EXTERNAL REVIEW 7-1
7.3 CRITICAL REVIEW REPORTS 7-2
8. WORKS CITED 8-1

Copyright 2012
Treated Wood Council

INDEX OF TABLES

Table ES-1 Life Cycle Impact Indicators Totals for CCA-Treated, Concrete, and Galvanized Steel, and Plastic Piles (per pile per year of service) ES-4
Table ES-2 Contributions to Impact by Stage for CCA-Treated Piles (per pile per year of service) ES-4
Table ES-3 National Normalized Impact Indicators Compared to U. S. Total Values ES-6
Table 4-1 CCA-Treated Marine Piling Treater Survey Results Summary 4-8
Table 4-2 Treating Process Outputs 4-10
Table 4-3 Estimated Constituent of Concern Service Life Releases to Marine Waters..... 4-22
Table 4-4 CCA-Treated, Concrete, Steel, and Plastic Marine Piling Life Cycle Inventory Summary (Cradle-to-Grave per Mcf and per pile) 4-23
Table 5-1 Impact Indicators, Characterization Models, and Impact Categories 5-2
Table 5-2 Summary of Impact Indicator Totals at Life Cycle Stage for CCA-Treated Marine Piling (per Mcf)..... 5-21
Table 5-3 Summary of Impact Indicator Totals at Each Life Cycle Stage for CCA-Treated Marine Piling (per pile per year of use) 5-21
Table 5-4 Contributions to Impact Indicators by Life Cycle Stage for CCA-Treated Marine Piling 5-22
Table 5-5 Summary of Impact Indicator Totals at Life Cycle Stages for All Marine Piling Products (per year of use and per average pile) 5-23
Table 5-6 Normalized Cradle-to-Grave Impacts of Marine Pile Usage Compared to U.S. Total Impact 5-24
Table 5-7 Sources of Energy by Product and Life Stage 5-24

INDEX OF FIGURES

Figure ES-1 Normalized Impact Indicators (Maximum = 1) ES-5
Figure 2-1 Diagram of Life Cycle System Boundary for CCA-Treated Marine Pilings..... 2-3
Figure 4-1 Map of U.S. Regions..... 4-2
Figure 5-1 Sensitivity Analysis - Beneficial Energy Recovery vs. Landfill Disposal 5-25
Figure 5-2 CCA-Treated Wood, Concrete, Steel, and Plastic Piles Normalized Impact Comparisons (Normalized to Maximum Impact = 1)..... 5-25
Figure 6-1 Life Cycle Carbon Balance of CCA-Treated Piling 6-3

Copyright 2012
Treated Wood Council

LIST OF APPENDICES

APPENDIX 1	Project Goal and Scope
APPENDIX 2	Example of the Treater Survey
APPENDIX 3	U.S. Electric Energy Grid Life Cycle Inventory Calculations
APPENDIX 4	Life Cycle Inventory Calculations
APPENDIX 5	Life Cycle Inventory Spreadsheet
APPENDIX 6	Assumptions
APPENDIX 7	Sensitivity Analysis Results
APPENDIX 8	Critical Review Reports and Responses

Copyright 2012
Treated Wood Council

EXECUTIVE SUMMARY

Chromated copper arsenate (CCA) was introduced in the 1930s and subsequently adopted throughout the United States for exterior and marine uses. While alternative copper-based water-borne preservatives such as alkaline copper quaternary (ACQ) and copper azoles became popular in the early 2000s, CCA remains a waterborne preservative of choice for many demanding, "heavy duty" applications, such as marine piling. This LCA has determined the cradle-to-grave environmental impacts for CCA-treated marine piling resulting from **1)** seedling production, growth, and harvest of forest products, **2)** manufacture, **3)** use, and **4)** final disposition of CCA-treated marine piling. This LCA also addresses the opportunities to reduce the environmental burdens associated with CCA-treated piling, and a comparison of the CCA-treated piling product to alternative products manufactured of concrete, galvanized steel, and plastic.

The LCA was commissioned by the Treated Wood Council (TWC), which represents the national interests of the wood preserving industry. CCA is a wood preservative standardized by the American Wood Protection Association (AWPA) for many applications including, marine exposure. CCA is dissolved in a water solution for pressure treating of wood products. CCA preservative was chosen to provide a benchmark for comparison to alternative, non-wood products.

This LCA has been completed in a manner consistent with the principles and guidance provided in the International Organization for Standardization (ISO) Standards 14040 and 14044 and includes ISO specified phases such as a Goal and Scope described in Section 2 (and included in Appendix 1). The four phases of an LCA include: **1)** Goal and scope definition, **2)** Inventory analysis, **3)** Impact assessment, and **4)** Interpretation.

Goal and Scope Definition

The Goal and Scope was developed in cooperation with the TWC membership and internal and independent external reviewers, and was revised iteratively as the LCA progressed. The goal is to identify the environmental impacts attributable to CCA-treated marine piles; identify opportunities to lessen impacts; complete LCAs for concrete, galvanized steel, and plastic marine piles (the primary alternative products); and make comparisons of the product impacts. The scope covers the cradle-to-grave life cycles of CCA-treated wood, concrete, galvanized steel, and plastic marine piles.

General Conclusions

- National impacts are considered small at less than 0.01 percent (one ten-thousandth) of the national totals. The marine industry should consider marine pilings as one of the many products that contribute impacts as a result of their use.

- Opportunities to lessen environmental impacts attributable to the manufacture, use, and disposition of CCA-treated guard rail posts include: increased recycling of used posts for energy recovery; reduction of releases from pilings during use; landfill minimization; manufacturing facility energy efficiency; and minimizing transportation (i.e. local sourcing of materials).

Copyright 2012
Treated Wood Council

- The fossil fuel use, greenhouse gas (GHG), net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for concrete piles.

- The fossil fuel use, GHG, net GHG, acidification, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for steel piles. The water use impact indicator value for steel piles is less than the values for CCA-treated piles.

- The fossil fuel use, GHG, net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for plastic piles.

- Of the four piling types, steel piles have the highest impact indicator values for fossil fuel use, GHG, net GHG, acidification, smog potential, and eutrophication. Concrete piles have the highest impact indicator value for air emission ecotoxicity. Plastic piles have the highest impact indicator value for water use.

- Proximate marine ecotoxicity from CCA-treated piles is best assessed using site specific evaluation.

Inventory Analysis

The cradle-to-grave life cycle inventory (LCI) was developed for life cycle stages of CCA-treated marine piling including: seedling production, planting and growth of trees, harvest of logs, milling of logs into piles, and drying of piles; production of CCA preservative and pressure treatment of piles with CCA preservative; use of CCA-treated piles in marine service (including removal at the end of the useful life); and disposition (including recycling and disposal in landfills). These processes are combined into four life cycle stages: **1)** Pre-treatment; **2)** CCA-treated piles at the treating plant; **3)** CCA-treated piles during service life; and **4)** CCA-treated pile disposition. A cradle-to-grave LCI also was developed for concrete, galvanized steel, and plastic piles to support product comparisons. LCI treated wood inventories first were calculated per 1,000 cubic feet (Mcf). Values for all products were normalized to an average pile and then to one pile per year of use for comparison between products.

The LCI was developed using publicly available data for most life cycle stages and a survey of wood preserving facilities for the preservative application stage. The primary source of public data was the National Renewable Energy Laboratory (NREL) LCI Database. The LCI was assembled in spreadsheet format and did not use proprietary LCA software. Inclusion of the spreadsheet files as a part of the complete LCA report enhances the transparency of this overall LCA process.

Wood species used to make piles are primarily southern pine and Douglas fir. Douglas fir is refractory to CCA treatment, so this LCA only considers southern pine piles. U.S. LCI Database information available through NREL for southeastern forests is used to develop inventory data for the average green, bark covered logs for piles prior to treatment. An inventory of inputs and outputs was developed for the production of CCA preservative which then was used as an input

Copyright 2012
Treated Wood Council

to the wood treatment process. The treatment process also includes peeling (or debarking) logs prior to treatment, with the shavings and bark used as fuel in the process and with excess wood and bark material sold as fuel or mulch. Other inputs to the treatment process were based on the survey results and calculations.

Wooden piles and piles manufactured of alternative materials are assumed to provide equal structural performance. Wooden piles and their alternatives also are assumed to provide equal average service lives of 40 years. No inspections or maintenance is assumed necessary for any of the pile types. The use life stage begins with transportation from the treating plant to the marine service use site, includes the full service life period, and is completed with removal from service.

The post-use stage inventory (i.e., final fate) included portions of piles going to alternate fates, including reuse as treated wood in other applications or disposal in landfills. Pile recycling as fuel for energy recovery is considered only as an alternative under the sensitivity analysis. Assumptions are applied to calculate the input and outputs necessary for each final fate.

Inventories were prepared for concrete, galvanized steel, and plastic marine piles sized for equivalent use. No equivalent life cycle inventories (data inputs and outputs) were identified from concrete, galvanized steel, or plastic pile manufacturers. Therefore, this LCA includes an LCI of production inputs and outputs for alternative piling products, calculated using published data, with professional judgment and assumptions used as necessary.

Impact Assessment

Impact indicators are assessed for CCA-treated, concrete, galvanized steel, and plastic marine piles based on the data inputs and outputs determined in the LCI phase. The impact indicators were chosen to be applicable to the products evaluated and reflect current environmental concerns. The following indicators were evaluated:

- Anthropogenic greenhouse gas (GHG) emissions
- Net change in GHG amounts in the atmosphere (Net GHG), including biogenic GHG absorbed and emitted, and anthropogenic GHG emissions;
- Fossil fuel usage;
- Releases to air potentially resulting in acid rain (acidification);
- Amount of water used;
- Releases to air potentially resulting in smog;
- Releases to air potentially resulting in eutrophication of water bodies; and
- Releases to air with potential ecological toxicity.

For each material, the life cycle inputs and outputs are calculated and summarized in Table ES-1.

While not an impact indicator, total input energy is tracked as a relative measure of the resources required for the cradle-to-grave life cycle. This includes renewable and biogenic energy sources, such as solar, wind, or wood and fossil fuel sources.

Copyright 2012
Treated Wood Council

Impact indicator values for releases of GHG emissions and for releases potentially related to acid rain, ecological impact, smog, and eutrophication use potency factors from the USEPA's "Tool for Reduction and Assessment of Chemical and Other Environmental Impacts" (TRACI) model.

Table ES-1 Life Cycle Impact Indicators Totals for CCA-Treated, Concrete, and Galvanized Steel, and Plastic Piles (per pile per year of service)

		Pile Type			
Impact Indicators (per pile per year of service)	Units	CCA-treated	Concrete	Galvanized steel	Plastic
GHG Emissions	lb-CO_2-eq	36	67	114	94
Net GHG Emissions	lb-CO_2-eq	-1.2	67	115	94
Fossil Fuel Use	MMBTU	0.12	0.31	0.55	0.52
Acid Rain Potential	H^+-mole-eq	8.7	19	41	21
Water Use	gal	5.9	6.7	4.2	14
Smog Potential	g NOx/m	0.042	0.091	0.13	0.083
Eutrophication Potential	lb-N-eq	0.0024	0.0055	0.0055	0.0044
Air Emission Ecotoxicity Potential	lb-2,4-D-eq	0.086	0.48	0.40	0.13

Some life stages contribute more to the total cradle-to-grave impact indicators than others, as shown in Table ES-2. The pre-treatment stage has the highest contribution to the cradle-to-grave total for net GHG (a credit). The treatment stage has the highest contribution to the cradle-to-grave total for fossil fuel use, acidification, water use, smog, eutrophication, and air ecotoxicity. The disposition stage has the highest impact for GHG emissions.

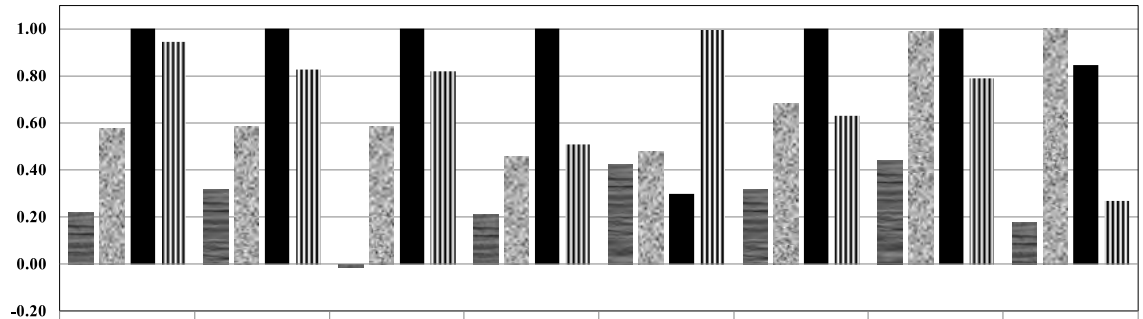
Table ES-2 Contributions to Impact by Stage for CCA-Treated Piles (per pile per year of service)

		Portions by Life Cycle Stage				
Impact Indicator	Units	Pre-treatment stage	CCA treating stage	CCA pile use stage	CCA pile disposition stage	CCA pile cradle-to-grave
GHG Emissions	lb-CO_2-eq	1.4	13	1.1	21	36
Net GHG Emissions	lb-CO_2-eq	-48	16	3.1	27	-1.2
Fossil Fuel Use	MMBTU	0.014	0.063	0.0059	0.037	0.12
Acid Rain Potential	H^+-mole-eq	0.36	5.1	0.30	2.9	8.7
Water Use	gal	0.77	5.1	0	0	5.9
Smog Potential	g NOx/m	0.0027	0.028	0.0042	0.0076	0.042
Eutrophication	lb-N-eq	0.00021	0.0017	0.00032	0.00022	0.0024
Air Emission Ecotoxicity	lb-2,4-D-eq	0.0018	0.056	0	0.029	0.086

Alternative products to CCA-treated marine piles include concrete, galvanized steel, and plastic marine piles. The 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 for maximum impact value to 1.0, and all other values are a fraction of 1.0. The normalized comparative analysis is shown on Figure ES-1.

Copyright 2012
Treated Wood Council

Figure ES-1 Normalized Impact Indicators (Maximum = 1)



	Fossil Fuel Use	GHG	Net GHG	Acid Rain	Water Use	Smog	Eutrophication	Air Emission Ecotoxicity
CCA-treated pile	0.22	0.32	-0.01	0.22	0.42	0.32	0.44	0.18
Concrete pile	0.57	0.59	0.58	0.46	0.48	0.69	0.99	1.00
Steel pile	1.00	1.00	1.00	1.00	0.30	1.00	1.00	0.84
Plastic pile	0.95	0.83	0.82	0.51	1.00	0.63	0.79	0.27

National normalization establishes impact indicators calculated from U.S. national resource uses and emissions as 100 percent, and compares impact indicators as a result of 22.5 million (estimated number of CCA-treated marine piles currently in service) piles installed of either CCA-treated wood, concrete, galvanized steel, or plastic piles.

National normalization, as shown in Table ES-3, uses example scenarios in which impact indicator values per marine pile type are multiplied by 22.5 million and divided by the U.S. total impact indicator values to provide the normalized impact for each product scenario as a percent of the annual U.S. total impact indicator value. Thus, the total annual fossil fuel input for all CCA-treated piles would be approximately 0.0031 percent or approximately three one-hundred thousandths of the total fossil fuel energy consumed in the U.S. annually.

Marine impacts, due to releases from piling of any material, should be considered in a broad context. Pile products are installed to provide vertical and horizontal support to piers and wharfs, and single or groups of piles are used together as dolphins. These marine structural products are installed to support the maritime industry. Releases from these structures, associated vessels, and surrounding infrastructure all contribute to marine environment impacts within their immediate proximity. For instance, copper is released not only from CCA-treated piling, but also from antifouling paint on boat bottoms. Based on a study of copper leached from anti-fouling paints, a 50 foot boat might release 1.5 pounds of copper per year if using professional grade antifouling paint or 0.49 lbs per year if using leisure boat paint. As a comparison, a CCA-treated marine pile is estimated to release 0.021 lbs of copper per year, based on the assumptions used for this LCA. Potential impacts of released copper are limited to the immediate proximity of the piling structure, and within 10 feet for small structures (NOAA, 2009). Oil and fuel are released from engine operation and refueling. Dredging is done to keep marinas open. Each is a local impact, but not all can be considered using the metrics applied in this LCA. Therefore, this LCA reports releases from CCA-treated marine piles, but has not attempted to normalize such impact for evaluation of the piling product in comparison to local impacts, nor mitigating measures that could be used.

Copyright 2012
Treated Wood Council

Table ES-3 National Normalized Impact Indicators Compared to U. S. Total Values

Impact Category	Annual marine pile impact as a fraction of U.S. total annual impact categories (assumption based on 22.5 million marine piles)			
	CCA Pile	Concrete Pile	Steel Pile	Plastic Pile
Greenhouse Gas Emissions	0.0052%	0.0095%	0.016%	0.0098%
Net GHG	-0.00017%	0.0096%	0.016%	0.0098%
Fossil Fuel Use	0.0031%	0.0081%	0.014%	0.014%
Acid Rain Potential	0.0043%	0.0091%	0.020%	0.0083%
Water Use	0.00011%	0.00012%	0.000074%	0.00039%
Smog Potential	0.0023%	0.0049%	0.0071%	0.0040%
Eutrophication	0.0017%	0.0039%	0.0039%	0.0029%
Air Emission Ecotoxicity	0.0043%	0.024%	0.020%	0.0044%

Readers are cautioned that the LCA process has a degree of uncertainty introduced by the broad scope, variability among producers and products, on-going changes in technology, limited data on key processes, and assumptions. Calculated values are accurate for the intended use in this LCA.

Interpretation

A company considering what material to use for marine piles should review the impact indicators, as presented in this LCA, as some of the many characteristics of the products. Other characteristics include appropriateness for the intended use, purchase price, ease of installation, proven performance, aesthetics, ease of disposal, and worker acceptance. Using the impact indicators in the impact assessment, the comparisons of results for CCA-treated wood to concrete, galvanized steel, and plastic piles support the following conclusions:

- Impact indicators for CCA-treated wood are lower than all three alternative material marine piles for fossil fuel use, GHG, net GHG, and potential for acidification, smog, eutrophication, and air emission ecotoxicity.
- Water use for CCA-treated piles is less than for concrete and plastic, but more than for galvanized steel.
- CCA 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 (Brooks, 2010), provides a tool to evaluate potential marine ecotoxicity for specific projects in which CCA-treated marine piles are being considered.

The impact indicator values stated in this LCA are intended to provide generalized indications of potential resource use and environmental releases, and to support the comparison of CCA-treated wood to concrete, galvanized steel, and plastic marine piles. The results are for the U.S. average market for these products. Results for individual producers or specific products can vary from these values, as will wood products treated with other preservatives.

Copyright 2012
Treated Wood Council

The carbon embodied in wood products, such as piles, is stored for decades while the product is in use. Temporary storage of carbon in the wood product reduces atmospheric levels of CO_2. However, this LCA does not provide credit for temporary storage and accounts for all carbon removals from, and emissions to, the atmosphere without regard for time.

Copyright 2012
Treated Wood Council

1. INTRODUCTION

1.1 BACKGROUND

The use of wood products is a defining aspect of humanity. People have used wood to make tools, weapons, homes, and, of course, fire since before recorded history. Some early discoveries related to wood preservation include fire-treating stakes to create harder, more durable points on spears or charring fence posts to retard decay. People also discovered that some wood species, such as redwood, last longer than others in harsh environments.

Treatment of railroad ties with creosote began in the late 1800s and quickly became the standard because of the significant improvement in wood tie life that the treatment provided. Chromated copper arsenate (CCA) was introduced in the 1930s and subsequently adopted throughout the United States for exterior and marine uses.

Over the years, industry has consistently modified its formula for wood preservation in order to meet consumer preferences and government regulations. While alternative copper-based water-borne preservatives such as alkaline copper quaternary (ACQ) and copper azoles became popular since the early 2000s, CCA remains a waterborne preservative of choice for many demanding, "heavy duty" applications, such as marine pilings.

Pressure treating of wood products is done at approximately 400 facilities in the U.S., with roughly 350 facilities using some type of waterborne treatment (Miller, 2009). Gross sales for the wood preserving industry were estimated at $4.5 billion in 2007, with employment provided for 14,800 people (Vlosky, 2009). In a 2007 study of wood treaters, Vlosky estimates that 29 percent of waterborne preserving was done using CCA, equivalent to 52.9 million pounds of CCA use annually.

CCA is a mixture of chromic acid, cupric oxide, and arsenic pentoxide. Because CCA fixes strongly to wood, it provides wood excellent protection from decay in a variety of environments. CCA has a proven track record for the past 80 years.

This study investigates the environmental impacts related to CCA-treated marine pilings (interchangeably referred to as marine piles) and provides general comparisons to alternative piles.

1.2 PURPOSE

In 2008, the Treated Wood Council (TWC) contracted with AquAeTer, Inc. to conduct a Life Cycle Assessment (LCA) of CCA-Treated Marine Piling including LCAs of concrete, galvanized steel, and plastic pilings for comparison. The purpose of the LCA is to quantitatively evaluate environmental impacts associated with the national production, service life, and disposal of CCA-treated marine piling and to compare the CCA-treated piling LCA results to similar results for piling manufactured from concrete, galvanized steel, and plastic. The intended audiences for the LCA include: **1)** members of the TWC; **2)** government regulators; **3)** environmental advocates; **4)** life cycle inventory database users; and **5)** end users.

Copyright 2012
Treated Wood Council

The LCA is intended to answer the following questions:

- What are the environmental impacts resulting from seedling production, growth, harvest, manufacture, service life, and final disposal of CCA-treated marine piling?
- What are the opportunities to reduce the impacts?
- How do the environmental impacts of CCA-treated marine piling compare to those of concrete, galvanized steel, and plastic, the primary alternative marine piling products in the market?

1.3 STRUCTURE AND ISO CONFORMITY

This LCA is conducted and presented in a manner limited by the Goal and Scope and consistent with the principles and guidance provided by the International Organization for Standardization (ISO) in standards ISO 14040:2006, Environmental Management -- Life Cycle Assessment -- Principles and Framework (International Organization for Standardization (ISO), 2006) and ISO 14044:2006, Environmental Management – Life Cycle Assessment – Requirements and Guidelines (International Organization for Standardization (ISO), 2006).

1.4 DEFINITION OF THE PRODUCTS

Marine piles are used for various functions as parts of marine structures. Piles provide vertical and horizontal support to piers and wharfs, which also include decks and other structural components. Single or groups of piles together are used as dolphins. Dolphins are installed near or onto piers or wharfs as bumpers to keep ships from damaging the pier, wharf, supporting piles or other components. Dolphins also are placed to guide vessels to moorings, fend them away from hazards, or to support navigational aids.

Wood treated with CCA to marine retentions can also be used as fenders or cushions between ships and structures, a use that is not addressed in this LCA. CCA-treated piling intended for foundation or freshwater applications also is not included.

The product of primary focus in the LCA is CCA-treated marine piles treated according to American Wood Protection Association (AWPA) standards for Use Category (UC)-5A, UC-5B, and UC-5C exposure (American Wood Protection Association, 2010), with retentions of 1.5 outer and 0.9 inner zone for UC5A and 2.5 outer and 1.5 inner zone for UC5B and UC5C, pounds per cubic foot (pcf), intended for marine (salt water) exposure. Such piles typically are driven into soil or sediment using pile drivers.

The service life is the amount of time the marine piles remain in service. The service life in marine applications can vary greatly, depending on treatment, wood species, use intensity, inspections and maintenance, and location-specific environmental and biological challenges, such as presence of ship worms and other organisms that attack wood. Smith (Smith, S. T., 2006) summarized data from the U.S. Navy indicating average service life of marine piles, treated with CCA, is approximately 40 years. An average life assumption for piling has been used as part of the inventory phase of the LCA. At the end of useful life, piling is modeled as removed from service and **1)** recycled for other secondary uses, **2)** burned as fuel, or **3)** disposed in a solid waste landfill meeting current Subtitle D (non-hazardous) landfill requirements. The

Copyright 2012
Treated Wood Council

fraction of used piling to each disposition option reflects current industry practice. Landfills for construction and demolition (C&D) waste and municipal waste of both bioreactor and dry designs were modeled.

The products compared to CCA-treated marine piling are piling manufactured from reinforced concrete, galvanized steel, and plastic. In order to support comparison of products through their cradle-to-grave life cycles, an LCA has been completed for each of the comparative products. The LCAs for the alternative products do not include independent manufacturing inventory data (primary data) and consequently, comparisons made with the alternative products are done as a general comparison to provide a broad understanding of how the products might compare. Additional data collection and analysis would be needed to make definitive statements regarding the comparability of the products.

A "typical" concrete, steel, and plastic pile product has been assumed to be representative of the general product category. The comparative products have approximately the same dimensions and generally are used interchangeably with CCA-treated marine piles. For the purposes of this LCA, the alternative products are assessed using the same cradle-to-grave life cycle that starts at material extraction and/or product recycle and ends at final disposition. The alternative products are assumed to have the same boundary conditions and the same service life of 40 years. Published data and reasoned assumptions are made to complete the LCA for the comparable life cycle for each alternative product.

Copyright 2012
Treated Wood Council

2. GOAL AND SCOPE

As part of the marine piling LCA, a Goal and Scope Document was developed prior to beginning the inventory of inflows and outflows. Specifically, the goal and scope for CCA-treated marine piling follows the framework specified in Section 5.2 of ISO 14040:2006 and Section 4.2 of ISO 14044. The purpose of the Goal and Scope Document is to clearly define the intent of the LCA.

- The goal defines what the client intends to accomplish through the LCA process. That is, "Why do the LCA?"
- The scope clarifies what is to be included within the assessment and what is not included.

The Goal and Scope Document was subjected to two levels of technical review and an independent external review intended to assure the quality and accuracy of the document and the LCA. The Goal and Scope Document has been used to guide the LCA process. The detailed Goal and Scope document prepared to support completion of this LCA is included as Appendix 1.

The LCA addresses CCA-treated marine piling for use in marine (salt water) applications as components of marine structures. This product was chosen as a baseline for the purpose of conducting the LCA. It is not the intent of this assessment to include all possible preservative types in the marketplace for this application, nor to endorse the specific preservative chosen for the analysis. Rather, a baseline preservative was chosen for the purpose of conducting the assessment, with the understanding that preservative formulations and preservative types can change. The baseline product assessment provides the user a tool by which to evaluate a group of treated wood products in the marketplace.

Marine structures encompass a wide variety of structural types, functions, and construction materials. Structures using or supported by driven CCA-treated wood piling comprise a significant subset of the driven pile market. This LCA focuses on those applications where treated wood piles typically are used and for which piles made of alternate materials also can be used.

The Life Cycle Process Diagram of CCA-treated marine piling (Figure 2-1) illustrates the cradle-to-grave life cycle system boundary considered in the LCA. In this Figure, the process is shown in blue with the inputs to the process shown in yellow and the outputs from the process shown in pink.

For this LCA, the "cradle-to-grave" life cycle of CCA-treated marine piling was assessed. Thus, the LCA addresses inputs and outputs beginning with seedling production, planting and growing of trees, the harvest of logs, the peeling and shaping of logs, the manufacture of the components of the CCA preservative, the treatment of piles with CCA, the installation and normally-intended service life of CCA-treated marine piling, removal, transportation between points, and finally disposition. Disposition includes **1)** recycling for fence or landscape use, **2)** combustion for energy recovery, or **3)** disposal in landfills. Combustion for energy recovery is assumed to not occur under current practice. However, evolving technology, such as gasification, would allow greater utilization for energy and is therefore considered under the sensitivity analysis. Inputs of

Copyright 2012
Treated Wood Council

resources and outputs of products and wastes for each process in the life cycle were estimated and totaled.

Marine pilings are installed in coastal salt water and brackish environments. Because the components of CCA, chromium, copper, and arsenic, are partially released from the piles to this environment over the pilings' service or use life, the scope addresses releases and environmental consequences.

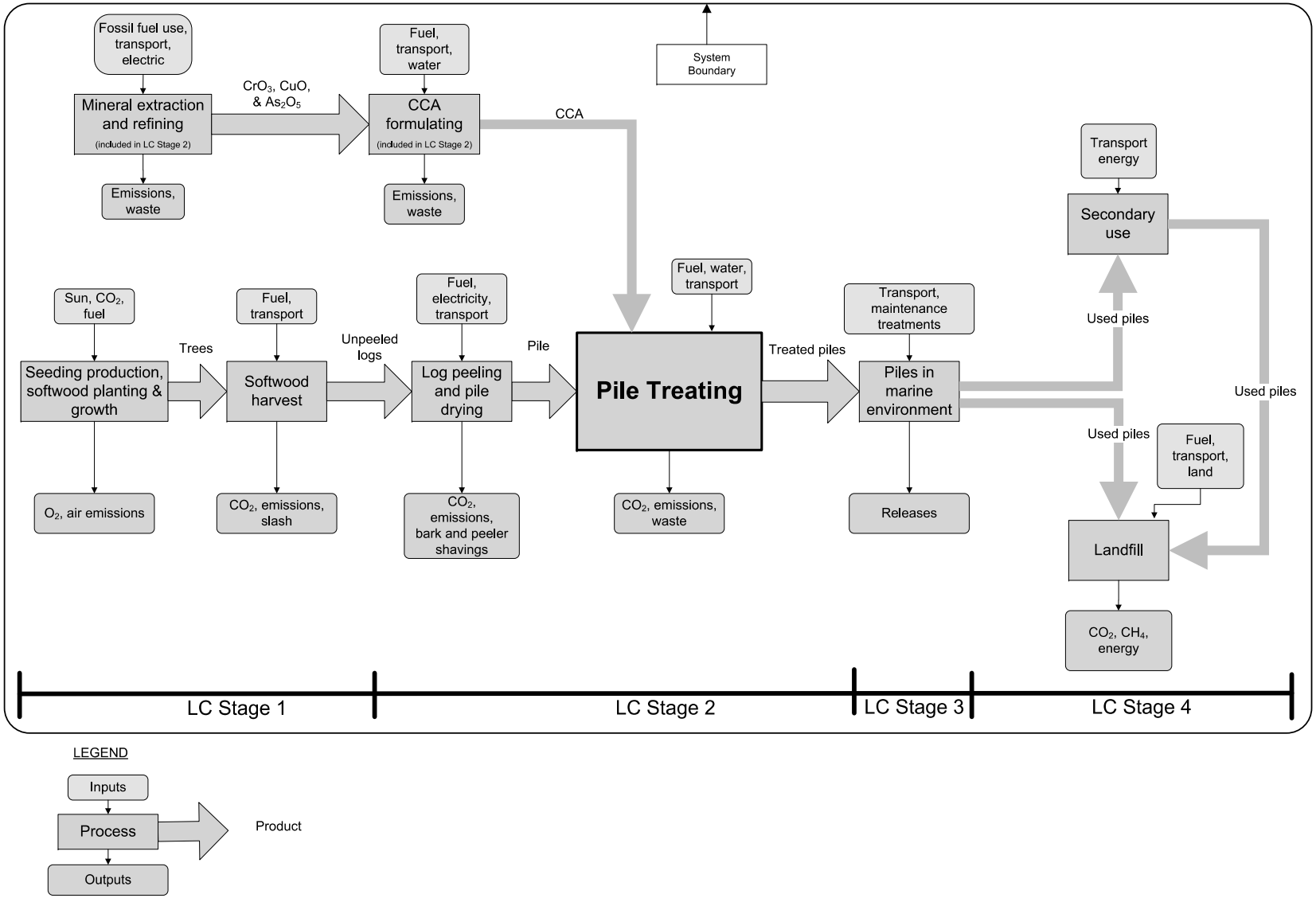
Alternate products to CCA-treated marine piling are concrete, galvanized steel, and plastic piles. This report provides an LCA of the alternate products to support comparison of impact indicators, based on the functional unit of one typical pile per year of service. Equivalency of piling products is assumed to result from piling of similar cross-sectional end area, since the required end area of the pile often depends on the soil loading capacity. Alternate concrete and plastic piles are assumed to be square, and steel pipe piles are assumed to be round and of similar diameter at the mid-point of the "equal" wood pile.

The cradle-to-grave life cycle of the alternative products addresses inputs and outputs beginning with material extraction and/or recycling, refining, the manufacture of the alternative marine pile, the installation and normal intended use of the pile, removal, transportation between points, and final disposition. Disposition includes reuse, recycling, or disposal in landfills. For alternative products, inputs of resources and outputs of products, emissions, and wastes for each process in the life cycles were estimated and totaled.

Through the iterative LCA process, the TWC decided that the scope should not include impact indicators for human health, based on the opinion that the measures for these indicators do not reflect actual risk and can be subject to misinterpretation. Furthermore, the goal and scope has been altered to only consider air emissions in the calculation of impact indicators. In this LCA, some release to land and water are estimated, but not used to determine impact.

Copyright 2012
Treated Wood Council

Figure 2-1 Diagram of Life Cycle System Boundary for CCA-Treated Marine Pilings



Copyright 2012
Treated Wood Council

3. LIFE CYCLE INVENTORY

3.1 METHODS DISCUSSION

3.1.1 Choice of Spreadsheet

An early choice made by AquAeTer in completing the inventory phase of the LCA for CCA-treated marine piling was whether or not to use proprietary LCI software programs, such as SimaPro®, or to use linked spreadsheets developed specifically for this LCA. Publicly available inventory data are available from the U.S. Department of Energy, National Renewable Energy Laboratory (NREL) U.S. Life Cycle Inventory (LCI) Database. These individual LCI modules can be downloaded in spreadsheet format, and AquAeTer's understanding is that all the pertinent NREL data are made available in proprietary LCI programs, such as SimaPro® as well as non-proprietary software programs. The proprietary software is powerful, but is only transparent to those who have purchased the software license. In order to provide the greatest degree of transparency and to allow full functionality by the authors, AquAeTer decided to complete the LCI using linked spreadsheets rather than using proprietary software. The inventory data developed for life cycle stages, including preservation of the piles, service life, and disposal (or beneficial reuse), have been developed in a spreadsheet format and are incorporated with existing data from the NREL databases. Each separate input is integrated and proportioned appropriately with the production, service life, and final disposition stages of the product life.

The use of spreadsheets for the LCI allows members of the TWC and interested parties to download and use the results at no cost. Final versions of the spreadsheets will have protections in place to prevent accidental formula manipulations.

3.1.2 Primary and Secondary Data

The Consortium for Research on Renewable Industrial Materials (CORRIM, 2002) defines primary and secondary data as follows:

Primary data are those collected using recognized inventory data collection rules from specific facilities or operations; such data are typically labeled to indicate the date of collection and the estimated reliability of the data.

Secondary data are those obtained from secondary sources such as simulation studies, or published articles containing industry or region-wide, or company specific information.

Applying CORRIM's definitions for this study, AquAeTer generated primary data by surveying TWC member wood treating facilities using CCA during the 2007 or 2008 calendar years to determine representative rates of inputs and outputs. An example of the treater survey is included as Appendix 2. The survey results are included as a ***tab***[1] within the spreadsheet file and

[1] Reference here and elsewhere in this document to "***tab***" or "***tabs***" is intended to be a reference to one or more "worksheets" within a single spreadsheet program electronic file or "workbook." On the computer screen, the individual "worksheets" usually appear as folder "***tab***s" that open individual worksheets for viewing.

Copyright 2012
Treated Wood Council

calculations required to develop the normalized rates are made transparently. These primary data then are incorporated into the appropriate inventory functional unit columns.

All other functional unit data are obtained from secondary sources, such as other life cycle inventories that were downloaded from the NREL's U.S. LCI Database (National Renewable Energy Laboratory) or obtained from other literature sources. Sources of secondary data are referenced in calculations included in Appendix 3, U.S. Electric Energy Grid Life Cycle Inventory Calculations and Appendix 4, Life Cycle Inventory Calculations.

3.1.3 Format of the LCI Spreadsheets

The format of the LCI spreadsheets reflects the sequential primary life cycle stages of CCA-treated marine piling as a progression from left to right. Additionally, the first section of the spreadsheet defines process components that are used repeatedly in the life cycle stages, such as energy and fuel production, combustion, and transportation. The LCI spreadsheets are included as Appendix 5.

Electric energy production is listed first (left portion of the spreadsheet), because it is used in nearly all stages and for all products (treated wood and the alternatives). Then, other inputs are entered using modules from the U.S. LCI inventory, including fuel production and combustion, and truck, rail, barge, and ocean vessel (ship) transportation. For ease of reference, these primary process categories were highlighted (with gray shading) and grouped under the heading "Energy and Other Inputs" on the "Piles LCI" inventory ***tab***. Note that each of these inputs has associated outputs to the environment, such as CO_2 and other releases that are proportional to the amount used. In the spreadsheet, each column with numeric data represents a process with specific inputs and outputs, a subtotal of processes, or a summed total of processes.

Additional life cycle stages are identified on the "Piles LCI" inventory ***tab*** and include distinctive color coding for easy reference. At the end of each life cycle stage, life cycle inventory totals are computed for inputs, outputs, and assessment indicators.

Other ***tabs*** in the spreadsheet workbook are used for supporting calculations that produce values used in the LCI. For example, in the "Landfill" ***tab***, a series of assumptions (based on available literature) and calculations are shown that allow an estimation of how much methane and CO_2 are emitted from disposed treated piles and how much carbon would be sequestered in the landfill. These values are linked to the "Piles LCI" worksheet as inputs and outputs in the "Landfill Stage" section.

3.1.4 Use of NREL LCI Modules

The National Renewable Energy Laboratory, U.S. Life Cycle Inventory Database (National Renewable Energy Laboratory) provides extensive LCI data for public use. The Life Cycle Inventory Database is described on its website as follows:

> *NREL and its partners created the U.S. Life Cycle Inventory (LCI) Database to help life cycle assessment (LCA) experts answer their questions about environmental impact. This database provides a cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material, component, or*

Copyright 2012
Treated Wood Council

assembly. It's an online storeroom of data collected on commonly used materials, products, and processes.

The critically reviewed LCI data are consistent with a common research protocol and with international standards. The LCI data support efforts to develop product LCAs, support systems, and LCA tools.

Developing the LCI spreadsheet required the use of several modules from NREL's U.S. LCI Database. The U.S. Electric LCI, detailing inputs and outputs related to use of electrical energy from the U.S. grid, alone required use of NREL LCI data modules for coal mining, oil and gas extraction, crude oil refining, and utilities. The wood-product manufacturing data modules included softwood log planting, growth, and harvesting in the Southeastern U.S. Transportation modules also were used to develop inputs and outputs for product transport.

Where the LCI data modules are used, the resulting process inputs and outputs are entered as a column in the "Piling LCI" ***tab*** of the spreadsheet. For the LCI inventory spreadsheet, and because of the wide variety of inputs and outputs, especially related to specific chemicals that are emitted or discharged, the components displayed in the primary "Piling LCI" ***tab*** of the spreadsheet are limited to those most applicable to this LCI. For example, emissions/discharges of copper are presented, even where the numbers are minimal, because copper is a component of CCA, but acetone is not presented on the primary LCI spreadsheet because it is not a primary component of CCA and not directly related to the products in question. However, acetone (and all other available emissions data) was tracked and is included in calculations of impact indicators in a separate spreadsheet entitled "ChemicalFactors."

During the inventory process, some data simplifications were done. For example, most values that were manually entered were rounded to two significant figures. Some numbers were combined to reduce the number of inputs or outputs. For example, the much smaller amount of lignite coal used for electric production was added to, and assumed to be the same as, bituminous coal. Similarly, the inputs of hydro, solar, wind, and geothermal are combined in an "other renewable energy" input.

3.1.5 Inputs from Nature or from Technosphere

"Inputs from nature" are generally considered as those resources that are mined from the earth, such as coal, iron ore, limestone, or crude oil and are not readily sold to end users. "Inputs from the technosphere" are resources that have been processed or altered by technology and typically are "sold" to downstream processes or users. For example, crude oil is removed from nature and then refined into fuels, such as gasoline and diesel fuel, and sold to users as resources from the technosphere. For another example, electricity is a product from the technosphere that results from use of various fuels derived from nature. For consistency in accounting for fuels, inputs used to generate electricity and to produce fuels are considered "from nature," even if some processing before such use was involved.

3.1.6 Electricity and Supporting Processes

The inputs and outputs related to the electricity use and other supporting energy processes are included on the "Piles LCI" ***tab*** of the spreadsheet under the gray shaded ( ) column

Copyright 2012
Treated Wood Council

heading "Energy and Other Supporting Processes." Energy modules on the NREL website provide information on the fraction of average U.S. grid electricity generated by source type. The U.S. grid **average** was used instead of the Eastern U.S. grid because this better supports comparative analysis, eliminates geographic differences for which treaters have little control, and recognizes that sources of electricity are likely to evolve significantly over the next few decades. These grid inputs include coal combustion at 58 percent, nuclear at 22 percent, hydropower at 8 percent, natural gas at 17 percent, residual oil at 3 percent, biomass at 2 percent, and other renewable sources at 1 percent with line losses of 10 percent. The modules provide data about the resource inputs and environmental outputs of combusting the fuels for power and the environmental inputs and outputs of actual fuel production, such as mining, oil and gas well operations, refining, and other processing. However, its format does not associate or proportion inputs and outputs from each generation source type or fuel production process. Because of the complexity of proportioning the several separate processes into the U.S. average electric grid, a separate spreadsheet file, "Electric Energy LCI.xls," was constructed to support the needed calculations. The calculations are explained in detail in Appendix 3, U.S. Electric Energy Grid LCI Calculations.

The "Electric Energy LCI.xls" file is used to assemble, in a single spreadsheet workbook, the basic data downloaded from NREL and to link these data to average U.S. grid electricity. The completed spreadsheet workbook is used in the "Piles LCI" ***tab*** by cell references to this file or by copying sections of this file into other files, such as "ChemicalFactors.xls," a spreadsheet used to calculate impact indicators.

Data inputs and outputs for selected other fuel production and combustion data also have been incorporated into the "Electric Energy LCI.xls" workbook for convenience, such as natural gas, oil, and coal production and combustion in industrial boilers. The data from the supporting processes are linked to the "Piles LCI" ***tab***.

In addition, transportation modules from NREL including truck, rail, barge, and ship transport are included as the "transport" ***tab*** and linked within the gray-highlighted columns ( ) of the "Piles LCI" ***tab***. The transportation calculations are further explained within Appendix 4.

Electricity and other supporting processes are proportioned to life cycle activities in the following sections.

3.1.7 Distributions

Each column of the Energy and Other Supporting Processes group is repeated in each stage of the product life under a gray ( ) subheading of "Energy and Other Supporting Process Distributions." The amount of each input, such as electricity, used in a life stage is listed in the "Production/Use Amount" line (line 6) and the units of use, kilowatt hour (kWh) for electricity, are shown in the next line. The next line calculates the "distribution factor," which is the amount used divided by the unit production rate of the input. For example, the unit rate for electricity is 1,000 kWh. A process using 800 kWh of electricity would have a distribution factor of 0.8 (800/1,000). Each specific process input and output related to electricity is calculated by multiplying the distribution factor times the standard input or output values of the reference process. Following the same example above, using US electricity average (as further explained

Copyright 2012
Treated Wood Council

in Appendix 3), the standard output of CO_2 is 1,600 lbs per 1,000 kWh, so the life stage process CO_2 emission would be 0.8 x 1,600 or 1,280 lb CO_2.

Copyright 2012
Treated Wood Council

4. LIFE CYCLE INVENTORY ANALYSIS

4.1 INTRODUCTION TO CCA-TREATED MARINE PILING LIFE CYCLE INVENTORY ANALYSIS

The inventory analysis phase of the LCA involves the collection and analysis of data needed to accomplish the goal of the LCA. For each stage of the product life cycle, the inputs of energy and raw materials, outputs of products, co-products, and waste, and environmental releases to air, water, and soil are determined. The inventory analysis steps include data collection, data validation, relating data to unit processes, relating data to functional units, data aggregation, refining the system boundary, and completing inventory reporting. These steps are consistent with the requirements of ISO 14044 (International Organization for Standardization (ISO), 2006).

The unit processes for CCA-treated marine piling addressed in this LCA cover the "cradle-to-grave" stages as follows: seedling production, planting and growth of trees, harvest of logs, peeling of logs to piles, and drying of piles, production of CCA preservative, pressure treatment of piles with CCA preservative, service life of CCA-treated piles in marine structures, removal at the end of useful life, and disposition (including beneficial reuse and disposal in landfills). These are illustrated in Figure 2-1, Life Cycle System Boundary Diagram of CCA-Treated Marine Piling. Unit processes are combined into four main life cycle stages (Figure 2-1):

1. Forestry: including forest operations and harvesting of logs[2];
2. Pile peeling, pile drying, preservative manufacture and treatment of CCA-treated marine piles, prior to installation;
3. Use of CCA-treated marine piles; and
4. CCA-treated marine piling end-of-life disposition.

Data related to the various processes are collected and entered into spreadsheets that facilitate the calculations needed to proportion inputs and outputs to each unit process appropriately. The data from unit processes are summed to determine inventory totals at each of the primary stages. The completed inventories are used in the following sections of the LCA to assess and interpret impacts and support comparisons to alternate products.

4.2 CCA-TREATED MARINE PILING LIFE CYCLE INVENTORY

4.2.1 CCA Treated Marine Piles Introduction

The first life cycle stage of CCA-treated marine piling includes the seedling production, planting and growth of the tree, and harvest of logs suitable for use as piling. The inputs and outputs are based on the downloaded modules from the NREL's U.S. LCI Database modules covering Wood Product Manufacturing. Use of this module includes an assumption that forest management practice for piling logs is approximately the same as for lumber logs.

[2] Prior to peeler mill processing.

Copyright 2012
Treated Wood Council

The second stage of the CCA-treated marine piling life cycle includes peeling (removing bark and shaping pile) logs, drying, and treating the piles with CCA preservative. Each process uses either primary data from wood treatment surveys (including pile drying and treatment) or inputs and outputs developed by AquAeTer (including the manufacture of CCA preservative). Developed LCI data were prepared using published research and analogous process information specifically for this assessment, because LCI data for these processes were not publicly available.

The third stage of CCA-treated marine piling life is service life in a marine structure. The model includes the installation, use, and eventual removal of treated wood piles.

The fourth stage covers the final disposition options, including beneficial reuse as a treated wood secondary product or disposal in a landfill. A portion of all piles removed from service is assumed for each fate. Of the portion reused, a portion will decay in place and the remaining portion is assumed to be subsequently disposed in landfills.

After each of the four life cycle stages, inputs and outputs are totaled, so that the progressive increases of input resources and outputs can be tracked. This method allows the user easier access to the stages that result in significant changes. The LCI spreadsheets are included as Appendix 5.

4.2.2 Log Growth and Harvest Stage Prior to Wood Treatment (LC Stage 1)

The inventory of inputs and outputs associated with the production of logs sold to wood treaters for pile manufacture and preservative application is included in the "Piles LCI" ***tab*** in the columns under the yellow-highlighted heading ( ), "Softwood Log Production Prior to Treatment Stage."

It was decided to use existing LCI data for the untreated wooden pile production. For the pile production stage, the main source of forest products LCI data is Johnson et al. (Johnson, et al., 2004) and (Johnson, et al., 2005). The inventory data from the studies data are available through the U.S. Department of Energy National Renewable Energy Laboratory (NREL) U.S. LCI Database. The data cover the production of wood grown on Southeastern U.S. forest land with an average level of management intensity (i.e., fertilization and thinning) and delivered to the sawmills.

Figure 4-1 Map of U.S. Regions

Map Source: (Vlosky, 2009)

Copyright 2012
Treated Wood Council

This LCA focuses on wood produced and treated in the southern states (Figure 4-1) because CCA preservative primarily is used to treat southern pine[3]. In the western states, Douglas-fir is the primary species used for piles, but is refractory to CCA treatment. Thus, all of the treaters responding to the CCA-treated marine piling questionnaire are located in the southern states.

The Southeastern lumber database module, "Rough green lumber processing, at sawmill, US SE", was downloaded from the NREL U.S. LCI Database and appropriate portions copied into the "Avg Log" ***tab*** of the workbook. Because log volume is lost during peeling, appropriate log volume must be accounted for as green log prior to peeling. Based on data gathered from log peelers, 18.4 percent of the average log is lost during peeling. Thus, approximately 1,225 cubic feet (1.225 Mcf) of green unpeeled log is needed to yield 1,000 cubic feet (1.0 Mcf) of peeled log. Conversions were made in the "Avg Log" ***tab*** to account for the additional volume, and then linked to the "Piles LCI" ***tab*** in the column headed, "Whole log production (green, prior to peeling)." Processes including inputs and outputs related to forestry, log harvesting, and transportation are normalized to 1.0 Mcf of whole green log prior to peeling (1.225 Mcf of peeled product).

Total inputs and outputs for green pile production prior to treatment are calculated in the life cycle process, titled, "LCI Total-Untreated Green Pile Production." For each 1.225 Mcf of green unpeeled log, approximately 43 kWh of electricity and 2,600 ton-miles of truck transport are used. Emission outputs of approximately 1,700 pounds of CO_2 from fossil fuel result.

Because logs are measured when they are green, the LCA calculations have been modified to consistently use the green wood density (green mass/green volume). Where calculations refer to moisture content of wood, the reference is oven dry basis. Moisture content based on an oven dry basis is the weight of water contained in the wood divided by the oven dry weight of the wood.

4.2.3 CCA Production (LC Stage 2)

The inventory of inputs and outputs related to the production of CCA preservative sold to treaters for pressure treatment of piles is included in the "Piles LCI" ***tab*** in the columns under the green highlighted heading ( ), "CCA Production Stage."

Chromated Copper Arsenate, Type C (CCA-C) is a well-established wood preservative standardized by the AWPA in the Standard for Waterborne Preservatives P5-09 (American Wood Protection Association, 2010). CCA-C is the formulation currently in use in the U.S. Formulations A and B are no longer used in the U.S, and are not considered in this LCA. The formulation of CCA-C is described in the AWPA Standard P5-09 as shown below. CCA is prepared as a 60 percent (by weight) actives concentrated liquid that is delivered to treating plants by tanker truck. At the treating plants, CCA is diluted with water to concentrations appropriate for the treated wood product. CCA formulation includes production of the three main ingredients: chromium, copper, and arsenic, as well as mixing these into the product concentrate solution.

[3] Southern pine is a term used to describe a collection of several pine species (Panshin, et al., 1980), typically, longleaf pine (*Pinus palustris* Mill.), shortleaf pine (*P. echinata*. Mill.), loblolly pine (*P. taeda* L.) and slash pine (*P. elliottii* Engelm.).

Copyright 2012
Treated Wood Council

AWPA P5-09, Section 6, states the following regarding the composition of CCA-C:

> *6.1 The active ingredients in chromated copper arsenate shall have the following composition on a 100% oxide basis:*
>
> *Hexavalent chromium, as CrO3 .....47.5%*
> *Copper, as CuO 18.5%*
> *Arsenic, as As2O5.....34.0%*
>
> *6.3 The solid, paste, liquid concentrate or treating solution shall be made up of compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:*
>
> *Hexavalent chromium - e.g., potassium or sodium dichromate, chromium trioxide.*
>
> *Bivalent copper-e.g. copper sulfate, basic copper carbonate, cupric oxide or hydroxide.*
>
> *Pentavalent arsenic-e.g., arsenic pentoxide, arsenic acid, sodium arsenate or pyroarsenate.*

CCA-C is established under the Goal and Scope for this LCA as the reference treatment for marine piling. It is not intended that this LCA make a detailed inventory for the production of CCA-C preservative. Rather, the Goal and Scope document expected reasonable assumptions and analogous data to be used to develop approximate estimates of inputs and outputs for CCA-C production. LCI assumptions are included in Appendix 6. Because there are several primary U.S. formulators of CCA used by the treating industry, many different suppliers of ingredients to those formulators, and limited LCI data available from the formulators and component suppliers, assumptions were made to complete the input and output estimates. The data, assumptions, and calculations used to develop the inputs and outputs attributable to the mining and production of copper, chromium, and arsenic and the production of CCA-C are presented in detail within Appendix 4.

For this LCA, inputs and outputs for CCA production are assumed to be the weighted totals for the basic components of the formulation: chromium, copper, and arsenic. These are described in more detail below. Supporting calculations are made in the appropriate ***tab***s within the spreadsheet file. In the "CCA" ***tab*** of the spreadsheet, the relative weights of components are calculated for each pound of CCA used in wood treatment. CCA preservative typically is sold and accounted for on a 100 percent metal oxides basis. The solution concentrate typically is 60 percent metal oxides by weight. Thus, 1.67 pounds of concentrate is required to obtain 1.0 pound of metal oxides of CCA (1 / 0.6 = 1.67).

4.2.3.1 Copper

The production of copper, as needed for CCA production, is developed in the "Cu" ***tab***. Copper compounds, generally basic[4], copper carbonate or copper sulfate (Freeman, 2009), are purchased and used by formulators. The copper compounds can be either formed directly from mined ore that has been refined, or from recycled, scrap, or off-specification copper sources, such as wire,

[4] "basic" is the stable form of copper carbonate

Copyright 2012
Treated Wood Council

pipe, or sheeting manufacturers. This process does not involve melting or other high-energy input, so relatively little input energy is required.

In many instances, inputs and outputs required for recycling of post-use materials have not been considered in the inventory impacts. Although most copper used in CCA concentrate comes from recycled sources (Freeman, 2009), it would not be appropriate to account for it as if no inputs or outputs are associated with recycling and preparation for use. Confidential sources stated that copper used in the copper compound is either recycled "off-spec" copper products or reclaimed copper, such as used wiring, and not virgin; however, the amount of "off-spec" versus reclaimed was widely variable and a function of market demand. It was assumed that one-third of the total inputs and outputs of virgin copper product production (including mining, refining, transport, and production) provided a reasonable assumption of environmental impacts associated with copper used in the copper concentrate.

A study entitled "The Life Cycle of Copper, Its Co-Products and By-Products" was used for inputs and outputs for the mining and production of copper (Ayres, et al., 2002). The study includes inputs at the mining stage and provides findings per ton of copper concentrate. The study also reports the inputs and outputs required for production of copper from the concentrate into pure copper bricks. A second study, published by the European Copper Institute (Deutsches Kupferinstitut) provides an assessment of energy inputs and impacts applicable to the production of three copper products. Neither study was specific to copper sulfate or carbonate, but both were assumed to be applicable as energy input and assessment impacts. This is reasonable, since most of the inputs and outputs related to the production of copper, including mining, ore processing, and refining, are required for the copper compounds. For each of the three products (LCAs for copper roof sheeting, copper wire, and copper tubing), input energy consumption, and output emissions were converted to a common basis, such as pounds emission per pound of copper. The inputs and outputs are included within the "Cu" ***tab*** and entered into the "Piles LCI" ***tab***, "CuO Production" process.

4.2.3.2 Chromium

The production of chromium, as needed for CCA production, is developed in the "Cr" ***tab***. Production (Papp, 1994) includes mining of chromite ore, benefication of the ore, processing the concentrated ore with heat and soda ash to produce sodium dichromate, transport to the U.S., and processing the chromate to form either potassium or sodium dichromate or chromium trioxide. For the purposes of this LCI, the model assumes processing the chromate with sulfuric acid to form chromium trioxide. This LCI assumes all chromium is sourced from South Africa, the primary source of chromite ore (Papp, 2009). Mass balance calculations and yield rates are used to estimate the amount of chromite ore needed to manufacture dichromate and then chromium trioxide. Inputs and outputs of production are proportioned accordingly.

No LCI input or output data were identified for chromium production. Therefore, as analogous process for chromite mining and sodium dichromate production, LCI data for mining of bauxite and production of alumina from bauxite were downloaded from the NREL database and used.

Copyright 2012
Treated Wood Council

A detailed explanation of the data, assumptions, and calculations is provided within Appendix 4. The calculations are made within the "Cr" ***tab*** and entered into the "Piles LCI" ***tab***, CrO_3 production process.

4.2.3.3 Arsenic

The production of arsenic, as needed for CCA production, is developed in the "As" ***tab***. While copper and chromium are the primary products for which ore is mined and processed, arsenic is produced as a bi-product of refining waste flue dust from copper mining (Loebenstein, 1994) 1994). Arsenic is separated from dust by heating the dust to vaporize the arsenic and then condensing the purified arsenic. Heat energy (as electricity) is calculated using physical characteristics and assumptions. China is the primary producer of arsenic for use in the U.S. and transport inputs includes ocean shipping from China to the U.S.

The calculations are made within the "As" ***tab*** and entered into the "Piles LCI" ***tab***, As_2O_3 production process.

4.2.3.4 CCA Preservative Ingredient Proportions

Inputs and outputs for each of the three main ingredients of CCA are shown in the first three columns of the "CCA Production Stage" section. CCA component quantities are determined based on how much of each is used for each pound of CCA preservative that is delivered to a treating plant. In the right column of the section titled, "CCA Production Stage," the total inputs and outputs related to the production of each pound of CCA preservative are calculated. Electric energy and transport inputs for CCA production are totaled for CCA production and then proportioned by CCA use rather than proportioning them to CCA production.

4.2.4 CCA Piling Treatment Stage (LC Stage 2)

The inventory of inputs and outputs related to the treatment of piles with CCA preservative at wood treating plants is included on the "Piles LCI" ***tab*** in the columns under the light blue-highlighted heading ( ), "CCA Pile Treatment Stage." The treatment stage processes include drying piles by air exposure in stacks or drying with applied heat, pressure treatment with CCA preservative, storage of untreated and treated piles, and transportation of piles and preservatives to the treating facility.

4.2.4.1 Wood Piling

An average or "typical" wood pile for marine use is assumed to be 40-feet long with an average (mid-point) diameter of approximately 12-inches. Thus, the volume is calculated to be 29 cubic feet (cf) and 1.0 Mcf of wood piling equals 34.6 piles (American Wood Protection Association, 2010).

Logs for piles must first be peeled to remove the bark and produce relatively uniformly shaped (i.e., round) piles. Of the log with bark, 18.4 percent of the mass is assumed to be removed as biomass byproduct with 81.6 percent remaining as pile product. Based on "Rough Green Lumber Processing, at Sawmill, US SE" module (National Renewable Energy Laboratory), approximately 15 kWh of electricity is required to peel each pile or 516 kWh/Mcf.

Copyright 2012
Treated Wood Council

Biomass is produced in the treating stage as a result of peeling and end trimming piles received as logs with bark. Some of the produced biomass is used as fuel in boilers for steam to dry the piles prior to treatment. However, more biomass is produced than can be used. In the LCA, the excess amount is assumed to be sold as either biomass used for off-site energy recovery or for landscape material. The amount of natural gas that would produce the same energy output as the amount of excess biomass used for energy recovery is calculated in the "Trt" ***tab*** and then entered in the LCI as a natural gas credit in the "Pile Peeling and CCA Treatment" column of the "CCA Pile Treatment Stage." The credit (offset) is inventoried in the LCI as a negative use of natural gas and reduces the total amount of natural gas extraction and combustion attributed to the CCA-treated piling over the life cycle.

Green southern pine wood has an overall density of approximately 71.0 pounds per cubic foot (pcf) based on an estimated whole log average moisture content of 96 percent. The peeled piles must be dried prior to treatment. For adequate treatment, the outer two to three inches must be dried to approximately 20 percent moisture. The LCI assumes piles are dried to an overall, whole-log moisture content of 22.5 percent (oven dry basis) and accounts for the fuel requirement to perform the drying step.

The AWPA Standards specify CCA marine piling retentions for Use Category 5A (1.5 pcf outer 0.5-inch of the pile and 0.9 pcf for 0.5 to 2.0-inch of the pile) and 5B/5C (2.5 pcf outer 0.5-inch of the pile and 1.5 pcf for 0.5 to 2.0-inch of the pile) for southern pine piles (American Wood Protection Association, 2010). In addition, AWPA Standard T1-10 (American Wood Protection Association, 2010) requires CCA penetration to 3.5 inches or 90 percent of the sapwood[5]. Different retentions are required for other wood species within these Use Categories. The higher retentions are required for the more challenging environments.

4.2.4.2 Treater Survey

Life cycle inventory data related to piling treatment with CCA preservative are based on results of a questionnaire completed by representative treating plants. An example of the treater survey is included in Appendix 2. The questionnaire was prepared by AquAeTer, reviewed by TWC, and circulated to member plants by the TWC. Individual plants were identified by a number only, with TWC keeping the treater's identity confidential. Results with treating plants identified only by number were provided to AquAeTer for compilation and use in this LCA.

AquAeTer compiled the treater responses into a spreadsheet and then processed the results to determine average or representative values for inventory inputs and outputs normalized to 1.0 cf of treated wood. The actual survey results are included on the "PileSurv" ***tab***. Added rows, used to normalize data per 1.0 cubic foot (cf), are highlighted in green. In some instances, results from treaters required conversion from reported units to standard units used in the LCI. These conversions and the applied assumptions are included on the "PileSurv" ***tab***.

[5] Sapwood is defined as the wood of pale color near the outside of the log. Under most conditions, the sapwood is more susceptible to decay than heartwood. For contrast, heartwood is the wood extending from the pith to the sapwood, the cells of which no longer participate in the life processes of the tree. Heartwood can contain phenolic compounds, gums, resins, and other materials that usually make it darker and more decay resistant than sapwood. (USDA, 2010).

Copyright 2012
Treated Wood Council

The values then were used in the "Piles LCI" spreadsheet in the first column of the section labeled, "Pile Peeling and CCA Treatment." A complete description of the data manipulations and calculations performed on the treater survey results, "PileSurv" ***tab*** is provided within Appendix 4.

Fourteen (14) plants provided responses to the questionnaire. The Southern State treaters accounted for 100 percent of the surveyed CCA-treated marine piling volume.

The total volume of CCA-treated marine piling and sawn material by treater survey reporting plants in 2007 or 2008 is approximately 2,800 Mcf. Of this, approximately 400 Mcf (14 percent) was sawn wood treated for marine use and the rest was marine piling. The respondents reported total CCA treatment volume of 15,850 Mcf, water borne treatments other than CCA of 2,800 Mcf, oil borne treatments (creosote and pentachlorophenol) of 7,200 Mcf, and total treatment volume of 25,800 Mcf. Thus, for the survey respondent treaters, marine end use treatment accounted for 18 percent of CCA treatment and 11 percent of all treatment. Vlosky (Vlosky, 2009) estimated total water-borne treatment of marine piling in 2007 at approximately 20,300 Mcf, thus, approximately 14 percent of total U.S. water-borne treated piling production was covered by the survey responses.

Respondents of the treater survey reported approximately 19 percent of piles were purchased dry, 71 percent were kiln dried at the treating plant, and 10 percent were air dried at the treating plant. Half of the respondents reported using biomass for at least part of the plant heat energy needs. Approximately 61 percent of the biomass fuel used was generated on-site, such as from the peelers.

4.2.4.3 Inventory Inputs from Treater Surveys

Weighted averages are calculated for inputs and outputs for use in the inventory. The weighting basis includes total CCA treatment volume and total volume of all treatments. Values important to the calculation of inventory inputs and outputs then were entered into the "Piles LCI" ***tab*** in the column labeled "Pile Peeling and CCA Treatment." Based on the survey, significant inputs resulting from CCA treatment of 1.0 Mcf of marine piling are included in Table 4-1.

Table 4-1 CCA-Treated Marine Piling Treater Survey Results Summary

Question	Units	Minimum	Maximum	Average	Weighted Average	Sum of all data from survey respondents
Marine Products					of total	
Piles UC5A	cf	0	151,500	10,821	6.4%	151,500
Piles UC5B and 5C	cf	2,896	590,000	159,013	93.6%	2,226,179
Sawn Lumber UC5	cf	0	146,713	26,751	0	374,514
All other CCA treated product						
Distribution poles vol.	cf	25,326	1,915,510	639,125	0	7,030,372
Transmission poles vol.	cf	109,723	109,723	109,723	0	109,723
Lumber, Timber	cf	35,802	387,200	199,478	0	1,396,343
Total All CCA Marine Piling & Products	cf	2,896	694,000	196,585	17.4%	2,752,193
Total other CCA products	cf	303,309	2,266,113	935,623	0	13,098,725

Copyright 2012
Treated Wood Council

Question	Units	Minimum	Maximum	Average	Weighted Average	Sum of all data from survey respondents
Total all CCA products	cf	306,205	2,580,544	1,132,208	0	15,850,918
All oil-borne treatment	cf	0	5,616,398	512,281	0	7,171,932
All water borne treatment	cf	573,199	2,582,055	1,331,643	0	18,643,003
All treatment	cf	573,199	6,603,155	1,843,924	0	25,814,935
Drying						
Piles - Purchased dry	%	0%	100%	30%	19%	
Piles - Kiln Dried	%	60%	100%	89%	71%	
Piles - Air Dried	%	0%	100%	60%	10%	
Piles - Steam Dried	%	0%	0%	0%	0%	
Fixation Use	%	0%	100%	7.1%	5.6%	
Inputs						
Estimate CCA Concentrate Use	pounds	143,640	2,693,425	961,424	0	13,459,935
Water use in CCA solution	pcf	12	28	18	18	
Avg CCA Retention	pcf	0.28	1.3	0.55	0.55	
Diesel fuel rate	gal/cf	0.0059	0.11	0.037	0.038	
Gasoline use rate	gal/cf	0	0.0031	0.00046	0.0012	
Propane use rate	gal/cf	0	0.0021	0.00029	0.0014	
Process & heating energy usage during year						
Electric use rate	kWh/cf	0.14	2.4	1.0	1.0	
Natural gas use rate	Mcf/cf	0	0.030	0.0029	0.0019	
Propane process use rate	gal/cf	0	0.061	0.0048	0.0035	
Fuel Oil use rate	gal/cf	0	0.073	0.0052	0.0025	
Total wood biomass fuel used	tons	0	12,933	3,750	6,689	
Fraction wood biomass fuel used that is generated by onsite processes	%	20	100	75	61	
Total biomass fuel use rate	ton/cf-all treatments	0	0.0054	0.0017	0.0021	

Note: Additional details on the survey results and the methods for developing useful values for the LCI are provided in Appendix 4.

The calculations required to estimate inputs and outputs associated with treating marine pilings with CCA are made in the "Trt," "PileSurv," and "PileRel" ***tabs*** of the Piling LCI spreadsheet. Calculations and conversions of data obtained through the treater surveys are done within the "PileSurv" ***tab***, as discussed above. Supporting calculations are made in the "Trt" ***tab***. Where these calculations import (by reference) results from the "PileSurv" ***tab***, they are highlighted in green.

The volumes and weights of logs with bark, peeled piles, biomass from peeling, and dried piles are calculated. For each pile produced, approximately 460 pounds of biomass is produced. Weighted average transport miles for green logs, treated outbound piles, and CCA concentrate are used to calculate the ton-miles of transport by truck, rail, and ocean ships.

The average CCA preservative use rate, as reported in treater surveys (for all respondent use of CCA), was 0.55 pcf (gross retention). However, the highest CCA retentions are required for marine piling where other CCA treated products have lesser required retention. As previously stated, AWPA minimum retentions for southern pine marine piling are 1.5 pcf (outer) and 0.9 pcf

Copyright 2012
Treated Wood Council

(inner) for UC5A and 2.5 pcf (outer) and 1.5 pcf (inner) for UC5B and UC5C. The "outer" assay zone is from 0 to 0.5-inch deep and the "inner" zone is from 0.5 to 2.0-inch deep. Typical marine piling retention was calculated in the "Trt" ***tab***, using these minimum retentions plus 10 percent and assuming half the "inner" retention in the zone from 2.0 to 3.5-inch deep. Using these professional assumptions, results in a gross retention of 1.32 pcf. The retention level is used in the "Piles LCI" ***tab*** to calculate CCA use in marine piling.

According to the treater surveys, the average treating facility uses approximately 2.1 tons of biomass and 1,890 cubic feet of natural gas per Mcf of piling for process heat[6]. On an energy basis, the biomass provides approximately 91 percent of the heating energy. Peeler operations generate an estimated 8.0 tons of biomass per Mcf of piles. Based on survey of peelers, 9 percent of the excess biomass is assumed to be sold for energy recovery and the remainder sold for other uses, such as landscaping material. The portion sold for energy is assumed to offset natural gas use at other locations, such as kilns or boilers. The natural gas volume equivalent to the energy of the biomass is entered in the LCI as a credit, that is, as a negative value use of natural gas.

4.2.4.4 Inventory Outputs from Treater Surveys

For solid waste generation, the sum of each treater's hazardous, process, and other waste disposal amounts were divided by the total treatment volume for all preservatives at each treating facility. The waste generation rates for each facility were then used with the total plant production to determine a weighted average of waste generation. The weighted average waste generation was entered as an output of solid waste on the "Piles LCI" ***tab***.

None of the treaters reported discharge of waste water to municipal sewage plants. This is expected, since both the effluent limitations (regarding NPDES discharges of process water) and the pretreatment standards (regarding discharges to POTWs of process water) in 40 CFR 429, Subpart F - Wood Preserving – Water Borne or Nonpressure Subcategory, call for "no discharge of process wastewater pollutants.

Five of the 14 respondents reported CCA metals in storm water runoff, while two reported zero metals in storm water runoff and seven stated metals concentrations were unknown. Data from the five reporting facilities were evaluated to estimate releases of copper, chromium, and arsenic in storm runoff per Mcf of CCA product treated. These rates were used in the "Piles LCI" ***tab*** as representative of marine piling treatment. Estimated CCA metals release rates in storm runoff, per the treater survey results, are as follows:

Table 4-2 Treating Process Outputs

CCA Metals in Runoff	Release Rate (lb/Mcf)	Release from Avg Plant Treating 1,132 Mcf/yr (lb/yr)
Arsenic	0.0040	4.5
Chromium	0.015	18
Copper	0.0067	7.6

[6] Some facilities use biomass fuel and others use natural gas or a combination. Considering all treater responses, the "average" facility uses a percentage of both.

Copyright 2012
Treated Wood Council

In the "PileRel" tab, releases of CCA metals from treated product were calculated using data from published leaching studies. Releases due to storm runoff from stacks of treated piles are based on average precipitation of 32-inch per year (Hoffman, 1988), piling storage for three months, piles in stacks of 100, and CCA metals concentration per Lebow (Lebow, et al., 2008). The resulting estimate for copper runoff is 0.005 lb/Mcf. Application of runoff data from Brooks (Brooks, 1997) supported broadening the copper result to estimate chromium and arsenic runoff rates at 0.0012 and 0.00089 lb/Mcf, respectively. These calculation results are lower, but compare well to the runoff rates derived from the treater survey results. The higher survey results are used in the LCI.

4.2.4.5 CCA-Treating Proportions

CCA preservative use is proportioned to CCA marine piling treatment. Based on the theoretical calculation of CCA retention, 1.3 lbs of CCA is needed for each 1.0 cf of piling treated. The total inputs and outputs directly associated with treatment activity are totaled in the "CCA Pile Treating" column. Electricity use, fuels production, combustion, and transport are proportioned to wood treatment based on the amounts of each used for 1.0 Mcf of pile in the wood treatment stage. The inputs and outputs for treatment are summed to produce the total inputs and outputs for the treatment stage in the column headed "Treatment Stage Total." These are then added to the totals for logs prior to peeling and treating and summarized in the column headed "CCA Treated Piles."

4.2.5 CCA-Treated Piling in Marine Use - Service Life Stage (LC Stage 3)

The inventory of inputs and outputs related to the service life stage of CCA-treated marine piling is included on the "Piles LCI" ***tab*** in the columns under the blue-highlighted heading ( ), "CCA-Treated Piling - Marine Use Stage." Factors discussed below for piling service life are developed in the spreadsheet ***tabs***, "PileLife" and "PileRel." A detailed explanation of the data, assumptions, and calculations made in the ***tabs*** is provided within Appendix 4.

A standardized or "typical" marine pile application is assumed in the LCI of CCA-treated marine pilings where piles are installed in sediment and used to support a marine structure. Inputs and outputs associated with pile driving is considered similar for all pile products and thus not included.. The total pile length modeled is 40-feet. Any required hardware is assumed generally equivalent for all pile types and not further addressed. Maintenance of piles while in service is rare and is assumed not to occur.

The useful life of CCA-treated wood marine pile varies greatly. Service life is a function of quality and species of wood, quality and type of treatment, use intensity, and environmental factors such as water temperature, salinity, and native biota that can attack treated wood. Smith (Smith, S. T., 2006) summarized data from the U.S. Navy (1998) and concluded that average service life of marine piles, treated with CCA, is approximately 40 years. Based on the professional opinion of the authors, Navy research, and contact with industry sources, a 40 year average service life for CCA-treated marine piles is modeled in this LCI.

While in service, 5 percent of the wood piles mass is assumed to decay aerobically with the carbon fraction converted to carbon dioxide and released to the environment. CCA preservative

Copyright 2012
Treated Wood Council

is assumed to leach from piles into the marine water environment. The "PileRel" ***tab*** includes an estimate of likely releases from the typical pile's four distinct exposures: above water air and weather exposure, tidal wet and dry exposure between high and low tide elevations, submerged in sea water, and buried in sediment or soil. The portion of a pile in each exposure is assumed to be 15, 10, 25, and 50 percent, respectively.

Releases of CCA metals from piles submerged in sea water are estimated based on several referenced studies. Estimate number one uses algorithms developed by Brooks (Brooks, 2003). The data prepared by Brooks were based on studies of CCA-treated materials that were manufactured in accordance with the best management practices (BMPs) specified by the Western Wood Preservers Institute (2006). Estimate number two is based on leaching test performed on treated wood ground to a size less than 3 millimeters (Townsend, 2003). Estimate number three uses data from samples taken from CCA treated lumber following 14 years exposure in a New York canal (USEPA, 2008b). Estimate number four uses data reported by Brooks (Brooks, 1997), which incorporates results of a study done by Gjovik (Gjovik, et al., 1977), and uses the results of CCA-treated marine piling sampled for remaining copper over 1, 3, 5, and 8 years of exposure. Chromium releases are expected to be in the trivalent (Cr+3) rather than the hexavalent (Cr+6) form (Song, 2006). The findings of these studies were evaluated and a relationship established where releases are a percentage of initial retention and percentage of pile above sediment line and reported in pound per Mcf of installed CCA-treated wood pile. The above studies and resulting estimates are further explained within Appendix 4. The resulting releases to marine waters are provided in Table 4-3.

Inputs and outputs for the piling service life stage are subtotaled in the "Pile in Marine Use" column and the energy and transportation portions are calculated and added to the subtotal in the "LCI Total-Pile Use Stage" column. These are then added to the totals, through treatment, in the "Pile at Life End" column.

4.2.6 Piling End-of-Life Disposition Stage (LC Stage 4)

The inventory of inputs and outputs related to the post service life disposition stage of CCA-treated marine piling is included on the "Piles LCI" ***tab*** in the columns under the red-highlighted heading ( ), "CCA-Treated Piling Post-Use Stage." The data, assumptions, and calculations used to develop the inputs and outputs attributable to the post-use disposition are presented in detail within Appendix 4. The data are entered and calculations made in the "PileLife" and "Landfill" ***tabs*** and the applicable data entered by reference into the "Piles LCI" ***tab***.

At the end of useful life of the marine piles, it is assumed the piles are removed from service and disposed or reused. Disposal is modeled as if occurring in a solid waste landfill meeting current Subtitle D (non-hazardous) landfill requirements. Some removed piles can still be structurally sound and suitable for further service as treated wood, such as reuse as piling, marine fenders, or camel logs, as fence posts, or other application that extend the useful life of the treated wood product. Recycling piles removed from service for energy recovery in industrial boilers, cement kilns, or other biomass energy facilities with appropriate designs, controls, and permits is a valid option, but not one currently utilized.

Copyright 2012
Treated Wood Council

Disposition assumptions are made and applied in the "PileLife" ***tab***. The baseline assumptions include; 30 percent reused as treated wood in applications such as fence or landscaping, 70 percent disposed in landfills, and zero percent beneficially used as fuel for energy production. Of the reused portion, 50 percent ultimately aerobically decays in place, 50 percent is assumed disposed in landfills, and 0 percent is assumed beneficially used as fuel.

Current practice can result in a small fraction of CCA-treated piling being combusted for energy, such as when mixed with construction and demolition waste. That practice is thought to be rare. Thus, this LCA assumes that current practice is that no such material is combusted for energy. However, utilization of biomass for energy, rather than landfill disposal, offers the potential to reduce use of fossil fuel and to reduce GHG emissions. Recycling of CCA-treated wood for energy is feasible with properly-designed combustion and emission control systems. Evolving technologies, such as gasification with the produced synthetic gas used for other fuels or combusted for energy, offer means to recycle CCA-treated wood for energy while also achieving near complete control of metals. This option is further developed in this LCA in the sensitivity analysis section.

Disposition transport is assumed to be 100 percent by truck. Transport miles for each fate are assumed as 50 miles to a landfill and 50 miles to a facility for reuse. Truck ton-miles of transport are calculated using assumed distances and fractions to each fate.

The portion of marine piles having a secondary service life, such as fencing material or other marine uses, carry the environmental impacts associated with such secondary service and disposition separately. However, since its primary service life was as a marine pile, it is fair to assume that the marine pile should carry some portion of the secondary use burdens. AquAeTer judged that the secondary uses generally are low value applications in which the degree of treatment for piles is more than justified for the secondary use, such as landscaping. Allowing the secondary use to carry the full burden of the eventual disposal burdens seems to unfairly place too much on that use and lessen the appropriate burden of the primary (pile) product. Thus, for this LCA, the marine pile retains 25 percent of the secondary use disposal burdens (i.e. landfill construction, emissions, and transport).

Transport impacts are applied to piles used for energy recovery or disposed in landfills. Piles beneficially used for energy (in sensitivity analysis) are assumed to be combusted in large cogeneration or utility type boilers that include scrubbers or electrostatic precipitators and that can achieve approximately 60 percent thermal to electric energy conversion efficiency and all wood carbon is modeled as if released as biogenic carbon dioxide in the boiler exhaust.

The data, assumptions, and calculations used to develop the inputs and outputs attributable to the disposal of treated piles in landfills are presented in detail within Appendix 4. The data are entered and calculations made in the "Landfill" ***tab*** and the applicable data are entered by reference into the Piles LCI. The LCI assumes that CCA-treated marine piles are disposed in a variety of landfill types, including municipal landfills of wet (bioreactor) or dry types with and without methane collection, and construction and demolition (C&D) waste landfills. Assumptions about the fate in each type are made based on USEPA reports (USEPA, 2006) and (USEPA, 2008) and professional judgment.

Copyright 2012
Treated Wood Council

The energy and transport inputs to construct a municipal waste landfill (Menard, et al., 2003) are proportioned on a per-ton disposed basis to the pile volume placed into landfills. Emissions of methane and carbon dioxide resulting from decay of the carbon contained in the treated piles are estimated based on USEPA data. A portion of the methane is assumed to be collected. Methane capture efficiencies depend on the landfill type and are further explained in the landfill calculations included within Appendix 4. Of the captured methane, part is assumed to be used to generate electricity and the rest is assumed to be destroyed by flaring, so that all the recovered methane is converted to carbon dioxide. The landfill stage considered for this LCI is 100 years of product life in the landfill after disposal. This time frame was chosen to allow the primary phase of anaerobic degradation to take place (i.e., primary generation of methane is completed in the 100-year time frame).

Based on USEPA landfill data (USEPA, 2006), this LCI assumes that 77 percent of the carbon in CCA-treated wood placed in landfills is sequestered. This estimate uses data generated from the disposal of round tree limbs, the largest pieces tested. The wood preservatives contained in piles likely will significantly reduce the degradation of wood in landfills and increase the sequestration of carbon in landfills; however, no data from published sources were found to support such claims. Thus, the USEPA value of 77 percent sequestration was used.

The CCA metals not leached during product life are shown in the LCI as released to land in the landfill phase. Given the limited decay of wood and the long-term storage design for landfills, including landfill liners designed to contain leachate, this LCA assumes metals will remain in the landfill permanently.

The total inputs and outputs associated with CCA-treated marine piling disposition are shown in the "CCA Pile Post-Use Stage Total" column.

4.2.7 CCA-Treated Marine Piling Inventory Totals

The life cycle stages from cradle-to-grave are summed on the "Piles LCI" ***tab*** in the columns under the green-highlighted heading ( ), "CCA-Treated Marine Piles Cradle-to-Grave." The sum includes the stages: seedling production, planting and growth of trees, harvest of logs, peeling of logs to piles, drying, production of CCA preservative, pressure treatment of piles with CCA preservative, service life of CCA-treated marine piles, removal at the end of the service life, and disposition by reuse, combustion for energy, and disposal in landfills. Cradle-to-grave inputs and outputs have been summarized in Tables 4-4.

4.3 CONCRETE MARINE PILING INVENTORY

One of the goal and scope items of this LCA is the comparison of CCA-treated marine piles to alternate products. The alternate products chosen for comparison to CCA-treated wood piles are concrete, steel, and plastic marine piles.

A peer reviewed and published "cradle-to-grave" life cycle inventory for concrete marine piles was not identified; thus, AquAeTer developed an LCI of concrete marine piles. Published LCI data on cement, concrete, aggregate, and steel were used, but a survey of manufacturers was not done to gather inventory inputs and outputs for concrete pile production, so some inputs and outputs at the concrete pile manufacturing facility are not be fully accounted for. Information on

Copyright 2012
Treated Wood Council

cement, aggregate, and steel reinforcement necessary for the manufacture of concrete piles was downloaded from the NREL's U.S. LCI database. In particular, data from the NREL (National Renewable Energy Laboratory) were downloaded for cement production (SS_Portland_Cement_Production.xls), hot rolled sheet steel (SS_Hot rolled sheet, steel, at plant.xls), and limestone production (SS_Limestone, at mine.xls). Additional data were obtained and used as needed. Simplifications and assumptions were required to complete the inventories. Calculations and assumptions used for the concrete piles inventory are shown in the "Conc" ***tab***.

Assumptions were made and applied to the design of an "equal" concrete pile that would perform approximately the same function as the "typical" CCA-treated piling. Data from Concrete Technology Corporation supports an approximate weight of 158 pounds per cubic foot (Concrete Tecnology Corporation (CTC)) of steel reinforced concrete pile.

Inputs and outputs for the manufacture of concrete piles were modeled using NREL LCI database module information for cement, steel, and limestone (for aggregate). Calculation of concrete components and steel use are shown in the "Conc" ***tab***. Steel is assumed for four strands of 0.625-inch longitudinal reinforcement, a spiral of 0.125-inch diameter wire with 3-inch pitch, and 7-inch diameter. The equivalent pile is assumed to be 40-feet in length with a square cross section, rounded corners, 10-inches per side and a cross-sectional area approximately equal to a 12-inch diameter wood pile.

Concrete piles are precast, prestressed, and manufactured under controlled conditions. The concrete pile LCI includes applied heat of approximately 120°F during curing. The high strength concrete is estimated to include a design mix of approximately 24 percent cement, 8 percent water, 38 percent coarse aggregate, and 30 percent fine aggregate (by weight). The concrete piles are assumed installed by pile driver in the same manner as CCA-treated marine piles.

The average service life for concrete piles is modeled at 40 years, the same as for CCA-treated wood piles. Concrete is subject to chemical attack and the reinforcing steel can rust and expand, causing the surrounding concrete to spall. Also, cycling weather can cause cracks to grow, accelerating degradation. Structural and impact loads, such as from ships, further stress the piles. Additionally, changing needs at marine transportation centers results in piles removed while still sound as new or upgraded facilities are installed to replace the current ones. The actual service life of concrete marine piles is assumed to vary greatly.

Additional inputs related to the pile casting process are estimated for electricity and natural gas (to heat the concrete for accelerated curing), diesel, and water. Transportation of components to the casting plant is assumed to be by truck and assumed distances are provided in the "Conc" ***tab***. Transportation of concrete piles is assumed the same as used for CCA-treated piles. Disposition transport is assumed to be 90 percent by truck and 10 percent by rail. Modeled distances for each are shown in the tab and total transport by each mode is calculated for the average concrete pile.

Concrete includes chromium and lead at concentrations of approximately 34 parts per million (ppm) and 42 ppm, respectively (Limbachiya M, 2006) and Portland cement contains approximately 3.8 ppm of cadmium (Sugiyama T, 2007). Crushed concrete samples, leached with sea water, reportedly lose approximately 50 percent of the chromium contained in the

Copyright 2012
Treated Wood Council

concrete, 40 percent of the cadmium, and none of the lead (Webster, 1996). Loss of metals from concrete piles while in service is expected to be much less. A concrete release model, based on Webster's findings, calculates leaching from the outer 10 percent (approximate 0.5-inch) of the concrete pilings. An estimate of constituents of concern leaching from concrete piles to marine waters is included in Table 4-3.

At the end of their service lives, concrete piles are removed for disposition. This concrete pile LCI model assumes 80 percent are disposed in landfills and the remaining 20 percent are recycled to aggregate by crushing with the contained steel also being recycled. Piles recycled to aggregate are expected to be a lower grade material than newly mined aggregate, and are modeled to offset new aggregate, but at a lessened rate to new aggregate. The impacts of this credit are investigated in the sensitivity analysis.

Concrete piles disposed in landfills have inputs and outputs associated with landfill construction and closure proportional to the mass of disposed piles. No emissions or releases are assumed to result from concrete piles once disposed in a landfill.

In a manner similar to the life cycle of CCA-treated piles, concrete marine pile manufacture, service life, and disposal is tracked on the "Piles LCI" ***tab*** of the spreadsheet. LCI totals were summed at the end of service life stage and at the cradle-to-grave life cycle stage. These totals are used for comparison to life cycle stages of CCA-treated marine piles.

The life cycle inventory values for concrete piles are shown in Table 4-4. The sum includes the extraction of raw materials, cement production, concrete pile manufacture, use as marine piles, removal at the end of the useful life, and final disposition. The inventory totals are shown per pile.

Additional information on the calculation of concrete pile inputs and outputs is included within Appendix 4.

4.4 GALVANIZED STEEL MARINE PILING INVENTORY

As with concrete piles, a peer reviewed and published "cradle to grave" life cycle inventory of concrete-filled galvanized steel marine pile inputs and outputs was not identified, so a comparable LCI was developed. Published LCI data on steel production were used, but a survey of manufacturers was not made to inventory inputs and outputs for steel pile production, so some inputs and outputs at the steel pile manufacturing facility are not be fully accounted for. Information on hot rolled sheet steel, cement production, and limestone was downloaded from the NREL's U.S. LCI database. Cement and limestone are assumed used in a fraction of steel piles (professional assumption assumed applicable to 10 percent of steel piles). Additional data were obtained and used as needed. Simplifications and assumptions were required to complete the inventories.

Calculations and assumptions used for the concrete-filled steel piles inventory are shown in the "SteelPile" ***tab***. Assumptions were made and applied to the design of an "equal" steel pile capable of performing the same function as the "typical" CCA-treated piling.

Copyright 2012
Treated Wood Council

Steel piles typically are constructed of standard schedule steel pipe. Steel marine piles are generally not tapered and are approximately the same dimensions as wood piles of similar class and length. The steel piles are hollow with a bottom drive tip to increase bearing capacity and prevent filling the pile with soil while being driven. The steel piles are hot-dip galvanized to limit corrosion. Instead of galvanizing, some steel piles are finished with a tar substance applied to limit corrosion. This LCI only considers hot-dip galvanizing of steel piles. Steel piles can remain hollow or can be filled with concrete after being driven. Concrete fill increases pile strength and can minimize internal corrosion.

The weight for a schedule 30 steel pipe at 12 inch diameter and 40 feet long is modeled as 1,753 pounds. A bottom driving cap of 100 lbs also is assumed. Thus, the calculated weight of steel used per pile is 1,853 pounds per pile.

According to ASTM A653 G235, 2.54 ounces of zinc is needed to galvanize 1 square foot of steel on both sides (GalvInfo, 2010). This level of coating is needed to provide sufficient protection for a 40 year life, as shown in calculations within Appendix 4. Based on this zinc application rate, approximately 20 pounds of zinc is needed per marine pile.

Inputs and outputs for the production of steel are based on the NREL LCI for hot rolled sheet steel (SS_Galvanized_Sheet_Production.xls) and are applied to steel piles based on the pounds of steel used per pile. We note that LCI data are not available for zinc galvanizing and have not included inputs and outputs for the production of zinc needed to galvanize piles.

Inputs for hot dip galvanizing of the fabricated piles are estimated to include 100 gallons of water per pile, used for caustic and acid rinses before galvanizing and for quenching after galvanizing. According to California Steel Industries website (California Steel Industries (CSI)), the process of galvanizing steel requires the steel be heated to between 1,300 $^{\circ}$F and 1,500 $^{\circ}$F as a heat treatment prior to galvanizing, and galvanizing liquid must be kept at around 850 $^{\circ}$F during the galvanizing process. Energy requirements to heat the steel and the galvanizing solution were calculated.

Transportation of steel piles includes steel transport to a manufacturing plant, pile transport to a marine storage yard, then transport to the installation site. Steel source is unknown, but likely includes a mix of domestic and international sources. A model of sources is applied in this calculation. It is assumed that transport of piles from the manufacturer to the marine yard and to the installation site is by truck. Because steel pile manufacturing yards are less frequent than CCA-treating facilities, the distance is assumed at least as great as the data received as part of our survey of CCA treaters; thus, the CCA-treated pile distribution distances were used. Disposition transport to recycle sites was assumed by truck and distances are based on professional judgments.

The estimated average life of steel piles is assumed to be the same as for wood and steel piles at 40 years. Based on corrosion rates documented by the Galvanizing Association of Australia (Galvanizers Association of Australia (GAA), 2010), marine exposure will result in over 2/3 of the galvanizing used in our model (assuming ASTM A653 G235) to be lost in the 40 year time period. The service life of galvanizing lasts until approximately 1/3 of the zinc remains (Galvanizers Association of Australia (GAA), 2010). Zinc lost from piles is shown in the LCI as

Copyright 2012
Treated Wood Council

released to the marine environment. An estimate of constituents of concern leaching from galvanized steel piles to marine waters is included in Table 4-3. Pile spacing is assumed to be the same as for alternative materials, since all are designed to meet the same standards.

At the end of the steel pile's service life, nearly all piles are assumed to be recycled as scrap steel. Even with 100 percent recycling of steel, the recycling does not fully offset the original manufacture. Resources to produce steel from raw materials are offset by recycled steel, since each pound recycled means approximately one pound not needed from raw material. However, resources used to make products from steel billet, such as to melt, roll, shape, galvanize, and transport the products, must be reinvested in each life cycle of a steel product, thus cannot be offset by recycling.

New manufacture of steel products includes primary steel production from raw materials, including allocations for iron ore, coal, and other energy sources, iron making by blast furnace or direct reduction, and steel making by open hearth furnace, basic oxygen furnace, or electric arc furnace. Total energy input to a U.S. integrated steel mill is approximately 25 million BTU per metric ton (Fenton, 2005). Scrap steel can be converted to new steel product in mini-mills, utilizing electric arc furnaces and other steel forming equipment, with input electric energy of approximately 10 million BTU per metric ton (Fenton, 2005). Thus, offsets for recycling used steel product should be allowed for the resources used in making steel from raw materials minus the resources needed to process pure recycled steel.

Thus, this LCA uses two functions to account for steel recycling:

1. Offset of steel manufacture based on the NREL steel flows and adjusted for assumed average U.S. used steel pile recycle rate of 100 percent for post-use steel and a recycling to steel yield of 95.24 pounds for each 100 pounds recycled (International Iron and Steel Institute (IISI), 2006). This results in an effective offset of 95.24 percent.

2. Restore part of the above offset by electricity from grid for the equivalent electric energy that would be used at an electric hearth furnace mini-mill at 10 million BTU/metric ton, which equates to 1.33 kWh/pound.

As stated previously, all steel piles are assumed to be recycled, so no landfill apportionment is made for steel piles in the LCA.

In a manner similar to the life cycle of other piles, steel marine pile manufacture, service life, and disposition is tracked on the "Piles LCI" ***tab*** of the spreadsheet. LCI totals were summed at the end of the service life stage and after disposition. These totals are used for comparison to life cycle stages of CCA-treated marine piles.

The life cycle inventory values for steel piles are shown in Table 4-4. The sum includes the extraction of raw materials, steel production, steel pile fabrication and galvanizing, service life as marine piles, removal at the end of the useful life, with final disposition to recycling. The inventory totals are shown per pile.

Copyright 2012
Treated Wood Council

Additional information on the calculation of steel pile inputs and outputs is included within Appendix 4.

4.5 PLASTIC MARINE PILING INVENTORY

A life cycle inventory of plastic piling was not identified, so applicable life cycle input and output data were obtained from various sources and used to complete a comparable LCI. In particular, data from the NREL Life Cycle Database were downloaded for HDPE, ethylene, and hot rolled sheet steel production (surrogate used for steel cable). An LCI modeling recycled plastic (Arena, et al., 2003) also was used to develop inputs and outputs necessary for collection and processing of post-consumer plastic.

Plastic marine piles offer another alternative material to treated wood piles. Plastic piles do not represent a clearly defined standard design or mix of materials. Plastic piles can be made of recycled plastics, generally polyethylene, but often include other materials such as steel fiber, steel reinforcing bar, used tires, mineral filler, virgin plastic, or concrete. Assumptions were made and applied to the design of an "equal" plastic pile that would perform approximately the same function as the "typical" CCA-treated piling. In Appendix 6, life cycle inventory assumptions, defining a "standard" plastic pile, are presented. The assumptions are used in calculations included within Appendix 4 and in the "PlasticPiles" ***tab*** of the spreadsheet defining the inputs and outputs associated with the manufacture and service life of plastic piles.

The general category of plastic piles covers an evolving variety of products. The plastic content can vary from as little as approximately 30 percent by weight to as much as 100 percent, and can be derived entirely from post-consumer use recycled material to entirely virgin plastic (Platt, 2005). Plastic can be partially or entirely high-density or low-density polyethylene, polyvinyl chloride, or other types. Fiberglass reinforcement can be included (Platt, 2005). Thus, it was necessary to make assumptions, as noted above and in the "PlasticPiles" tab, to represent the "typical" product. Plastic is not rigid enough by itself, so the steel reinforcement, similar to what is used for concrete, is assumed. For this LCI, the composition of a "standard" plastic pile is assumed to be 47.5 percent recycled plastic (a mixture of post-consumer recycled milk bottles, grocery bags, and tires), 0 percent virgin HDPE plastic, 10 percent talc (mineral filler), and 42.5 percent steel (by weight). Inputs and outputs for the manufacture of plastic piles use NREL LCI database information for limestone (analogous process assumed for mineral filler), HDPE, and steel. Calculation of plastic components and steel use is shown in the "Plastic Piles" ***tab***. Steel is assumed to be four bars of 1.375-inch longitudinal reinforcement. The equivalent pile is assumed to be 40-feet in length with a square cross section, rounded corners, 10-inches per side and an area approximately equal to a 12-inch diameter wood pile.

Recycled plastic does not carry the inputs and outputs of virgin material, but use of these plastics does require significant energy to collect and process. Processes required for plastic recycling include collection, compaction, sorting, reprocessing, and disposal of reject material. The reprocessing can include prewashing, sorting, grinding, washing, flotation, drying, fine screening, and storage (Arena, et al., 2003). Electric, diesel, and gas energy inputs were estimated to be approximately 8 MJ/kg (3,400 BTU/lb) for recycled polyethylene terephthalate (PET) and 8,900 BTU/lb (21 MJ/kg) for recycled polyethylene (PE). These compare to approximately 21,000 BTU/lb (49 MJ/kg) for energy input to the manufacture of virgin high

Copyright 2012
Treated Wood Council

density polyethylene (HDPE). This LCA uses the lower (PET) value for recycled plastic, which is approximately 16 percent of the energy input to virgin HDPE. This value compares well to the results of a separate LCA on thermoplastics recycling (Garrain, et al., 2007).

Inputs and outputs related to the production of HDPE were downloaded from the NREL LCI database for HDPE (SS_Ethylene production.xls and SS_High density polyethylene resin, at plant.xls and (Franklin Associates, 2007)) and proportioned according to mass. Additional electric energy is assumed necessary to process the mixture and extrude the product. These and other assumptions are used in the "PlasticPiles" ***tab*** of the spreadsheet to create the data needed for the LCI.

The physical and mechanical properties of plastic piles are similar to those for treated wood piles, thus the spacing of both is assumed to be the same. The plastic piles are assumed installed by pile driver in the same manner as CCA-treated marine piles.

No data were identified documenting the service lives of plastic marine piles. The designs of the plastic piles, now in service in marine environments, have not yet developed enough history to accurately predict service life. Plastic does degrade slowly over time due to the marine environment. Changing needs at marine transportation related and other facilities means that piles can be removed while still sound, as new or upgraded facilities are installed to replace the current ones. The actual service life of plastic marine piles is expected to vary greatly. Thus, the average service life of plastic marine piles is modeled at 40 years, the same as for CCA-treated piles.

Releases from installed plastic piles to marine water is complex due to the unknown mix of plastics used to make plastic composite piles and the wide variety of additives used to formulate the plastic products. The USEPA (USEPA, 1992) lists additives potentially in plastics including antimicrobials such as oxybisphenoxarsine and isothiazalone, blowing agents such as azobisformamide, chlorofluorocarbons, and pentane, flame retardants including aluminum trihydrate, antimony oxide, halogenated hydrocarbons, and organophosphates, and plasticizers including phthalates, aliphatic di- and tri-esters, polyesters, phosphates, and trimellitates. Plastic pellets, and by implication fragments of plastic from piles, accumulate in the marine environment and can be consumed by fish, waterfowl, and other species (Rios, et al., 2010). The plastic pellets not only carry their own chemical load, but accumulate chemicals such as PCBs and DDE (a chemical similar to DDT), "serving as both a transport medium and a potential source of toxic chemicals in the marine environment" (Mato, et al., 2001). The manufacture of primary plastic products, the collection, processing, and transport of recycled plastic in pellet form, and abrasion of plastic piles while in use contribute to plastic in the marine environment. Although releases and impacts to marine environments are known to exist from plastic use, no appropriate quantifiable release or impact data were identified for inclusion in this LCA.

The plastic pile market is not yet sufficiently mature to know how piles will be handled when removed from service. In theory, the plastic could be recycled again to make more piles or other products. However, the presence of steel, mineral filler, and other materials incorporated into the piles could make such recycling problematic, by current technologies. Professional opinion is that following removal from the marine environment service, 20 percent will be recycled to the

Copyright 2012
Treated Wood Council

plastic reuse markets and 80 percent will be disposed in landfills. For piles to be recycled, it is assumed they must be ground or shredded into flake material, which requires electricity.

The decay of plastic piles disposed in landfills is unknown, so assumptions are required. Polyethylene is known to be highly resistant to biological decay. In fact, modern landfills are lined with HDPE. However, even the HDPE does not last forever and is known to break down over time. In this LCI, it is assumed that the fraction of carbon in plastic piles that decays into carbon dioxide and methane is five percent over the primary phase of anaerobic degradation in the landfill (less than 100 years). Thus, it is assumed that 95 percent of the carbon is sequestered and that carbon dioxide and methane contain 3.7 percent and 1.3 percent of the carbon, respectively. These assumptions are used in the "Plastic LF" ***tab*** to estimate average inputs, outputs, and fate of plastic piles in landfills.

The life cycle inventory values for plastic are summarized in Tables 4-4. The sum includes the extraction of raw materials, refining, recycled plastic impacts, plastic pile manufacture, service life as marine piles, removal at the end of the useful life, and final disposition. The inventory totals are shown per pile (Table 4-4).

Additional information on the calculation of plastic pile inputs and outputs is included within Appendix 4.

Copyright 2012
Treated Wood Council

Table 4-3 Estimated Constituent of Concern Service Life Releases to Marine Waters

Constituent of concern release	CCA-treated marine pile	Concrete marine pile	Galvanized steel marine pile	Plastic marine pile
	(lb/pile/yr)	(lb/pile/yr)	(lb/pile/yr)	(lb/pile/yr)
Copper	0.021			
Chromium	0.00012	0.000087		
Arsenic	0.0042			
Zinc			0.17	
Cadmium		0.000047		
Organic constituents				Not quantified

Copyright 2012
Treated Wood Council

Table 4-4 CCA-Treated, Concrete, Steel, and Plastic Marine Piling Life Cycle Inventory Summary (Cradle-to-Grave per Mcf and per pile)

Infrastructure Process	Units	CCA-Treated Marine Pile (/Mcf)	CCA-Treated Marine Pile (/pile)	Concrete Marine Pile (/pile)	Steel Marine Pile (/pile)	Plastic Marine Pile (/pile)
Inputs from technosphere						
Electricity- Avg. US Grid	kWh	14,799	428	701	2375	599
Natural gas, processed, at plant (feedstock)	ft3	29,299	847	1452	4302	1079
Natural gas, combusted in boiler	ft3	1,704	49	103	650	1665
Diesel fuel, at plant (feedstock)	gal	0	0	0	0	0
Diesel fuel, combusted in boiler	gal	16	0.47	0.60	1.5	0.39
LPG, combusted in equipment	gal	4.9	0.14	0	0	0
Residual Oil, processed (feedstock)	gal	0	0	0	0	0
Residual Oil combusted in boiler	gal	9.8	0.28	0.082	0.17	0.050
Diesel fuel, combusted in equipment	gal	68	2.0	1.5	0.048	0.050
Gasoline, combusted in equipment	gal	4.6	0.13	0.075	0.16	0.048
Hog fuel/Biomass (50%MC)	lb	5,593	162	19	65	16
Coal-Bituminous & Sub. comb in boiler	lb	9.5	0.27	0.39	0.68	0.17
Energy (Unspecified)	Btu	55,037	1,591	145,427	16,695	0
Truck transport	ton-miles	12,037	348	826	703	485
Rail transport	ton-miles	5,138	148	198	690	475
Barge transport	ton-miles	336	10	16	53	13
Ship transport	ton-miles	21,033	608	33	996	16
Diesel Use for Transportation	gal	139	4.0	9.2	9.1	6.3
Residual Oil Use for Transportation	gal	41	1.19	0.12	1.8	0.038
Harvested sawlogs	ft3	1,225	35	0	0	0
Treated piles	ft3	-38	-1.1	0	0	0
Zinc	lb	0	0	0	20	0
Steel	lb	0	0	0	1,853	808
Landfill Capacity	ton	22	0.62	1.6	0	0.76
Inputs from nature						
Water	gal	8,176	236	267	167	556
Bark from harvest	ft3	110	3.2	0	0	0
Unprocessed coal	lb	8,285	239	659	1,418	851
Unprocessed U3O8	lb	0	0	0	0	0
Unprocessed crude oil	gal	97	2.8	13	11	47
Unprocessed natural gas	ft3	-922	-27	352	490	2717
Biomass/Wood energy	Btu	0	0	0.021	0.012	0.097
Hydropower	Btu	3,885,069	112,278	195,629	632,528	209,026
Other Renewable Energy	Btu	289,165	8,357	13,736	46,584	11,711
Biogenic Carbon (from air)	lb	18,167	525	0	0	0
Other mined mineral resources	lb	0	0	3,764	309	1,005
Outputs to nature						
CO2-Fossil	lb	30,796	890	2,599	4,356	3,106
CO2-Non-fossil	lb	-51,958	-1502	20	69	18
Carbon monoxide	lb	42	1.2	5.6	4.2	18
Ammonia	lb	0.11	0.0033	0.0063	0.0050	0.0021
Hydrochloric acid	lb	5.5	0.16	0.30	0.81	0.22
Hydrofluoric acid	lb	0.62	0.018	0.030	0.10	0.027
Nitrogen oxides (NOx)	lb	75	2.2	4.9	5.0	3.9
Nitrous Oxide (N_2O)	lb	0.66	0.019	0.0057	0.0067	0.0039
Nitric oxide (NO)	lb	0.30	0.0088	0	0	0
Sulfur Dioxide	lb	162	4.7	9.6	26	9.7
Sulfur Oxides	lb	10	0.30	0.85	0.924	3.1
Particulates (PM10)	lb	55	1.6	0.50	0.31	0.15
VOC	lb	4.8	0.14	0.24	0.42	0.35
Methane	lb	919	27	3.3	8.7	31
Acrolein	lb	0.095	0.0027	0.000058	0.00019	0.000052
Arsenic	lb	0.0024	0.000068	0.000087	0.00028	0.000082
Cadmium	lb	0.00039	0.000011	0.000014	0.000043	0.000016
Lead	lb	0.0031	0.000089	0.000091	0.00030	0.000085
Mercury	lb	0.00048	0.000014	0.000079	0.000066	0.000021
Arsenic to water	lb	5.9	0.17	0	0	0
Chromium to water	lb	0.18	0.0052	0.0035	0	0
Copper to water	lb	29	0.85	0	0	0
Zinc to water	lb	0	0	0.0095	6.7	0.044
Cadmium to water	lb	0	0	0.0019	0	0
Solid Wastes	lb	46,287	1,338	87	149	80
Process Solid & Hazardous Waste	lb	22	0.64	0	0	0

Notes: Table is generated in a spreadsheet program that includes limitations in display of significant figures. Values should only be considered relevant to two significant figures.
Releases to water include fresh and/or marine releases.

Copyright 2012
Treated Wood Council

5. IMPACT ASSESSMENT

5.1 GENERAL

The LCA impact assessment (LCIA) phase establishes links between the production, service life, and disposal of CCA-treated marine piling and potential environmental impacts. The impact assessment calculates impact indicators, such as greenhouse gas emissions and fossil fuel use. These impact indicators provide general, but quantifiable, indications of potential environmental impacts.

The LCIA was intended to be consistent with the goal and scope of the LCA. The quality of the LCI data, system boundaries and data cut-off decisions were sufficient to calculate the indicators. Also, the LCI functional unit, averaging, aggregation, and allocations were reviewed and found to be acceptable for conducting the impact assessment.

Steps of the LCIA for CCA-treated marine piling include:

1. Selection of Impact Categories - identifying relevant environmental impact categories;
2. Definition of Impact Categories – defining the characterization model;
3. Classification - assigning life cycle inventory results to the impact categories;
4. Characterization - modeling life cycle inventory impacts within impact categories using science-based conversion factors;
5. Normalization - expressing potential impacts in ways that can be compared to alternative products; and
6. Evaluating and Reporting Life Cycle Assessment Results - gaining a better understanding of the reliability of the assessment results.

The results of this impact assessment were used in comparison of alternative products on the market in competition with CCA-treated marine piles, including concrete, concrete-filled steel, and plastic piles. Weighting was not included in this impact assessment per the requirements of ISO 14044, Section 4.4.5, because weighting steps are value-choices and are not scientifically based.

5.2 IMPACT INDICATORS

The impact assessment uses the results of the inventory analysis by applying those results to general impact indicator categories. Impact indicator values were calculated in the LCI spreadsheet for each process unit in the products' life cycle stage and summed for each stage of the life cycle. This facilitates comparison of indicators between stages and helps quantify the relative contributions to each indicator, for example, particular manufacturing steps, use practices, or disposal options.

Copyright 2012
Treated Wood Council

The results of the LCI are used to quantify relative environmental impacts for comparative purposes using impact indicators. The target impact indicator, the impact category, and means of characterizing the impacts are summarized in Table 5-1.

For each impact category, impacts occur through a complex series of interactions. For example, contributions to global warming are thought to result from increasing levels of carbon dioxide and other chemicals that tend to trap energy within the earth's biosphere. However, the chemical reactions, positive and negative feedback loops, normal earth and solar variability, and other factors make reaching precise conclusions impossible. While GHG emissions associated with the production and use of a product can be calculated, the endpoint impacts, such as increased sea level or changes in agricultural productivity, remain unknown. Thus, for this LCIA, category impacts will be characterized by accepted mid-point indicators, such as tons of carbon dioxide equivalents emitted per unit of product. Such impact indicators are useful when comparing the relative potential impacts of one product to those of another.

Table 5-1 Impact Indicators, Characterization Models, and Impact Categories

Impact Indicator	Characterization Model	Impact Category
Greenhouse gas (GHG) emissions	Calculate total equivalent anthropogenic CO_2 emissions for CO_2, methane, and nitrous oxide per functional unit.	Global warming
Fossil fuel usage	Total amount of fossil fuel, based on BTU value, used in product life cycle per functional unit.	Resource depletion
Releases to air potentially resulting in acid rain (acidification)	Calculate total hydrogen ion (H+) equivalent for released sulfur oxides, nitrogen oxides, hydrochloric acid, and ammonia using factors from TRACI (Bare, et al., 2003). Acidification value is in units of H+ mole-eq. per functional unit.	Acidification
Releases with potential ecological toxicity	Use the impact factors from TRACI (Bare, et al., 2003) to calculate the ecotoxicity potential of air releases in units of lbs of 2,4-D-eq per functional unit.	Ecotoxicity
Releases to air potentially resulting in smog	Use the impact factors from TRACI (Bare, et al., 2003) to calculate the smog forming potential of releases in units of g of $NOx/m^{3/}m^2$ per functional unit.	Photochemical smog
Releases to air potentially resulting in eutrophication of water bodies	Use the impact factors from TRACI (Bare, et al., 2003) to calculate the eutrophication potential of releases in units of lb of N-eq. per functional unit.	Eutrophication
Amount of water used or consumed	Calculate total water use per functional unit.	Water use

Each impact indicator is a measure of an aspect of potential impact. This LCIA does not make value judgments about the impact indicators, meaning that no single indicator is given more or less value than any of the others. All are presented as equals. Additionally, each impact indicator value is stated in units that are not comparable to others. For example, millions of BTUs of energy cannot be compared to pounds of carbon dioxide equivalents or hydrogen ion mole equivalents. For the same reasons, indicators should not be combined or added.

For a corporate decision maker considering which product to purchase and use, the impact indicators should be viewed as a few of the many attributes of the products that need to be considered. Other attributes that also can be important include purchase price, ease of installation, proven performance, and aesthetics.

Copyright 2012
Treated Wood Council

Neither the TRACI model, a product of USEPA, nor the USEtox model (USEtox, 2008), a product of the Life Cycle Initiative (a joint program of the United Nations Environmental Program (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC)), provide an impact indicator for assessment of such releases. In this LCA, releases of constituents from marine piling to marine waters are estimated, but potential impacts of the releases are not assessed or compared.

5.3 IMPACT INDICATOR DEFINITION AND CLASSIFICATION

5.3.1 Greenhouse Gas (GHG) Emissions

Emissions of GHGs - carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) - are calculated for each unit process and multiplied by their global warming potential equivalence factors of 1, 21, and 296, respectively, to calculate pounds CO_2-equivalent emissions per Mcf and per functional unit of product (i.e., per marine pile per year of service). AquAeTer notes that there are many additional chemicals that have significantly larger factors, such as the hydro fluorocarbon HFC-123a with a factor of 1,300. However, these chemicals are either not associated with, or not reported in, inventories for the processes in the production of preservative-treated piles or alternate products, and therefore are not included in the inventory and are not a part of the impact assessment.

The intent of the GHG impact indicator is to quantify human-caused (anthropogenic) emissions that reportedly have the potential to affect the global climate. Although carbon dioxide molecules behave the same, whether from fossil fuels or biomass, they are addressed differently in calculating the GHG emissions. Carbon dioxide resulting from burning or decay of wood (biomass or biogenic material) grown on a sustainable basis is considered to mimic the closed loop of the natural carbon cycle (USEPA, 2009) and therefore is not included in the calculation of greenhouse gases. However, methane that results from the decay of wood or other carbon-based waste in landfills is included in the calculation of GHG. This methane is produced because disposal in engineered landfills results in anaerobic decay that would not be produced by natural combustion or surface (aerobic) decay.

Consideration limited to anthropogenic GHG emissions only tells part of the story for biogenic materials, such as wood and fails to recognize the removal of carbon dioxide during growth. Net GHG emissions include the full variety of carbon dioxide equivalent inputs and outputs that occur throughout the wood product's life cycle. These include removal during growth and releases related to biomass combustion, rotting wood or biomass (mulch or fence posts), and landfill decay as well as offset emissions realized when the biomass is substituted for fossil fuel to produce energy. Thus, when the life cycle includes fossil fuel offsets and/or sequestered carbon in products or landfills, the net emissions can be negative, meaning more carbon dioxide was removed than emitted. The results for net GHG emissions for the alternative piling products, which are not biogenic, are approximately the same as for the anthropogenic GHG emissions indicator. Along with the results of net GHG in this section, Section 6.1.4 provides a detailed discussion regarding the net carbon balance over the pile's cradle-to-grave life cycle.

Copyright 2012
Treated Wood Council

5.3.2 Fossil Fuel Usage

The chosen impact indicator for resource depletion is fossil fuel used to make, use, maintain, and dispose of products. Fossil fuel use currently is an issue related to global climate change, national security, and national and personal finances. The impact indicator unit of measure chosen is total million BTU (MMBTU) of fossil fuel used per functional unit.

5.3.3 Releases to Air Potentially Resulting in Acid Rain (Acidification)

The acidification impact indicator assesses the potential of emissions to air to result in acid rain deposition on the earth's surface. TRACI factors that relate the relative potential of released chemicals to form acids in the atmosphere (Bare, et al., 2003) are multiplied by the chemical release amounts to calculate equivalent acid rain potential as hydrogen ion (H^+) mole equivalents.

5.3.4 Water Use

The total amount of water used in each unit process of the product life is calculated in gallons per unit. Because water use data are not available for all supporting process units, specifically for electricity production, results for this impact category can be of limited value.

5.3.5 Releases to Air Potentially Resulting in Ecological Toxicity

Air emissions ecotoxicity is based on cumulative emissions to the air throughout all life cycle stages. TRACI offers a measure of ecological toxicity for air releases that includes ecologically toxic impact indicators that are normalized to a common herbicide of accepted ecological toxicity, 2,4-D (2,4-Dichlorophenoxyacetic acid). The amounts of constituents released to air during the products' life cycle stages are multiplied by the factors contained in TRACI (Bare, et al., 2003) to calculate the indicator values.

5.3.6 Releases to Air Potentially Resulting in Smog Formation

The smog impact indicator assesses the potential of air emissions to result in smog. Emission impact indicators from TRACI (Bare, et al., 2003) are used, as with other indicators noted above, to calculate the smog forming potential related to emissions. In response to questions about the units used in TRACI, Jane Bare (USEPA) provided the following explanation via email:

> *"This is the most common question I get within TRACI, so of course I am changing things in Version 2. The reason for the original units follows, but we could have just as easily divided everything by any reference chemical to make it into chemical equivalents.*
>
> *"They are in units of grams of NOx-equivalents per meter per kg emission. The reason for these units is that when the site-specific characterization factors were being developed on a state-wide basis, we first computed the expected change in NOx concentration by state (g/m^3) per kg emission. We then multiplied these concentration changes by the area of each state to obtain total NOx concentration impacts in units of g NOx/m, per kg emission. Finally, the relative reactivities of NOx and each VOC are used to derive the final smog factors for each pollutant.*

Copyright 2012
Treated Wood Council

"So I will agree that this is a very strange unit, which has been very confusing to people. Chances are very high that you will not see this unit in the next version."

As with the other impact indicators, this is only useful as a basis for comparison between products for which the same calculations, via LCI data, have been made.

5.3.7 Releases to Air Potentially Resulting in Eutrophication

The eutrophication impact indicator is normalized to pounds of nitrogen equivalent. The factors contained in TRACI (Bare, et al., 2003) are used to calculate the indicator values. Eutrophication characterizes the potential impairment of water bodies resulting from emission to the air of phosphorus, mono-nitrogen oxides (NO_x), nitrogen oxide, nitric oxide, and ammonia.

5.3.8 Impact Indicators Considered But Not Presented

The TRACI model and the USEtox model offer several additional impact indicators that were considered during the development of the LCA. However, for the reasons discussed below, these impact indicators were not fully evaluated and presented within this report.

5.3.8.1 Human Health

Since the inception of this LCA, specifically during the impact assessment phase development, the issue of assessing human health has received detailed and careful consideration. Fundamentally, human health impact is a measure of "risk" and risk is a function of chemical speciation, pathway, and exposure. AquAeTer And TWC have decided not to include human health indicators in the LCA scope because of a concern that any values could be misconstrued by readers as indicating that the products posed actual risks to the users.

In response to TWC's decision to exclude human health assessment, the independent external reviewers note that, "guidance does not exist that lists 'required' impact categories, with the exception perhaps, of those that have reached some level of global consensus on methodology" and further note, "the panel members cannot insist that [human health]…be included in the LCIA." The independent external reviewers have made it clear that they prefer the study to include the human health impact results. Also, the independent external review members state that their concern is heightened by the fact that the LCIA is intended to serve as a basis for comparison between treated wood and alternative products and, in their view, without addressing human health, the analysis does not meet the ISO 14044 guideline criteria (4.4.5) requirement of including a "comprehensive set of category indicators" for use in comparative assertions intended to be disclosed to the public and "that a comparison analysis without human health impacts can be misleading to decision makers.".

TWC members have considered the comments provided by the independent external reviewers. TWC believes that the exclusion of human health impacts from the LCA scope is compliant with ISO guidelines as long as such determination is clearly defined in the Goal and Scope. Definition of the Goal and Scope for an LCA project is defined by ISO as an iterative process. Through such iterations, the scope of this LCA by TWC has evolved to exclude human health impact evaluation and clearly explains such exclusion as a limitation of this LCA. For

Copyright 2012
Treated Wood Council

transparency, this LCA includes the life cycle emissions potentially related to human health, but does not use the emissions as a means of addressing human health impact indicators.

5.3.8.2 Releases to Land and Fresh Water

Releases to fresh water were not evaluated because water release data would not support meaningful impact conclusions. For example, while copper is known to be released from CCA treated wood during storage, releases are nearly always to the surface soil. Copper tends to bind to mineral and organic matter in soil, limiting potential impacts. Land and water impact indicator values are based on the concentration of constituents in the respective media. Estimates of amounts of constituents of concern leached from treated wood in storage, concentrations in soil or if mobilized and discharged into a water source, and specific constituents of concern, are poorly supported. Scientifically supported estimates of soil and water concentrations would require site-specific information such as facility practices, soil pH, soil organic content, local water quality (pH and hardness), precipitation, volumetric water flow off-site, and soil type. Research on these factors was well beyond the scope of this LCA, and cannot be extracted from site-specific and loosely applied to a "typical" site. Thus, the amount of leached constituents of concern was not retained in the analysis to determine impacts due to soil or fresh water related exposure.

Similarly, constituents of concern released in landfills likely will remain within the landfill or be captured in leachate, should a release occur. While data are available for some of the supporting processes, those processes are not the primary subject of this LCA and are not retained in the analysis.

5.3.8.3 Land Use

The quantity of waste products generated by life cycle stages of CCA-treated marine piles and land use modifications was considered as an impact indicator for this LCIA. It was determined that the primary product in CCA-treated marine piles is wood fiber, harvested from sustainable forests. Sustainable forest use does not result in a change in land use. Furthermore, quantification of land use modification due to procurement of natural resources was considered to be out-of-scope for this project. Therefore, land use was not retained as an impact indicator.

5.4 TOTAL ENERGY

The total amount of energy input to produce, use, and dispose of a product over its life cycle is not considered an impact indicator, but is calculated and reported in this LCIA. Total energy is the energy derived from all sources, including fossil, biogenic, and grid electricity converted to common units of millions of BTU (MMBTU) per unit. Energy sources are, to varying degrees, fungible, meaning they can be transferred from one use to another. For example, wood fuel (biomass) can, as in the case of piles, be used for heat to dry piles or it could be used for home heating pellets or to fuel electric power generation. Similarly, process heat could be from natural gas. Generally, products that require less input of energy will have lower environmental impact. Assessment of total energy allows users to compare this aspect of each product.

The mix of sources of the energy used, as well as the total amount, affects the life cycle indicator values for each of the products. Fossil fuel use contributes to GHG emissions while renewable

Copyright 2012
Treated Wood Council

biogenic, wind, nuclear, or hydroelectric power sources have little impact on GHG because they rely on fossil fuels only for ancillary process, such as transportation of materials.

5.5 RELEASES TO MARINE WATERS WITH THE POTENTIAL TO IMPACT ECOLOGICAL TOXICITY

Since the primary use application of marine piles is in marine environments, it was deemed important to estimate marine water releases. The identified marine releases are reported in Table 4-4. Impacts resulting from such releases in marine waters are largely dependent on local conditions. This LCA does not attempt to model marine ecotoxicity impact or compare the marine ecological toxicity to alternative products. The marine ecological toxicity impacts are highly localized and can vary significantly as a result of water flow or circulation rates, ambient levels of metals, and the number of piles in a row parallel to flow or current, as well as water quality conditions, pH, and temperature.

5.6 CHARACTERIZATION

For characterization of certain impact indicators, this LCA uses USEPA's TRACI (Bare, et al., 2003) model. The TRACI spreadsheet model includes specific chemicals and lists impact values for various environmental impacts, including those listed above.

The LCIA uses a separate workbook, "ChemicalFactors," including the TRACI spreadsheet, to calculate unit value impacts for each of the "processes" involved in the CCA-treated, concrete, steel, and plastic piles LCIs. Inventory inputs and outputs for most processes, such as electric power generation, wood combustion, or truck transportation are those downloaded from the NREL's U.S. LCI Database, as described previously. Individual spreadsheets within the "ChemicalFactors" workbook include the complete list of inputs and outputs for each "process." Pertinent data then are copied into a column of the process releases spreadsheet ("ProcEmis" ***tab***). The sum of products function is used to calculate the sum of the products of impact indicator value multiplied by the release for each chemical, resulting in release impact factors for each process. The TRACI factors are provided in "per kg" units. In the "ChemicalFactors" workbook, the TRACI factors are converted to "per pound" units to match the release units of the LCI. These then are entered into the "Piles LCI" ***tab*** for each process and proportioned to the products, so that final impact values for each life cycle stage can be determined.

5.7 NORMALIZATION

5.7.1 Product Normalization

Each piling product is normalized to units of measure that support comparisons to other products. In this LCA, data are normalized to one "typical" marine pile. Additionally, each piling product functional units are normalized to years of useful life (indicator value/pile/yr) in recognition that not all products can last the same amount of time.

Resource uses and releases occurring before service life begins, such as tree growth, and after service life is complete, such as end of life management, are totaled and averaged over the service life of the products. Assumptions are applied proportionally to the "average" pile averaging the full life-cycle impacts over the years of service. End of life impact contributions,

Copyright 2012
Treated Wood Council

whether occurring in the short-term (combustion) or long-term (landfill decay), are applied and averaged over the service life years.

5.7.2 National Normalization of Impact Indicators

Impact indicators, as described above for piling products, support comparison between products, but provide no basis for understanding practical magnitude. National normalization provides a means to compare the impact indicator values for marine piles to total U.S. annual impact values. Average U.S. impacts have been calculated for the TRACI impact indicators based on total U.S. emissions in 1999 (Bare, et al., 2006). The approach and these data were expanded and updated by more recent 2007 energy and fossil energy use (Energy Information Association (EIA), 2008), GHG emission data for the U.S. (USEPA, 2009), and national year 2000 water use (USGS, 2009).

Consider, for example, what is a significant cost for a household with the U.S. mean income of $50,000 per year. A new car costing $25,000 represents 50 percent of the mean annual household income. If the car lasts five years, $5,000 per year represents 10 percent of the annual income. This would be the financial "footprint" of the new car. If the family is comparing cars, one that costs $50,000 and lasts the same time would clearly be two times more expensive and, going from 10 percent to 20 percent of annual income would be significant. On the smaller scale, consider the purchase of a cup of coffee once a week, where a standard cup costs $1 per cup versus a fancy cup at $4 per cup. The annual costs for each would be $52 and $204, or 0.1 percent and 0.4 percent of annual income, respectively. At this point, the cost of the fancy cup has four times the impact, but is not significant to the family budget and the financial "footprint" is insignificant.

In the "Norm" ***tab***, these national average impact indicator values and U.S. totals have been converted to the units used in this LCIA and compared to the calculated impact indicators for a "typical marine pile" of CCA-treated southern pine and for alternate pile materials. The number of CCA-treated marine piles currently in service is estimated to be approximately 22.5 million. The U.S. normalization is made under four optional scenarios including: all of these 22.5 million piles are 1) CCA-treated pine; 2) concrete; 3) steel: or 4) plastic. For each optional scenario and impact indicator, the per pile per year value is multiplied by 22.5 million and divided by the U.S. total impact indicator values to provide the normalized impact for each product scenario as a percent of the U.S. total impact indicator value. Thus, the total fossil fuel input for all CCA-treated piles would be approximately 0.0031 percent of the total U.S. fossil fuel use in a year. Impact indicators for each pile product, normalized to 22.5 million piles per U.S. total impact values, are summarized in Table 5-6.

Cautionary Note – U.S. average impact indicator values for acidification, eutrophication, and smog are based on the 1999 Toxic Release Inventory (TRI). The TRI data are based on reports to USEPA of releases from larger, mostly industrial type facilities whose releases exceed the reporting thresholds. Thus, totals do not include small industrial facilities with emissions below reporting thresholds, transportation fuel use, home and commercial heating, or most agriculture emissions. Actual total U.S. releases can be significantly larger than stated and, thus, impact indicators for piles actually can be a smaller portion of the U.S. averages than indicated.

Copyright 2012
Treated Wood Council

5.8 CCA IMPACT ASSESSMENT

Impact indicator values were totaled at four stages along the life cycle of the treated wood product: harvesting of logs with bark, piling production and preservative treatment, CCA-treated marine piling at the end of marine service life, and CCA-treated marine piling following disposition fates, including reuse, recycling for energy, and landfill disposal. The impact indicator values calculated for CCA-treated marine piling life cycle stages are presented per Mcf in Table 5-2.

Impact indicator values were normalized to the units of one "typical" pile per year of service. The impact indicators again were evaluated at the four life cycle stages. The impact indicator values per pile per year of use are provided in Table 5-3.

The contribution to each indicator by life cycle stage for CCA-treated marine piles, is shown in Table 5-4. Relative impacts by stage allows for identification of impacts significant to totals in the gravity analysis as further discussed in Section 5.12.1.

The impact indicators are complicated by credits received during the pre-treatment and disposition stages (e.g., tree growth period in which CO_2 is consumed and recycling of used piles for energy recovery off-setting the need for fossil fuel resources). The credits are shown in Tables 5-2 and 5-3 as negative values. The credits are identified on Table 5-4 as bold values within parentheses.

Impact indicator values also were normalized to U.S. National Impact, where total estimated CCA-treated marine pile impact (22.5 million piles) is shown as a fraction of total annualized national impact resulting from all emissions. The results of this comparison are shown in Table 5-6.

The following is a summary of the findings by impact indicator during the life cycle stages of the CCA-treated marine pilings.

5.8.1 Greenhouse Gas Emissions

The cradle-to-grave GHG impacts of CCA-treated marine piling include primary contributions from the treatment and disposition stages with small impacts from the pre-treatment and use stages. Electric power related emissions (half due to treating plant electric use and half related to CCA production) and truck transport emissions are the most significant. During the end-of-life stage, carbon dioxide and methane emission from piles disposed in landfills also contribute to GHG impacts.

Considering all CCA-treated pilings in the U.S. (estimated to be 22.5 million), the GHG emissions would represent 0.0052 percent of the total U.S. GHG emissions expected in one year (as shown in Table 5-6).

Net GHG emissions are negative for the cradle-to-grave life cycle of CCA-treated marine piling, meaning that more GHG is removed during the life cycle than released. Considering all CCA-treated pilings in the U.S., the net GHG emissions would represent a reduction of 0.00017

Copyright 2012
Treated Wood Council

percent of the total U.S. GHG emissions expected in one year (as shown in Table 5-6). The most significant process for net GHG emissions is tree growth (which removes carbon dioxide).

5.8.2 Fossil Fuel Usage

The largest use of fossil fuel, during the cradle-to-grave life cycle of CCA-treated piles, occurs at the treating facility, the result of drying piles, preservative manufacture, treatment, and transportation of green piles and preservatives to the plant. Compared to annual U.S. fossil fuel use, the fossil fuel use required for all CCA-treated marine piles would be 0.0031 percent of the national annual total.

5.8.3 Emissions Potentially Resulting in Acid Rain (Acidification)

The cradle-to-grave acidification impacts of CCA-treated piles include relatively small impacts during the wood pile production stage and service life stage and increased impact during the treatment and the disposition stages. The values are shown in Tables 5-2, 5-3, and 5-4.

Considering all CCA-treated wooden piles in the U.S., acidifying emissions would be small at approximately 0.0043 percent of the total U.S. acidifying emissions expected in one year.

5.8.4 Water Use

Water use data were not identified for all processes, so results have only limited value. Water use data related to fuels and electricity production, some processes needed for CCA production, and landfill construction are not known. Given these limitations, water use is estimated. Most water associated with CCA-treated marine piling (87 percent) occurs in the treating stage, where water is used to make preservative treating solution. Considering all CCA-treated marine piling in the U.S., the water use impact accounts for a small 0.00011 percent (approximately one-millionth) of the U.S. total water use.

5.8.5 Emissions with Potential to Form Smog

The potential to impact smog formation is largely a result of processes during the treating stage. Processes of importance include truck transport (preservative, treated and untreated piles), ship transport (CCA production), and landfill disposal. Considering all CCA-treated marine piling in the U.S., the potential for smog formation is 0.0023 percent of the total smog forming emissions.

5.8.6 Emissions with Potential to Impact Eutrophication

Eutrophication impact is mainly driven by emissions of nitrogen and is related to fuel combustion, such as in boilers and transportation engines. These emissions are most significant in the CCA piling treatment and disposition life stages. Considering all CCA-treated marine piling in the U.S., the eutrophication impact accounts for approximately 0.0017 percent of the U.S. total eutrophication impact.

Copyright 2012
Treated Wood Council

5.8.7 Emissions with the Potential to Impact Ecotoxicity

The cradle-to-grave ecological impact of CCA-treated piles is a result of the treating stage (approximately two-thirds of its value) and the disposition stage (approximately one-third of its value) and a small amount from the wood pile production stage. The values are shown in Tables 5-2, 5-3, and 5-4.

Considering all CCA-treated wooden piles in the U.S., air emission ecotoxicity would represent 0.0043 percent in comparison to the total U.S. air emission ecotoxicity expected in one year.

5.9 CCA-TREATED MARINE PILES TOTAL ENERGY IMPACT

Total energy use, including fossil fuel use, is relatively minor at 0.0033 percent of the U.S. annual use. Of the total energy CCA-treated piles require, approximately 80 percent comes from fossil fuel sources, as shown in Table 5-7.

5.10 MARINE ECOTOXICITY

Marine releases to water have been inventoried in this LCA, but no comparison of piling products was done because of the highly localized nature of potential impact. For example, the National Oceanic and Atmospheric Administration (NOAA) found that "increases in sediment metal concentrations were limited to within 10 feet from small treated wood structures in marine and freshwater habitats." (NOAA, 2009). The NOAA data are based on CCA-treated materials that were manufactured in accordance with the BMPs specified by the Western Wood Preservers Institute (2006). Furthermore, no marine ecotoxicity impact characterization model was identified. Because marine ecological toxicity is an impact proximate to the structure, and tends to remain in the sediment, and no national marine water ecotoxicity benchmarks were identified in the research, no national comparisons are provided in this LCA.

Based on the findings of the LCA, it is estimated that 1.0 Mcf of CCA-treated marine piling can release to marine water approximately 5.9 pounds of arsenic, 0.16 pounds of chromium, and 29 pounds of copper, over a service life of 40 years. Stated differently, a common-sized CCA-treated marine pile can release to marine water approximately 0.0042 pounds of arsenic, 0.00012 pounds of chromium, and 0.021 pounds of copper, per year.

The potential for marine ecologically toxic effects for piling installations is best evaluated using site specific methods, as further discussed in Section 6.1.6.

5.11 CONCRETE, STEEL, AND PLASTIC PILING IMPACT ASSESSMENT

Impact indicators, defined in Table 5-1, were calculated for concrete, steel, and plastic piles in a manner similar to that described for CCA-treated piles. Primary data for cement, steel, HDPE, and limestone was available through the U.S. LCI database. Manufacturing data for the alternate material piles were not available; therefore, professional judgments were used.

Impact indicator values were totaled at two stages along the life cycle of the alternate piling products including: **1)** the new manufactured pile, and **2)** after service life and final disposition. For the manufactured material piles, there is no comparable life stage to growth of wood and impact values for piles in service are minimal. Thus, only the two life stages are summarized.

Copyright 2012
Treated Wood Council

Impact indicator values were normalized to per pile per year of service, assuming a service life of 40 years (equal to that of treated wood). The impact indicator values are provided in Table 5-5 normalized per pile and per year of use and in Table 5-6 normalized to percent of U.S. total impact.

The goal and scope of this study did not include an analysis of the contributing factors to each impact indicator. The purpose of the concrete, steel, and plastic piling assessments solely is to assess relative impacts when compared to CCA-treated marine piling. Therefore, no discussion of the impact indicators and their product-specific contributions is provided in this section. AquAeTer performed sensitivity analyses on inventory items of significance, related to the alternative products. The items addressed in the sensitivity analysis and their outcomes are included in Section 5.12.3. Additional discussion regarding the comparison of CCA-treated and alternate product marine piling is provided in Section 5.13.

5.12 DATA QUALITY ANALYSIS

ISO 14044, Section 4.4.4, discusses optional additional techniques to help better understand the significance, uncertainty, and sensitivity of the LCI results. These tools help distinguish if significant differences are or are not present, identify negligible LCI results, and guide the iterative LCIA process.

4.4.4.2 The specific techniques and their purposes are described below.

> *a) Gravity analysis (e.g. Pareto analysis) is a statistical procedure that identifies those data having the greatest contribution to the indicator result. These items can then be investigated with increased priority to ensure that sound decisions are made.*
>
> *b) Uncertainty analysis is a procedure to determine how uncertainties in data and assumptions progress in the calculations and how they affect the reliability of the results of the LCIA.*
>
> *c) Sensitivity analysis is a procedure to determine how changes in data and methodological choices affect the results of the LCIA.*

Each of the additional data quality analysis tools were used to better assess the impact assessment findings.

5.12.1 Gravity Analysis

The first step in gravity analysis is to identify the processes that are most significant to the impact indicator values. A first simple approach to see what processes have the greatest impact can be accomplished by inspecting the relative percentages, as shown in Table 5-4. These can also be identified directly from the LCI spreadsheet, summary tables, or by graphic representations of the results. The contribution by each process (column in the LCI tab) to each impact indicator is shown in the indicator rows of the "Piles LCI" ***tab***. Larger numbers represent larger contributions. The next step in gravity analysis it to ask: "Are these results reasonable?"

Copyright 2012
Treated Wood Council

To make the gravity of processes more apparent, the indicator values of each process are divided by the sum of the absolute value of each stage and shown as a percentage of the final in the lines under the heading, Analysis-Contribution by Stage to Impact Indicators. Negative contributions indicate the process reduced the impact.

Significant contributing processes include:

- GHG most significantly is impacted by electricity use at the treating plant, oil use in industrial boilers during the treating process, truck transport of the treated pile, and decay of the pile in landfills. Net GHG most significantly is impacted by credits during tree growth, emissions from electricity use at the treating plant, and emissions from decay in landfills;

- Fossil fuel use is most significantly impacted by pile production prior to treatment, preservative production, electricity use at the treating plant, truck transport of the treated pile, truck transport to the point of disposition, and fuel use related to landfill disposal;

- Acidification most significantly is impacted by electricity use at the treating plant, ship transport of elements used in the treating chemicals, truck transport of the treated pile, and disposal in landfills;

- Water use most significantly is impacted by preservative manufacture and treating of the pile;

- The potential to impact smog formation most significantly is impacted by transportation in all stages of the life cycle, preservative production, electricity use at the treating plant, wood combustion at the treating plant, and ship transport of elements used in the treating chemicals;

- The potential to impact eutrophication most significantly is impacted by transportation in all stages of the life cycle, preservative production, wood combustion at the treating plant, and ship transport of elements used in the treating chemicals; and

- Ecotoxicity from releases to air most significantly are impacted by electricity use at the treating plant, wood combustion at the treating plant, and disposal in landfills.

This assessment evaluated the primary causal factors for the impact indicators, as discussed above, and concluded they are reasonable and suitable for use in this LCA.

5.12.2 Uncertainty Discussion

The scope of this LCA, being cradle-to-grave, requires many data inputs that involve uncertainty. AquAeTer has strived to make realistic assumptions in all cases. However, some assumptions are based only on professional judgment. Some areas of uncertainty most likely to impact the results of the LCA are discussed below.

Copyright 2012
Treated Wood Council

5.12.2.1 CCA Production

The CCA preservative producers did not provide detailed LCI input and output data for CCA production, so AquAeTer made assumptions and used analogous processes to estimate the inputs and outputs. Assumptions used in the calculation of inputs and outputs resulting from the production of CCA are included in the CCA Production Calculation (within Appendix 4) and are summarized in Appendix 6. Because AquAeTer did not survey CCA producers, uncertainty exists.

5.12.2.2 CCA Releases

Limited data are available on lifetime piling releases of CCA. Most applicable data focus on releases from newer product. Estimates of releases of CCA constituents are judged reasonable and supported by available data.

As further explored in the sensitivity analysis, used pilings might provide a source of energy through combustion. In the sensitivity analysis, uncertainty exists in the estimates of constituents released from piling used as fuel. Emissions are assumed to be similar to untreated wood fuel. Facilities would require specific permits for piling fuel and typically will require advanced emission controls or specialized combustion systems. Such fuel also can be used in cement kilns, in which metals are bound to and incorporated into the cement product, or in gasification units, where metals are separated from the synthetic gas.

5.12.2.3 Biomass Production and End Uses

Biomass is generated when bark is peeled from logs. A large amount is used at the treating plants for energy to dry the piles. Excess biomass, greater than the amount used at the plant, is sold for use either as fuel or as mulch. The fraction to each end use is estimated.

5.12.2.4 Landfill Fate and Releases

AquAeTer bases its landfill emission estimates on data USEPA uses to estimate GHG emissions for its inventory. However, assumptions have significant impact on indicator values, especially for GHGs. As more landfills in the U.S. install methane collection systems and increase methane recovery efficiencies, landfill methane emissions will decrease. Further, in the LCI, CCA-treated wood is assumed to degrade to the same degree as round wood limbs disposed in a landfill. If treatment retards or prevents degradation of the wood in a landfill, as expected, then releases of methane could be significantly less. The assumptions used have uncertainty and result in uncertainty in our calculation of GHGs. Because of the landfill uncertainties, further analysis was conducted as part of the sensitivity analysis.

Additionally, estimation of releases of metals from landfills to soil and groundwater is uncertain. Modern landfills are designed to prevent such releases, so such releases could be stated as not occurring. However, the possibility that some release of metals and partially decomposed carbon-based matter does occur creates a level of uncertainty.

Copyright 2012
Treated Wood Council

5.12.2.5 Concrete, Steel, and Plastic Uncertainty Discussion

The comparative analysis phase of this LCA includes the assembly of simplified LCIs for each alternate piling product for comparison to CCA-treated piling. The scope allows for the cradle-to-grave LCI of concrete, steel, and plastic piles to include data inputs that involve professional judgments with uncertainty. AquAeTer strived to make realistic assumptions in all cases. However, some assumptions are based only on professional judgment. No survey of manufacturers of the products was done. Some areas of uncertainty most likely to impact the results of the LCI and LCIA are discussed below in the sensitivity analysis.

5.12.2.6 Uncertainty Conclusion

While the uncertainty of specific factors used within the LCI remains significant, AquAeTer has determined that, even with the uncertainty present in this LCA, the conclusions are reliable for the intended use.

5.12.3 Sensitivity Analysis

AquAeTer evaluated the many data inputs and assumptions required for the LCA. Certain items or categories stand out as most important in affecting the sensitivity of LCA impact indicator outcomes and are discussed in greater detail below. Additional information and model results, including analysis of items determined to be of less significance, are included in Appendix 7.

5.12.3.1 Copper

Although most copper used in CCA is off-specification copper that comes from recycled sources, as described in Section 4.2.3.1, it would not be appropriate to account for it as if no inputs or outputs are associated with collection, recycling and preparation of copper compounds for use. Without an LCI for recycled copper, this LCI assumes one third of the inputs and outputs associated with the production of new copper are reasonable and allocates those burdens to the recycled copper used in CCA.

As a sensitivity analysis, the ratio of recycled copper associated with copper used in CCA to new copper was varied. In our sensitivity analysis, the case where recycled copper is treated as if newly mined and produced is considered. Based on the model, as the fraction of newly mined copper increases the amount of energy required for its production increases. The CCA-treated piling indicators show sensitivity to the inputs and outputs related to copper production.

5.12.3.2 CCA Retention

If the CCA retention is increased to 125 percent of baseline, impact indicators increase. Marine ecotoxicity is directly proportional at an increase of 25 percent. All other impact indicator changes also are notable at between six and 20 percent. Relative to the other products, the sensitivity tests did not change the comparative results.

5.12.3.3 Biomass Use for Heating Fuel

Biomass is used by some pile treating facilities to fuel boilers. Based on treater survey results,

Copyright 2012
Treated Wood Council

approximately 90 percent of the heating fuel needed to dry piling wood is derived from biomass. The biomass is an alternate fuel to natural gas, and results in less fossil fuel use. Increases in biomass as boiler fuel reduces the need for fossil fuel energy sources. Treater data were used in the LCI; however, the practice varies by plant, thus, the amount of biomass and natural gas used to fuel boilers was altered in a sensitivity analysis.

Impact indicators are relatively insensitive to changes in biomass use as fuel for drying. Fossil fuel use is the indicator most significantly impacted. Natural gas use results in increases to GHG, fossil fuel use, and acidification, but decreases in smog potential, eutrophication, and ecological toxicity. Relative to the other products, the sensitivity tests did not change the comparative result.

5.12.3.4 CCA-Treated Piling Service Life

For all products, changes in piling life are inversely proportional to changes in impact indicators. Increasing life from 40 to 80 years results in a 50 percent decrease in all impact indicators.

5.12.3.5 End-of-Life Disposition

The baseline disposition model for piles assumes 30 percent are reused for other applications, 70 percent are disposed in landfills, and zero percent are recycled for energy recovery. A sensitivity test considers 70 percent of piles being recycled for energy and 20 percent being landfilled. Shifting used piles from landfill disposal to beneficial energy recovery significantly affects impact indicators for GHG, fossil fuel use, acidification, smog, and ecotoxicity as shown in Figure 5-1.

Metals and particulate emissions from power-generating combustion units are assumed in the LCI to be 90 percent less than for wood-fired "industrial" combustors due to larger size and improved emission controls typical of such units.

Large scale utilization of CCA-treated wood for fuel likely would use gasification systems that offer energy recovery without combustion emissions and result in lower impact indicators than those modeled in this sensitivity analysis.

5.12.3.6 Landfill Model Assumptions

Based on USEPA landfill data (USEPA, 2006) and discussed above in Section 4.2.6, 77 percent of wood fiber disposed in landfills is considered sequestered carbon after primary decomposition has occurred. Since the impacts of methane significantly impact emissions of GHG, sensitivity analysis of this input was done. Furthermore, preservative in the disposed wood is expected to increase carbon sequestration when compared to untreated wood. One case was modeled for sensitivity: 90 percent wood-fiber carbon sequestration in the landfill. Increasing sequestration to 90 percent improves the case of GHG (less methane is emitted), but increases the net values for most other indicators because less methane is collected and used to generate power. Additionally, it does not change the comparison of products.

Copyright 2012
Treated Wood Council

5.12.3.7 Concrete Piling Variables

Concrete needs steel for tensile and bending strength. Four 5/8-inch diameter steel strands are assumed in the baseline model. If the steel strands are doubled to eight, the impact indicators increase between three (ecotoxicity) and 21 (fossil fuel) percent.

The assumption regarding post-use fate of concrete piles is that 80 percent of used concrete piles have a post-use fate of landfill disposal and 20 percent are recycled for aggregate. If recycling to aggregate is more widely practiced, the aggregate produced from recycled piles is expected to be a lower grade material than newly mined aggregate, but could be used for offsetting some new aggregate. The impacts of this credit are investigated in the sensitivity analysis. The test case considers recycling of 100 percent of concrete piles to aggregate and recycled steel. Life cycle impacts are reduced with more recycling; however, changes are not significant to overall comparative results with CCA-treated marine piles.

5.12.3.8 Steel Piling Variables

Steel piling typically is manufactured from standard gage steel pipe. The baseline model assumes schedule 30 thickness steel pipe is used. If the pipe thickness is increased to schedule 40 pipe, approximately 20 percent more steel is required and most indicators are similarly increased.

Piling strength and corrosion resistance are improved if hollow steel piles are filled with concrete. The baseline model assumes that 10 percent of all steel piling are filled with concrete. If all steel piles are filled with concrete, impact indicators are increased between 15 (acidification) and 250 (water use) percent.

The baseline model assumes all steel piles are recycled when removed from service. If only 50 percent of piles are recycled, the fossil fuel, GHG, water use, smog potential, and eutrophication impact indicators increase while the acidification and ecotoxicity impact indicators decrease.

5.12.3.9 Plastic Piling Variables

Like concrete, plastic piling is assumed to require steel reinforcement and four 5/8-inch diameter strands of steel are assumed for the baseline model. If the steel strands are doubled to eight, the impact indicators increase between 40 (ecotoxicity) and 59 (fossil fuel) percent.

The baseline model assumes zero virgin HDPE in piles. Virgin plastic content can vary by manufacture, design, and plastic market conditions. With more virgin HDPE use, fossil fuel use, GHG, acidification, and smog potential all increase, while water use, eutrophication, and ecotoxicity decrease.

Recycling plastic piles to make additional plastic products is assumed to be difficult because plastic piles are a mixture of many materials and types of plastic, making recycling problematic. Twenty percent recycling is assumed on the basis that some recycling is likely, however widespread recycling is not currently done and is unlikely in the foreseeable future. The impacts of these assumptions are tested in this sensitivity analysis. Life cycle impacts are reduced with more recycling and increased with more landfill disposal; however, changes are not significant to

Copyright 2012
Treated Wood Council

overall comparative results with CCA-treated marine piles except for water use, which is favorable for plastic piles, if 80 percent or more of plastic piles are recycled.

5.13 COMPARISON OF CCA-TREATED MARINE PILING TO ALTERNATIVE PILING PRODUCTS

5.13.1 Discussion

The LCI data developed in Section 4 and assessed in Section 5 of this report conclude with impact indicator values for the cradle-to-grave life cycle of CCA-treated and alternative marine piling products normalized to one average piling per year of service use. Because some impact indicator values can be in the hundreds while other indicators are tenths or hundredths of one, comparisons are difficult. Thus, for product comparisons, impact indicators have been normalized to the product (CCA-treated pile, concrete pile, steel pile, or plastic pile) having the highest cradle-to-grave value. The product with the highest value through final disposition receives a value of one, and the other life cycle stages and values for other products then are fractions of one. Results of this normalization process are shown on Figure 5-2.

Additionally, the U.S. average impact indicator comparison is provided, as described in Section 5.7.2. Table 5-6 shows the percent of total U.S. average impact values per year that could be attributed to the current use of CCA-treated marine piling or, alternatively, to the same number of marine piles of each of the alternative materials.

5.13.2 Fossil Fuel Usage

Based on the finding of this study, steel marine piles have the largest impact on fossil fuel use per pile per year of use. Fossil fuel use for CCA-treated piles is the lowest of the four alternatives at 22 percent of the steel piles.

Fossil energy represents 77 percent of the input energy for CCA-treated piles and nearly all the input energy for concrete, steel, and plastic piles.

5.13.3 Greenhouse Gas Emissions

Steel marine piles have the largest impact on anthropogenic GHGs per pile per year of use. GHGs for CCA-treated piles are the lowest of the four alternatives at 32 percent of the steel piles.

Similarly, steel marine piles have the largest impact on net GHGs per pile per year of use. Net GHGs for CCA-treated piles are the lowest and reflect a credit of 1 percent, in comparison to the steel pile.

5.13.4 Releases to Air Potentially Resulting in Acid Rain (Acidification)

Steel marine piles have the largest impact on acidification per pile per year of use. Acidification from CCA-treated piles is the lowest of the four alternatives at 22 percent of the steel piles.

Copyright 2012
Treated Wood Council

5.13.5 Water Usage

While data on water use in some of the important processes are not available, the data available provide a basis for limited consideration. Plastic piles have the largest impact on water use per pile per year of use. Water use by CCA-treated piles is 42 percent of the plastic piles. The water use by steel piles is the lowest of the four alternatives at 30 percent of the plastic piles.

5.13.6 Releases to Air Potentially Resulting in Smog

Steel marine piles have the largest impact on smog forming potential per pile per year of use. Smog from CCA-treated piles is the lowest of the four alternatives at 32 percent of the steel piles.

5.13.7 Releases to Air Potentially Resulting in Eutrophication

Steel marine piles have the largest impact on eutrophication per pile per year of use. Eutrophication from CCA-treated piles is the lowest of the four alternatives at 44 percent of the steel piles.

5.13.8 Releases to Air Potentially Resulting in Ecological Toxicity

Concrete marine piles have the largest impact on air releases potentially resulting in ecological toxicity per pile per year of use. Air emission ecotoxicity from CCA-treated piles is the lowest of the four alternatives at 18 percent of the concrete piles.

5.13.9 Comparisons Conclusion

Figure 5-2 shows cradle-to-grave life cycle annual impact indicator normalized values for CCA-treated, concrete, steel, and plastic piles.

- The fossil fuel use, greenhouse gas (GHG), net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for concrete piles.

- The fossil fuel use, GHG, net GHG, acidification, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for steel piles. The water use value for steel piles is less than the value for CCA-treated piles.

- The fossil fuel use, GHG, net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for plastic piles.

- Of the four piling types, steel piles have the highest impact indicator values for fossil fuel use, GHG, net GHG, acidification, smog potential and eutrophication. Concrete piles have the highest impact indicator value for air emission ecotoxicity. Plastic piles have the highest impact indicator value for water use.

Copyright 2012
Treated Wood Council

- National impacts are considered small at less than 0.01 percent (one ten-thousandth) of the national totals. The marine industry should consider marine pilings as one of the many products that contribute impacts as a result of their use.

- Proximate marine ecotoxicity from CCA-treated piles is best assessed using site specific evaluation.

Copyright 2012
Treated Wood Council

Table 5-2 Summary of Impact Indicator Totals at Life Cycle Stage for CCA-Treated Marine Piling (per Mcf)

Impact Indicator	Units	Life Cycle Stage				CCA pile cradle-to-grave
		Pre-treatment stage	CCA pile treating stage	CCA pile use life stage	CCA pile disposition stage	
GHG Emissions	lb-CO_2-eq	1,905	17,544	1,462	29,373	50,283
Net GHG Emissions	lb-CO_2-eq	-66,306	22,338	4,245	38,048	-1,675
Fossil Fuel Use	MMBTU	20	87	8.2	52	167
Acid Rain Potential	H^+-mole-eq	502	7,128	416	4,024	12,070
Water Use	gal	1,062	7,114	0	0	8,176
Smog Potential	g NOx/m	3.7	39	5.9	10	59
Eutrophication	lb-N-eq	0.28	2.3	0.44	0.30	3.4
Air Emission Ecotoxicity	lb-2,4-D-eq	2.4	77	0	39	119

Notes:

Pre-treatment includes: seedling production, greenhouse growth, replanting a harvested area of forest, growing and maintaining the forest plantation until harvest, harvesting of the trees, and associated transportation.

CCA treating includes: peeling and drying piles, preservative manufacture, treatment, storage of untreated and treated piles, and transportation of green piles and preservatives to the plant.

Pile use includes: transportation of piles to the installation site and releases during use.

Disposition includes: disposal, reuse, and beneficial energy recovery and associated transportation.

Cradle-to-grave is the sum of pre-treatment, treating, use, and disposition.

Table 5-3 Summary of Impact Indicator Totals at Each Life Cycle Stage for CCA-Treated Marine Piling (per pile per year of use)

Impact Indicator	Units	Life Cycle Stage				CCA pile cradle-to-grave
		Pre-treatment stage	CCA pile treating stage	CCA pile use life stage	CCA pile disposition stage	
GHG Emissions	lb-CO_2-eq	1.4	13	1.1	21	36
Net GHG Emissions	lb-CO_2-eq	-48	16	3.1	27	-1.2
Fossil Fuel Use	MMBTU	0.014	0.063	0.0059	0.037	0.12
Acid Rain Potential	H^+-mole-eq	0.36	5.1	0.30	2.9	8.7
Water Use	gal	0.77	5.1	0	0	5.9
Smog Potential	g NOx/m	0.0027	0.028	0.0042	0.0076	0.042
Eutrophication	lb-N-eq	0.00021	0.0017	0.00032	0.00022	0.0024
Air Emission Ecotoxicity	lb-2,4-D-eq	0.0018	0.056	0	0.029	0.086

Copyright 2012
Treated Wood Council

Table 5-4 Contributions to Impact Indicators by Life Cycle Stage for CCA-Treated Marine Piling

Impact Indicator	Life Cycle Stage				CCA pile cradle-to-grave
	Pre-treatment stage	CCA pile treating stage	CCA pile use life stage	CCA pile disposition stage	
GHG Emissions	4%	35%	3%	58%	100%
Net GHG Emissions	**(51%)**	17%	3%	29%	100%
Fossil Fuel Use	12%	52%	5%	31%	100%
Acid Rain Potential	4%	60%	3%	33%	100%
Water Use	13%	87%	0%	0%	100%
Smog Potential	6%	66%	10%	18%	100%
Eutrophication	8%	70%	13%	9%	100%
Air Emission Ecotoxicity	2%	65%	0%	33%	100%

Note: Bold values in parentheses indicate negatives. Negatives are the result of credits recognized from energy recovery and off-sets for supplementing fossil fuel needs.

Copyright 2012
Treated Wood Council

Table 5-5 Summary of Impact Indicator Totals at Life Cycle Stages for All Marine Piling Products (per year of use and per average pile)

		CCA-treated pile			Concrete pile			Steel pile			Plastic pile		
Indicators Normalized to per pile per year of service	Units	Cradle-to-gate	Gate-to-grave	Cradle-to grave	Cradle-to-gate	Gate-to-grave	Cradle-to grave	Cradle-to-gate	Gate-to-grave	Cradle-to grave	Cradle-to-gate	Gate-to-grave	Cradle-to grave
GHG Emissions	lb-CO_2-eq	14	22	36	40	27	67	112	1.3	114	69	25	94
Net GHG Emissions	lb-CO_2-eq	-32	31	-1.2	40	28	67	112	3.0	115	69	25	94
Fossil Fuel Use	MMBTU	0.077	0.043	0.12	0.19	0.12	0.31	0.83	-0.28	0.55	0.52	-0.0037	0.52
Acid Rain Potential	lb-H+ mole-eq	5.5	3.2	8.7	8.7	10	19	23	18	41	17	3.6	21
Water Use	gal	5.9	0	5.9	6.9	-0.17	6.7	14	-10	4.2	22	-8.1	14
Smog Potential	g NOx / m	0.031	0.012	0.042	0.055	0.036	0.091	0.13	-0.0017	0.13	0.075	0.0089	0.083
Eutrophication	lb-N-eq	0.0019	0.00054	0.0024	0.0038	0.0016	0.0055	0.0081	-0.0025	0.0055	0.0041	0.00025	0.0044
Air Emission Ecotoxicity	lb-2,4-D-eq	0.058	0.029	0.086	0.39	0.089	0.48	0.14	0.27	0.40	0.088	0.039	0.13

Notes:

Cradle-to-gate includes pre-treatment and treating stages (as further defined in the Notes for Table 5-2) for CCA-treated pile, where gate is defined as point the product leaves the treating facility. Cradle-to-gate includes extraction of raw materials, cement production, and concrete pile manufacture for concrete piles. Cradle-to-gate includes steel acquisition (recycled and virgin), and steel pile manufacture. Cradle-to-gate includes extraction of raw materials, recycled plastic impacts, and plastic pile manufacture for plastic piles.

Gate-to-grave includes delivery of the piling to the use site, releases during use, and final disposition for all pile products.

Cradle-to-grave is the sum of cradle-to-gate and gate-to-grave.

Copyright 2012
Treated Wood Council

Table 5-6 Normalized Cradle-to-Grave Impacts of Marine Pile Usage Compared to U.S. Total Impact

Impact Indicator	Annual marine pile impact as a fraction of U.S. total annual impact categories (assumption based on 22.5 million marine piles)			
	CCA-treated wood piles	Concrete piles	Steel piles	Plastic piles
GHG Emissions	0.0052%	0.0095%	0.016%	0.0098%
Net GHG Emissions	-0.00017%	0.0096%	0.016%	0.0098%
Fossil Fuel Use	0.0031%	0.0081%	0.014%	0.014%
Acid Rain Potential	0.0043%	0.0091%	0.020%	0.0083%
Water Use	0.00011%	0.00012%	0.000074%	0.00039%
Smog Potential	0.0023%	0.0049%	0.0071%	0.0040%
Eutrophication	0.0017%	0.0039%	0.0039%	0.0029%
Air Emission Ecotoxicity	0.0043%	0.024%	0.020%	0.0044%

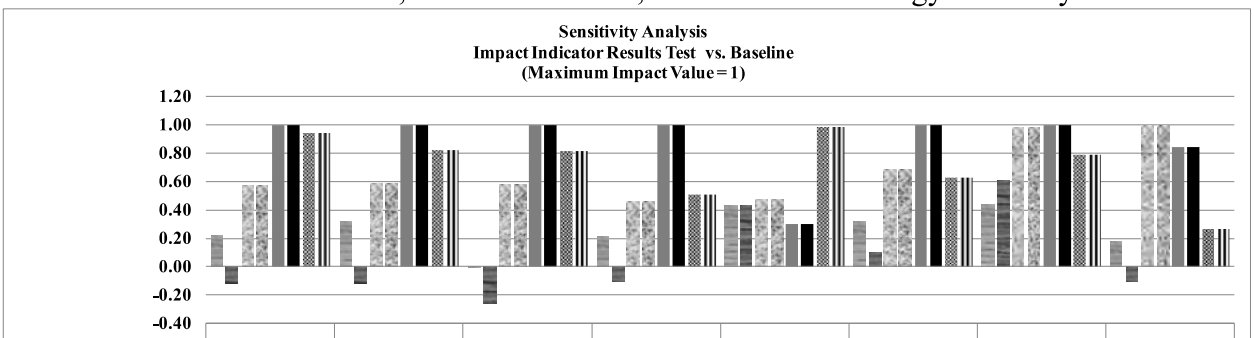
Note: Impact per year in each column is based on all 22,468,058 CCA-treated piles in service in the U.S. being manufactured of one of the pile types listed in the column.

Table 5-7 Sources of Energy by Product and Life Stage

Product and Life Cycle Stage	Total energy input MMBTU	Fossil fuel use MMBTU	Biomass energy MMBTU	Fossil intensity % of total	Biomass intensity % of total
CCA pile, cradle-to-gate	0.10	0.077	0.018	77%	17%
CCA pile cradle-to-grave	0.15	0.12	0.018	81%	12%
Concrete pile cradle-to-gate	0.20	0.19	0.00030	98%	0.15%
Concrete pile cradle-to-grave	0.34	0.31	0.0021	94%	0.64%
Steel pile, cradle-to-gate	0.84	0.83	0.000026	98%	0.0031%
Steel pile cradle-to-grave	0.62	0.55	0.0073	89%	1.2%
Plastic pile cradle-to-gate	0.54	0.52	0.00090	97%	0.17%
Plastic pile cradle-to-grave	0.54	0.52	0.0018	96%	0.34%

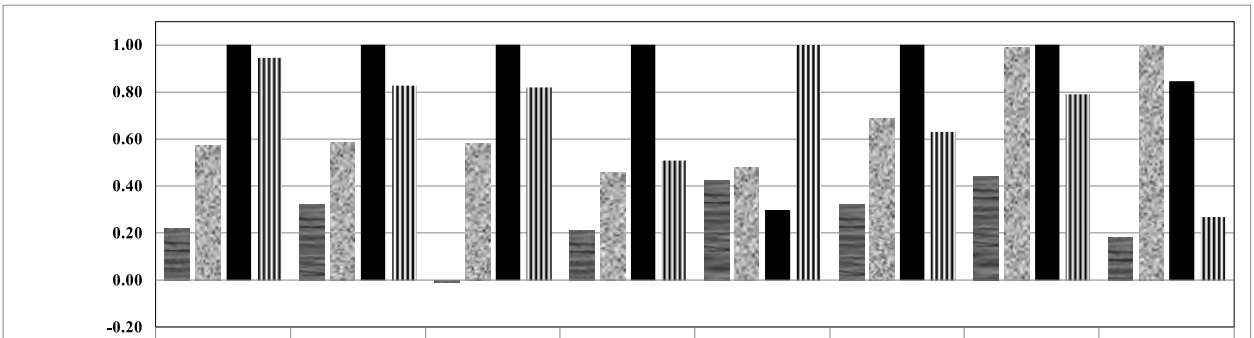
Copyright 2012
Treated Wood Council

Figure 5-1 Sensitivity Analysis - Beneficial Energy Recovery vs. Landfill Disposal
Baseline = 70 Percent Landfill and 30 Percent Reuse
Test case = 20 Percent Landfill, 10 Percent Reuse, and 70 Percent Energy Recovery



	Fossil Fuel Use	GHG	Net GHG	Acid Rain	Water Use	Smog	Eutrophication	Air Emission Ecotoxicity
Baseline CCA pile LC	0.22	0.32	-0.01	0.22	0.42	0.32	0.44	0.18
Test CCA pile LC	-0.12	-0.12	-0.26	-0.11	0.42	0.10	0.61	-0.11
Baseline concrete LC	0.57	0.59	0.58	0.46	0.48	0.69	0.99	1.00
Test concrete pile LC	0.57	0.59	0.58	0.46	0.48	0.69	0.99	1.00
Baseline steel pile LC	1.00	1.00	1.00	1.00	0.30	1.00	1.00	0.84
Test steel pile LC	1.00	1.00	1.00	1.00	0.30	1.00	1.00	0.84
Baseline plastic LC	0.95	0.83	0.82	0.51	1.00	0.63	0.79	0.27
Test plastic pile LC	0.95	0.83	0.82	0.51	1.00	0.63	0.79	0.27

Figure 5-2 CCA-Treated Wood, Concrete, Steel, and Plastic Piles Normalized Impact Comparisons (Normalized to Maximum Impact = 1)



	Fossil Fuel Use	GHG	Net GHG	Acid Rain	Water Use	Smog	Eutrophication	Air Emission Ecotoxicity
CCA-treated pile	0.22	0.32	-0.01	0.22	0.42	0.32	0.44	0.18
Concrete pile	0.57	0.59	0.58	0.46	0.48	0.69	0.99	1.00
Steel pile	1.00	1.00	1.00	1.00	0.30	1.00	1.00	0.84
Plastic pile	0.95	0.83	0.82	0.51	1.00	0.63	0.79	0.27

Copyright 2012
Treated Wood Council

6. INTERPRETATIONS

The objectives of the interpretation, as defined by ISO, are to analyze results, reach conclusions, explain limitations, and provide recommendations based on the findings of the inventory and assessment phases of the LCA; to report the results of the interpretation in a transparent manner; and to provide a readily understandable, complete, and consistent presentation of the results of the LCA study, in accordance with the goal and scope of the study. The key steps to interpreting the results of the LCA include: **1)** identification of the significant issues based on the results of the LCA phases; **2)** evaluation that considers completeness, sensitivity, and consistency checks; and **3)** conclusions, limitations, and recommendations.

This LCA report is intended to be the basis for communicating LCA findings to public policy decision makers. The intended audiences include:

- Members of the TWC;
- Government regulators;
- Environmental advocates;
- Life cycle inventory database users; and
- End users.

Because the LCA results are intended for public use and make direct comparisons to alternative products, care has been taken to adhere to the requirements of ISO 14044:2006.

6.1 IDENTIFICATION OF SIGNIFICANT ISSUES

The goal and scope, inventory, and inventory assessment phases of this LCA were reviewed to identify data elements that contribute most to the outcome of the results, and thereby are considered significant issues. Identification of the significant issues required a careful review of the products and processes included in the inventory and assessment phases.

6.1.1 Precision and Confidence

Readers should keep in mind that the LCA process is not exact science. Because of the broad scope, variability among producers and products, on-going changes in technology, limited data on key processes, and the need to make assumptions, these results are reasonable estimates. Calculated values are accurate for the intended use in this LCA.

6.1.2 Cradle-to-Grave Scope

Creating an LCA for the cradle-to-grave life cycle of CCA-treated piling provides meaningful results, but is a significantly more complicated process than assessing only a portion of the life cycle. The cradle-to-grave life cycle approach required development of information for various processes beyond simply treating wood with CCA, such as seedling production, planting and growing of trees, the harvest of trees, log peeler operation, pile drying, CCA formulation, the treatment of piles with CCA preservative solution, the installation and piling service life in marine environments, removal, transportation between points, and finally, disposition. Information also was developed for concrete, steel, and plastic piles related to raw materials,

Copyright 2012
Treated Wood Council

manufacture of piles, use, and disposition. Modeling the processes often required developing life cycle inventories by the use of published LCIs for analogous processes and making assumptions about the processes in the absence of full process knowledge. For example, data are available about bauxite mining and production, and are used in lieu of unavailable chromium mining and production data.

These issues are addressed in this LCA with assumptions, and by clearly identifying assumptions within the text and tables of the LCA.

6.1.3 Extended Time Frame

The life cycle of CCA-treated marine piling is greater than only the use stage of 40 years and includes 40 to 50 years of growth and 100s of years of degradation in a landfill. However, all stages of the product life cycle can be considered as occurring simultaneously. Trees are now growing, logs are being peeled and dried, piling is being treated and used, old piling is being recycled or disposed, and previously disposed piling is decaying in landfills.

For the alternative piling products, life of the product begins at manufacture (and includes processes such as natural resource extraction and refining), includes the service life and fates of recycling or disposal in landfills (except for plastic piling that might include some decay in landfills and result in emissions from landfills).

6.1.4 Carbon Accounting

One goal of this LCA is to determine the extent to which the existence and use of treated wood products impacts the carbon balance in the atmosphere. Renewable biologic materials (biogenic), such as food grain or wood, are viewed generally as carbon neutral, meaning carbon dioxide is removed from the atmosphere during growth and then returned as the products are used or disposed, such that on a net basis, the atmospheric carbon dioxide level is not altered. When fossil carbon fuel (such as oil, coal, and natural gas) is used, any emissions resulting from the fossil fuel use result in carbon dioxide in the air that would not have been there without human (anthropogenic) intervention. In practice, even biogenic materials are not completely neutral, due to emissions from transportation and processing that use fossil fuels. Alternatively, a biogenic material can be used or disposed in such a manner that the embodied carbon is not recycled to the atmosphere for many decades or even centuries. For example, books in libraries, wood in buildings that become historic, or biogenic material placed in “dry” landfills can store carbon so that their life cycle is carbon positive, or “better than carbon neutral” and better than the biogenic product’s natural life cycle.

As explained in Section 5.3.1, GHG calculations only consider CO_2 emissions from fossil fuel sources. Biogenic CO_2 sources are considered carbon neutral. However, when considering the carbon balance, in terms of CO_2-equivalents, it is appropriate to combine the two for an understanding of the system as a whole, as has been done in this LCA and reported as “net GHG.”

Accounting for the carbon inputs and outputs throughout a product’s cradle-to-grave life cycle is complex, but assessment can be done using accepted practices. However, a method to assign some benefit to reduced CO_2 atmospheric levels due to the long-term, but temporary, storage of

Copyright 2012
Treated Wood Council

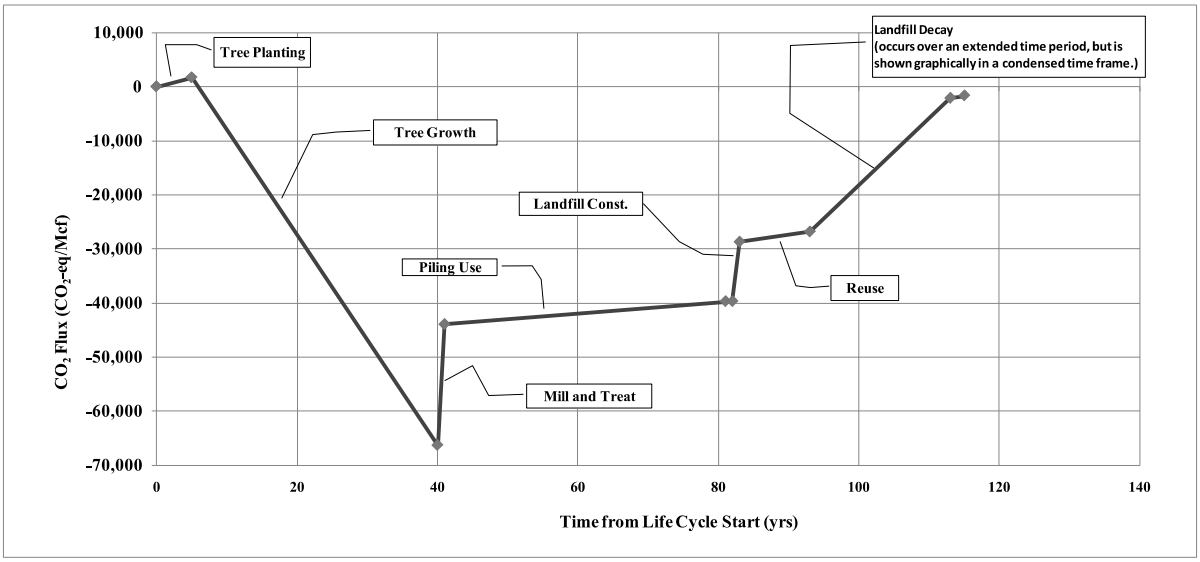
carbon in products is not clear. If release of one pound of carbon dioxide equivalents today counts as one pound, what is the appropriate value in terms of GHG emissions for one pound released in 50, 100, or 500 years from now? Therefore, a conscious decision was made to consider GHG emissions by current LCA accounting, such that releases are counted as equal to releases occurring today, as discussed below in Section 6.1.4.2.

6.1.4.1 Carbon/Carbon Dioxide Balance

This LCA addresses the "cradle-to-grave" life cycle of CCA-treated marine piling. For wood products, carbon (as carbon dioxide) is removed from the atmosphere through photosynthesis by trees as they grow, CO_2 is returned to the atmosphere as portions of the wood (or wood products) decay, at final disposition. If burned, as discussed in the sensitivity analysis, all of the original carbon taken from the atmosphere is returned as biogenic carbon dioxide.

When wood products are landfilled, portions of the biogenic material are stored, portions are released as biogenic CO_2, and a portion is converted to methane. AquAeTer's USEPA-based landfill model predicts that 77 percent of the wood carbon is stored long-term, and, depending on the mix of landfill types in use, approximately 17 percent and 6 percent of the wood carbon will be released to the atmosphere as biogenic carbon dioxide and methane, respectively. Considering that methane is estimated to have 21 times the global warming impact of CO_2, the 6 percent methane is equivalent to 126 percent of the original wood carbon. Of the 100 percent of CO_2 removal by the tree growth, 143 percent (126 percent + 17 percent) of its GHG equivalent is returned to the atmosphere (prior to consideration of the ancillary process using fossil fuels to get the wood products into the market). Thus, considering only the wood product volume landfilled and based on the landfill model and assumptions, the net GHG emission, as CO_2-equivalent, is approximately 1.4 times the GHG removal during wood growth. Additionally, fossil fuel based carbon dioxide emissions such as for electricity for milling, fuel for transport and heat, and fuel and raw materials used to manufacture wood preservatives, result during the wood product life cycle.

Figure 6-1 Life Cycle Carbon Balance of CCA-Treated Piling



Copyright 2012
Treated Wood Council

The case modeled in this LCA and illustrated in Figure 6-1, assumes approximately 70 percent of piles are disposed in landfills, zero percent are used for the production of electricity following primary use, and 30 percent are reused for other purposes, half of which are ultimately disposed in landfills and the remainder eventually rot in-place. The modeled scenario results in a net reduction of GHG emissions rather than an increase. In this example, the inputs and outputs of carbon related to the product begin at zero, rise due to transport and fertilizer for seedlings, and then drop well below zero as the trees grow during approximately 35 years. The flux of CO_2 emissions increases as a result of transport, milling, preservative manufacture, and treatment, shown between years 40 to 41. Emissions climb during the piling use stage, due to transportation emissions between years 41 and 81. Following the marine service life, CO_2 emissions are unchanged because no piles are combusted for energy recovery in this scenario. Following service life, and in this scenario, 70 percent of the piles are disposed in landfills. The impacts of landfill construction are illustrated in years 82 to 83. Releases of CO_2 from piles reused for fencing or landscaping are shown over the next 10 years. Finally, releases due to decay in landfills are shown as the next 20 years. The final value for the cradle-to-grave life cycle is shown at year 115. The decay of reused piles and piles in landfills actually occurs simultaneously, but is separated in time for clarity in this figure. The net impact is that approximately 1,700 lb of CO_2-equivalent per Mcf of CCA-treated piles is removed from the atmosphere over the cradle-to-grave life cycle of the piles (i.e., more carbon dioxide is removed from the atmosphere than added to it).

6.1.4.2 Time Value Issues

In the LCA, GHG emissions are totaled for the product's cradle-to-grave life cycle to a final number (essentially, a life-time carbon balance). However, it is important to understand that many decades are involved before the final value is realized. Piles installed by ports today contain carbon removed from the atmosphere over approximately the previous 40 years. That carbon will remain in the pile for the service life of the pile, and then some will be released back to the atmosphere as piles are combusted for energy or decay in secondary uses, some will be released back as CO_2 or methane as anaerobic decay occurs in landfills, and some will be sequestered in landfills for centuries.

There is value in storing carbon and thus preventing release. Sequestered carbon is an important part of the climate profile of the forest products industry (Miner, 2006). It is noteworthy that, especially for a product with a long service life such as marine piles, disposal happens up to 100 years in the future with decay-related releases occurring over the following 10 to 100 years. By current LCA accounting, such releases are counted as equal to releases occurring today. Use of a time-in-use factor allows some credit for this delayed release, but significantly adds to the complexity of the LCA. It also increases uncertainty in the method and results, and makes the LCA more difficult for readers to understand. Therefore, we note that time factors more accurately assess carbon balance and GHG emissions, but we provide no quantitative analysis in this LCA.

6.1.5 Use of TRACI for Impact Indicators

Use of the USEPA-sponsored TRACI model indicators is appropriate for this LCA because it is being prepared primarily for a U.S.-based audience and because of the broad scope of chemicals

Copyright 2012
Treated Wood Council

and impacts addressed. While TRACI is not well recognized in Europe, its factors for GHG equivalency are those accepted by the Intergovernmental Panel on Climate Change, and factors for air emissions with the potential to impact acid rain, smog, eutrophication, and ecological toxicity have similar basis to those used in USEtox. Thus, although some of the indicators could be less familiar to some readers, the inventory, impact indicators, and comparative analysis is valid internationally.

6.1.6 Potential Marine Ecotoxicity

Releases of CCA preservative constituents to the surrounding marine water are estimated to average approximately 0.021 pound of copper, 0.0042 pound of arsenic, and 0.00012 pound of chromium per year per installed marine pile. The potential for such releases to have a toxic impact to the marine ecology depends on numerous factors, including water flow or circulation rates, ambient levels of these and other metals, and the number of pilings in a row parallel to flow or current being considered for a project. Both copper and zinc are necessary nutrients for life, yet are potentially toxic at elevated levels. A modeling tool, such as the peer reviewed and NOAA Fisheries recognized Preservative Risk Assessment Model (Brooks, 2010), is an appropriate tool for evaluating potential ecotoxicity at specific projects for which CCA-treated marine piling are being considered. The National Marine Fisheries Service (NOAA, 2009) supports the following position in their guidelines for the use of treated wood in west coast fisheries:

> *"Overall, the use of treated wood products in aquatic environments with the examined formulations (ACZA, CCA and creosote) could be acceptable in many proposed projects. However, the products cannot be considered categorically safe, and therefore, require assessment. Many projects, that still propose to use treated wood, may pass a screening level examination and require relatively little assessment for the treated wood related impacts. These determinations require a level of local knowledge that is applied on a case-by-case basis, or through regional or watershed based programmatic examinations. The variability between locations makes it difficult to provide guidance on the scale of the entire west coast of the U.S. and Alaska."*

Alternative products also result in releases to the marine environment. Concrete contains metals such as cadmium and chromium. During use and removal, these metals are released from the concrete to the surrounding environment. A study of concrete in marine waters found that up to 50 percent of the chromium and 40 percent of the cadmium contained in pulverized concrete could be released (Webster, 1996).

As galvanized steel weathers, zinc is released to the environment. Zinc is a known marine ecological concern.

Estimating the marine impact of plastic is complex due to the unknown mix used to make plastic composite piles, the impacts plastics have on the food web, and the wide variety of additives used to formulate plastic products. There can be many different chemical additives contained in plastic that can leach from piles and each plastic product would need to be evaluated on its own unique characteristics. Plastic particles persist in the marine environment for many years and can negatively impact fish, marine mammals, and birds.

Copyright 2012
Treated Wood Council

Releases from piles should be considered in relation to other potential sources. For example, at the Shelter Island Yacht Basin in San Diego, CA, copper in the Basin water is a concern, as 93 percent of the copper has been found to come from passive leaching of antifouling paint on the bottoms of the boats (CA EPA Dept. of Pesticide Regulation, 2010). A second study focused on marinas in the Puget Sound, Washington. With no significant sources of metals identified (no CCA or ACZA piles present in the marina) other than boats with antifouling paint, water in the inner harbor area of Puget Sound consistently exceeded water quality criteria (Johnson, 2007).

Potential marine impacts in the immediate proximity of piling structures of any material should be considered in a broad context. Piling products are installed to provide vertical and horizontal support to piers and wharfs, and single or groups of piles are used together as dolphins. These marine structural products are installed to support the maritime industry. Releases from these structures, associated vessels, and surrounding infrastructure all contribute to impacts within the proximate marine environment. For instance, copper not only is released from CCA-treated pilings, but also from antifouling paint on boat bottoms. A study of leaching from anti-fouling paints (Ytreberg, et al., 2010) reports copper releases in natural brackish seawater at 3.2 to 3.6 micrograms per square centimeter per day (ug/cm^2/day) for professional grade anti-fouling paints and at 1.1 ug/cm^2/day for leisure boat paint. A 50 foot boat might release 1.5 pounds of copper per year if using professional grade antifouling paint or 0.49 lbs per year if using leisure boat paint. As a comparison, a CCA-treated marine pile is estimated to release 0.021 lbs of copper per year, based on the assumptions used for this LCA. Oil and fuel are released from engine operation and refueling. Dredging is done to keep marinas open. Each has a local impact, but not all can be considered using the metrics applied in this LCA. Therefore, this LCA reports releases from installed piling products, but has not attempted to normalize such impact for evaluation of the piling product in comparison to local impacts, nor mitigating measures that could be used.

The USEPA has evaluated CCA and its use for marine pilings in its Reregistration Eligibility Decision (RED) for Chromated Arsenicals (USEPA, 2008a) including studies as part of an Environmental Fate and Transport Assessment of CCA (USEPA, 2008b). The RED summarizes the human health and environmental risks associated with the use of CCA (including marine uses) and includes a thorough review of the scientific database underlying the pesticide's registration. The purpose of USEPA's review, as part of the reregistration, is to reassess the potential hazards arising from the currently registered uses of a pesticide, to determine the need for additional data on health and environmental effects, and to determine whether or not the pesticide meets the "no unreasonable adverse effects" criteria. Based on the findings of the RED, the USEPA found that CCA was eligible for reregistration.

6.1.7 Human Health Indicators

As discussed in Section 5.3.8.1, the TWC membership who funded this LCA believes that human health values could be misconstrued by readers as indicating that the products pose actual risks to the users. Thus, the TWC has limited the scope of this LCA, in accordance with ISO 14040, not to include calculations and presentation of impact indicators for human health (ISO 14040 Section 5.2.1.2).

Copyright 2012
Treated Wood Council

6.1.8 U.S. Average Electricity

Emissions resulting from the use of electricity from the grid, as well as offsets of the same due to recycling to energy, are significant contributors to the impact indicators. The selection of location-specific sources of electricity could lower impacts. For instance, locations in the Pacific NW use a larger fraction of hydropower. Therefore, the use of U.S. average energy is appropriate, recognizing that this LCA is intended to cover average production in the U.S. and that the mix of power sources will continue to change in the future.

6.1.9 Recycling Issues

In this LCA, recycled copper processed into copper carbonate is assessed one-third the inputs and outputs that would be associated with newly mined copper. This estimate approximates the processes of collecting, cleaning, dissolving, and producing powder form copper for use in preservative.

Recycled plastic life cycle inputs and outputs reflect recycling of post-consumer waste that is energy intensive, often requiring separate recyclable collection vehicles and routes, equipment to separate, sort and clean materials, and transport to reuse markets. Additional processing can include melting, pelletizing, flaking, and packaging material to produce useable feedstock for manufacturing use. Life cycle assessments were identified and used to estimate these factors.

Each product in this LCA includes consideration of some form of recycling. Some wood piles are recycled for further use as treated wood and others are recycled as fuel to energy production. A portion of concrete piles could be recycled by grinding to aggregate, if economically feasible. Steel piles are recycled following use, and a fraction of plastic piles are assumed to be recycled. In each case, credit in reduced inputs and outputs is allocated back to the product, as explained in calculation included within Appendix 4.

The methods for accounting for the environmental inputs and outputs related to recycling and use of recycled materials are neither clear nor universally accepted. AquAeTer has transparently applied methods and assumptions that, in our professional opinion, are reasonable and "fair" to each product.

6.1.10 Recycle and Disposal Assumptions

Final disposition of products following the service life stage can have a significant impact on the cradle-to-grave life cycle impact indicators. The use of used CCA-treated wood piles for energy recovery is not currently done; however, it is done for other treated wood products, such as railroad ties and utility poles. For the wood products, use of the post-use product to produce energy off-sets other sources of electricity and results in indicator value credits. Use of out-of-service piles for energy recovery will further improve most impact indicators for CCA-treated marine piles.

6.1.11 Wood Combustion Impacts

Emissions from wood combustion in industrial boilers contribute to impact indicator values. Emission rates are those listed in AP-42 for industrial boilers with only cyclone type particulate

Copyright 2012
Treated Wood Council

controls. The impact indicator values for wood combustion were used for wood combustion by wood treaters, since they do use industrial boilers represented by the AP-42 factors. Larger cogeneration or power generation type combustion units, such as used for biomass beneficially combusted as fuel to produce electricity, use particulate control equipment such as electrostatic precipitators. Therefore, in the sensitivity analysis assessing energy recover using CCA-treated piles, impact indicators were reduced 90 percent to reflect better particulate control, such as available on such combustion units.

6.1.12 Water Use

As noted previously, data on water use are not available for electrical energy production or other energy related inputs. Thus, while water use data are presented for CCA-treated marine piles and alternative products, the usefulness as a comparative indicator is limited. Additionally, water "use" is not clearly defined. For example, cooling water that is "used" and returned to the stream is quite different than water use that evaporates or that is incorporated into products, such as concrete.

6.1.13 Comparative Analysis

AquAeTer was unable to find published LCAs for the alternative products, concrete, steel, and plastic piles, so an LCI was completed for each using publicly available data sources and professional judgment. The methods used to derive the inventory and assess findings were done in a similar manner for both CCA-treated piles and the alternative products; however, independent manufacturing inventory data for concrete, steel, and plastic piles were not collected. Thus comparisons with the alternative products are done as a general comparison and to provide a broad understanding of how CCA-treated piles might compare. Additional LCI and LCA data collection and analysis of concrete, steel, and plastic piles would need to be done in order to make definitive statements regarding the comparability of the two products. The respective manufacturers are encouraged to complete and publish LCAs for concrete, steel, and plastic marine piles.

6.2 EVALUATION

6.2.1 Completeness Check

This LCA covers the cradle-to-grave life cycle of CCA-treated wood marine piles. A similar scope was used in the LCAs completed for concrete, steel, and plastic marine piles. Process inputs and outputs were addressed for the life cycle stages of each product. The evaluation was more detailed for the CCA-treated piles LCA than for concrete, steel, or plastic, and included surveying those treating plants using CCA preservatives. CCA production was modeled using published data and professional judgment. The LCAs for concrete, steel, and plastic products were done to create reasonable approximations for the cradle-to-grave product life cycle. Significant inputs or outputs have been considered so that the impact indicators presented support fair comparisons.

Copyright 2012
Treated Wood Council

6.2.2 Sensitivity Check

The objective of the sensitivity check is to assess the reliability of the final results and conclusions by determining how these are affected by uncertainties in the data, allocation methods, or calculation of category indicator results (International Organization for Standardization (ISO), 2006). A review of the Goal and Scope Document, included as Appendix 1, verifies that the data quality requirements have been addressed by this LCA. A review of the data quality analysis, as detailed in Section 5.12, describes the findings of our sensitivity analysis and uncertainty discussion. Based on the sensitivity tests conducted, we conclude that the assumed inputs can be varied within a wide, but reasonable, range without changing the overall conclusions of this LCA.

6.2.3 Consistency Check

The data, assumptions, and models developed to conduct this LCA have been reviewed to assure that these are used in a manner consistent between products and within the goal and scope. Areas considered include data quality along the product system lives, regional or temporal differences, allocation rules, system boundaries, and application of impact assessment methods. This LCA meets the consistency requirements.

6.3 CONCLUSIONS, LIMITATIONS, AND ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES

6.3.1 Conclusions

This LCA addresses CCA-treated wood marine piles, treated according to AWPA standards for UC-5A, UC-5B, and UC-5C exposure with retentions of 1.5 outer and 0.9 inner zone for UC5A, and 2.5 outer and 1.5 inner zone for UC5B and UC5C, pounds per cubic foot (pcf), intended for marine (salt water) exposure. Such piles typically are driven into soil or sediment using pile drivers. The LCA has determined the cradle-to-grave environmental impacts resulting from seedling production, growth, harvest, manufacture, use, and final disposition of CCA-treated piles; the opportunities to reduce the environmental burdens associated with CCA-treated piles; and made comparisons of the CCA-treated pile product to alternative products. This LCA has been completed in a manner as limited by the Goal and Scope, consistent with the principles and guidance provided by ISO in standards ISO 14040 and 14044, and includes ISO-specified phases such as a Goal and Scope described in Section 2.

Wooden pile manufacture is dependent on the production of round debarked piles from the peeler mill. This LCA has determined that the pre-treatment stage, including seedling production, planting, growth, and harvest of Southeastern species trees, prior to treatment, results in several impact indicators in excess of ten percent of their totals, including fossil fuel, water use and emissions with the potential to impact eutrophication.

The treatment stage, including peeling bark from the piles, production of CCA, drying piles, and pressure application of the CCA preservative, results in several impact indicators in excess of ten percent of their totals, including fossil fuel, water use and emissions with the potential to impact GHGs, acidification, smog, eutrophication, and ecological toxicity. Use of peeler biomass as a

Copyright 2012
Treated Wood Council

fuel to dry piles, and sales of excess biomass as fuel, offsets fossil natural gas use and reduces GHG and fossil fuel use.

The pile use stage includes transportation of piles to their use location and emissions during use, and results in two impact indicators in at or greater than ten percent of their totals including emissions with the potential to impact smog and eutrophication.

Post-use disposition of piles includes reuse for fencing and landscaping, and landfill disposal. The disposition stage results in several impact indicators in excess of ten percent of their totals including fossil fuel use, and emissions with the potential to impact acidification, smog, eutrophication, and air emission ecotoxicity. Disposal of piles in landfills most significantly impacts GHGs, as wood degrades and produces methane.

Impact values for each indicator are listed in tables in Section 5 for each product at each life cycle stage. The values alone do not provide intuitive meaning. These values have been normalized in two ways to make them more useful. The first normalization is to support product-to-product comparisons. Impact indicator values are normalized to the product (CCA-treated pile, concrete pile, steel pile, or plastic pile) having the highest cradle-to-grave value. The product with the highest value through final disposition receives a value of one, and the values for other products are fractions of one. These are depicted on Figure 5-2 for each product. From Figure 5-2, the following conclusions are reached.

- The fossil fuel use, greenhouse gas (GHG), net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for concrete piles.

- The fossil fuel use, GHG, net GHG, acidification, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for steel piles. The water use impact indicator value for steel piles is less than the value for CCA-treated piles.

- The fossil fuel use, GHG, net GHG, acidification, water use, smog potential, eutrophication, and air emission ecotoxicity impact indicator values for CCA-treated piles are less than impact indicator values for plastic piles.

The second means of normalization supports consideration of the overall significance or magnitude of the impacts. It helps to answer the question, "Do these impacts matter?" This normalization relates the total energy and impact indicator values for a representative number of marine piles (assuming that 22.5 million piles are of one of the three types considered) to the annual U.S. national impact values, as shown in Table 5-6. The U.S. impacts were calculated for U.S. annual emissions (Bare, et al., 2006) and for annual U.S. energy, fossil energy, and GHG emissions (Energy Information Association (EIA), 2008). From Table 5-6, the following conclusion is reached.

- National impacts are considered small at less than 0.01 percent (one ten-thousandth) of the national totals. The marine industry should consider marine pilings as one of the many products that contribute impacts as a result of their use.

Copyright 2012
Treated Wood Council

Proximate marine ecotoxicity from CCA-treated piles is best assessed using site specific evaluation.

6.3.2 Limitations

This LCA is limited to boundaries established in the Goal and Scope Document, as modified over the LCA process (Appendix 1). Limitations include reliance on published or publicly available information in many instances. Such information is assumed to be accurate.

As noted in this report, the Scope of this LCA was modified through an iterative process that included the TWC membership, AquAeTer, internal reviewers, and the independent external review team. The TWC, as sponsor of this report, decided that impact indicators for human health would not be calculated or presented in this LCA for reasons detailed in this report. The decision to eliminate human health impact discussion is noted as a limitation of this LCA. AquAeTer and TWC understand this omission is a variance from ISO guidance, but have supported our opinion in a reasoned manner and conclude that this variance is allowed under ISO 14040 Section 5.2.1.2.

Ratings of products by the impact indicator values in this LCA provide comparative values that are intended as a tool to assist in making judgments about a product's properties. Selection and the decision to purchase products, such as the marine piles addressed in this LCA, can require various value judgments that are beyond the scope of this LCA, such as purchase price, ease of installation, proven performance, and aesthetics.

The life cycle inventories completed for concrete, steel, and plastic piles were designed to represent the typical or average products on the market, and so by design, likely will not be accurate for any specific product in the categories. Further, the scope of investigation of the alternate products required use of publicly available information and professional judgments. A survey of manufacturers was not made to inventory inputs and outputs for concrete, steel, or plastic pile production, so some inputs and outputs at the concrete, steel, and plastic pile manufacturing facility are not be fully accounted for. Professional judgment was required to complete the inventories.

The manufacture of concrete piles starts with fundamental building components, and AquAeTer used readily available information for these processes provided in the U.S. LCI database. In addition, a confidential manufacturer of concrete products provided pertinent data on the manufacture of concrete products. The manufacture of concrete piles also requires the use of steel. Steel life cycle information is provided in the U.S. LCI database. In addition, the International Iron and Steel Institute was contacted and provided data used in the LCI. Water use is not reported in the available inventory data from NREL; thus, water use data were incorporated from the document, "Water Use in Industries of the Future: Steel Industry" (Ellis, et al., 2003).

The manufacture of steel piles starts with hot-rolled sheet steel. Hot-rolled sheet steel life cycle information is provided in the U.S. LCI database. In addition, the International Iron and Steel Institute was contacted and has provided data used in the LCI. Water use is not reported in the available inventory data from NREL; thus, water use data were incorporated from the document,

Copyright 2012
Treated Wood Council

"Water Use in Industries of the Future: Steel Industry" (Ellis, et al., 2003). Professional judgment used in the LCI for steel piles was determined through sensitivity analysis to have minimal impact. Thus, it was determined that information used to perform the LCI of steel piles comes from peer reviewed and published data sources and did not require additional "interested party" review.

The LCI modeling of the manufacture of plastic piles uses data from the NREL Life Cycle Database. Downloaded modules include HDPE, ethylene, and hot-rolled sheet steel production. An LCI on recycled plastic (Arena, et al., 2003) also was used to develop inputs and outputs necessary for collection and processing of post-consumer plastic. Marine releases from plastic were not estimated due to insufficient data.

It was determined that information used to perform the LCIs of alternative products comes from peer reviewed and published data sources and does not require further "interested party" review.

This LCA focused on CCA-treated wood marine piles as a baseline preservative for the purpose of conducting the assessment, with the understanding that preservative formulations and preservative types can change.

6.3.3 Environmental Improvement Opportunities

One of the goals of the LCA is to determine how the industry might incorporate changes in the various life cycle stages of CCA-treated piles to reduce environmental burdens associated with the manufacture, use, and final disposition of the product. The following are opportunities for the continued improvement of CCA-treated marine piles based on the findings of this LCA.

6.3.3.1 Biomass Utilization

The LCA shows clear benefits to the impact indicators considered, particularly fossil energy, GHG, acidification, and ecological toxicity, with the use of biomass as an energy source and therefore significant potential remains for further biomass use. The baseline assumption in this LCA is no (zero percent) post-use wood piles being recycled for energy. The environmental aspects of CCA-treated marine piles can be improved as more piles are recycled for energy, as long as such energy recovery is done at permitted facilities with appropriate emission controls. The industry should continue and perhaps broaden its outreach to Federal and State legislators to recognize and reward beneficial recycling of post-use wood piles as a renewable source of energy.

6.3.3.2 Reduction of Releases from Piling During Use

The LCA has identified releases of constituents of concern from CCA-treated piles during use in marine environments. Industry efforts to reduce such releases could reduce impacts to local marine environments. For example, polyethylene wraps or coatings are offered by some piling providers. However, there are no accepted quality standards for such coatings and data documenting the long term reduction of releases or longevity of the coatings are not available.

Copyright 2012
Treated Wood Council

6.3.3.3 Landfill Minimization and Selection

The treated wood industry and marine authorities should seek to minimize releases of methane resulting from disposal of wood in landfills in two ways: minimize disposal in landfills, and minimize disposal to landfills that do not have methane collection systems. Minimizing landfill disposal is doubly beneficial, since it is generally accomplished by shifting the disposition of post-use piles to biomass use instead of disposal, thus offsetting other fossil fuel use and reducing landfill emissions. Landfills that collect methane become carbon positive as the carbon dioxide equivalent release becomes less than the amount sequestered.

6.3.3.4 Energy Efficiencies

Production facilities should, to the extent practical and cost effective, continue to strive to reduce energy inputs through conservation and innovation.

6.3.3.5 Transportation

Production facilities should continue to strive to source materials from locations closer to use, and to use the most efficient modes of transportation. Rail transport of raw materials or products can reduce environmental burdens when compared to truck transport.

Copyright 2012
Treated Wood Council

7. CRITICAL REVIEW

7.1 INTERNAL REVIEW

An internal review of the LCA product was provided using a team of three knowledgeable and experienced reviewers. The purpose of the AquAeTer internal review is to provide a review of the LCA process prior to draft submittal to TWC's member review panel. The review team reviewed and commented on the LCA products. AquAeTer addressed the internal review team comments, as appropriate, and maintains a record of all comments and responses for future reference.

Following AquAeTer's internal review evaluation, documents were submitted to TWC for review. TWC assembled a member team to review the LCA. AquAeTer provided TWC with the draft Goal and Scope and draft LCA reports for review. TWC managed the reviews and provided comments to AquAeTer. AquAeTer addressed comments, as appropriate, and maintains a record of comments and responses for future reference.

This LCA is a product of work done by AquAeTer in accordance with its agreement with TWC. The technical and editorial comments of all reviewers were carefully considered and in most instances incorporated into the final document. In instances where review comments conflicted with AquAeTer opinions or the opinions of other reviewers, an appropriate effort was made to reach consensus with the members of the TWC review team.

AquAeTer Internal Reviewers:

- James H. Clarke, PhD., Professor of the Practice, Civil and Environmental Engineering, Earth and Environmental Sciences, Vanderbilt University;
- Maureen E. Puettmann, PhD., Independent Consultant, Environmental Life Cycle Assessment, WoodLife; and
- Craig R. McIntyre, PhD., Independent Consultant, Wood Scientist, and Chemist to the Wood Preservation Industry, McIntyre Associates, Inc.

TWC Reviewers:

- TWC Members

7.2 INDEPENDENT EXTERNAL REVIEW

AquAeTer issued the LCA to TWC following the comment and response period. One of TWC's goals in conducting the LCA is for comparison of treated wood products to alternative products. A second goal is the distribution of LCA for public use. In accordance with ISO guidance, specific requirements are applied to an LCA that is intended to be used in comparative assertions and those LCAs disclosed to the public. Each LCA report was submitted for independent external review. TWC was responsible for issue of the report to the independent external review panel.

Copyright 2012
Treated Wood Council

The external review process is intended to ensure consistency between the completed LCA and the principals (ISO 14040:2006, 4.1) and requirements (ISO 14044:2006) of the International Standards on LCA and enhance the credibility of the LCA. The independent external review members include parties familiar with the requirements of LCAs and parties having appropriate scientific and technical expertise. The independent external review team selected a member to act as chairperson per the requirements of ISO 14040:2006, 7.3. Dr. Paul Cooper served as chairperson for the external review team.

The independent external review was tasked to verify whether the LCA has met the requirements for methodology, data, interpretation and reporting, and whether the LCA is consistent with the principles. The independent external review did not verify nor validate the goals that were chosen for the LCA nor the ways in which the LCA results were to be used. The independent external review is not an endorsement of the comparative assertions that are done based on the findings of the LCA.

Independent External Review Team:

- Paul Cooper, PhD., Professor of Wood Science and Technology, University of Toronto, Department of Forestry Science;
- Mary Ann Curran, PhD., Life Cycle Assessment Research Program Manager, USEPA, Office of Research and Development; and
- Yurika Nishioka, PhD., Consultant, Sylvatica Life Cycle Assessment Consulting.

7.3 CRITICAL REVIEW REPORTS

The Goal and Scope Document and LCA Procedures and Finding Report of CCA-Treated Piling have been reviewed by AquAeTer's internal review team, TWC review team, including members of TWC, and an independent external review team. Comments and responses from AquAeTer's internal review team and the TWC review team are managed in project files and available for review upon request. The independent external review panel review comments and associated responses are included in Appendix 8.

Copyright 2012
Treated Wood Council

8. WORKS CITED

AFC News Source Plastic in the Plankton [Online] // AFC News Source. - http://www.acfnewsource.org/environmental/plsatic_plankton.html.

American Galvanizers Association Galvanize it [Online]. - American Galvanizers Association, 2002. - 04 21, 2010. - http://www.galvanizeit.org/images/uploads/publicationPDFs/SP_SGRS_02.pdf .

American Wood Protection Association Standard Factors 3-Volumes of Round Forest Products [Book Section] // 2010 AWPA Book of Standards. - Birmingham : American Wood Protection Association, 2010.

American Wood Protection Association Standard P5-09 Standard for Waterborne Preservations [Book Section] // 2010 AWPA Book of Standards. - Birmingham : American Wood Protection Association, 2010.

American Wood Protection Association Standard T1-10 Use Category System: Processing and Treatment Standard [Book Section] // 2010 AWPA Book of Standards. - Birmingham : American Wood Protection Association, 2010.

American Wood Protection Association Standard U1-10 Use Category System: User Specification for Treated Wood [Book Section] // 2010 AWPA Book of Standards. - Birmingham : American Wood Protection Association, 2010.

Arena U., Mastellone M. I. and Perugini F. Life Cycle Assessment of a Plastic Packaging Recycling System [Journal] // International Journal of Life Cycle Assessment. - 2003. - 2 : Vol. 8. - pp. 92-98.

Ayres R. U., Ayres L. W. and Rade I. The Life Cycle of Copper, its Co-Products and By-Products. [Journal]. - [s.l.] : Mining, Mineral and Sustainable Development, 2002. - Vol. 22.

Bare J. [et al.] TRACI–The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts [Journal] // Journal of Industrial Ecology. - [s.l.] : The MIT Press, 2003. - 3-4 : Vol. 6. - pp. 49-78. - http://mitpress.mit.edu/jie.

Bare J., Gloria T. and Norris G. Development of the Method and U.S. Normalization Database for Life Cycle Impact Assessment and Sustainability Metric [Journal] // Environ. Sci. Technol. . - 2006. - 16 : Vol. 40. - pp. 5108-5115.

Brooks K. M. Environmental Risk Assessment for CCA-C and ACZA Treated Wood [Online] // Western Wood Preservers Institute. - April 15, 2003. - http://www.wwpinstitute.org. - Available from http://www.wwpinstitute.org.

Copyright 2012
Treated Wood Council

Brooks K. M. General Risk Assessment Model Aquatic Guide (Excel file) [Online]. - 2010. - http://www.wwpinstitute.org/.

Brooks K. M. Literature Review and Assessment of the Environmental Risks Associated with the Use of CCA Treated Wood Products in Aquatic Environments [Online]. - August 1, 1997. - http://www.wwpinstitute.org.

CA EPA Dept. of Pesticide Regulation U.S. EPA Registration Review for Coppers (Docket No. EPA-HQ-OPP-2010-0212). - Sacramento : [s.n.], December 16, 2010.

California Steel Industries (CSI) The Process of Galvanizing Steel [Online]. - December 9, 2009. - http://www.californiasteel.com/GetPublicFile.aspx?id=59.

Concrete Tecnology Corporation (CTC) [Online] // Piling Properties. - Concrete Technology Corporation. - April 20, 2010. - http://www.concretetech.com/products/pile_properties.htm..

Cooper P Leaching of CCA - Facts and Contradictions [Conference] // The 2003 Colley/Hartford Memorial Lecture. - [s.l.] : American Wood Preservers Association, 2003.

CORRIM Life Cycle Environmental Performance of Renewable Materials In The Context Of Residential Building Construction: Phase I Interim Research Report [Report]. - [s.l.] : Consortium for Research on Renewable Industrial Materials, 2002.

Crawford D [et al.] Laboratory Studies of CCA-C Leaching: Influence of Wood and Soil Properties on Extent of Arsenic and Copper Depletion [Report]. - [s.l.] : The International Research Group on Wood Preservation, 2002. - Paper prepared for the 33rd Annual Meeting.

Deutsches Kupferinstitut Life Cycle Assessment Data: Copper Tube, Copper Wire, Copper Sheet [Online]. - 2008. - http://www.kupfer-institut.de/lifecycle/.

Deutsches Kupferinstitut Life Cycle Assessment Data: Copper Tube, Copper Wire, Copper Sheet [Online]. - 2008. - 2008. - http://www.kupfer-institut.de/lifecycle/.

Ellis Mark, Dillich Sara and Margolis Nancy Industrial Water Use and Its Energy Implications. [Report]. - [s.l.] : U.S. Department of Energy, 2003.

Energy Information Association (EIA) Annual Energy Review 2007 [Online]. - U. S. Dept. of Energy, Energy Information Administration, Washington, D.C., 2008. - http: //www.eia.doe.gov/aer.

Fenton M.D. Mineral Commodity Profiles—Iron and Steel [Online]. - US Geologic Survey, 2005. - 2010. - http://pubs.usgs.gov/of/2005/1254/2005-1254.pdf.

Franklin Associates Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Two Polyurethane Precursors [Report]. - Prairie Village, Kansas : Franklin Associates, 2007.

Copyright 2012
Treated Wood Council

Freeman M. H. Personal Communication. - 2009.

Galvanizers Association of Australia (GAA) Durability of Heavy Galvanizing and Service Life: A Guide to the Service Life of Galvanizing in the Australian Environment [Online]. - 2010. - 2010. - http://www.gaa.com.au/technical_solutions/technical_acrogc.html.

GalvInfo GalvInfoNote 1.10 Useful Galvanized Sheet Metrics. [Online] // GalvInfo Center. - International Zinc Association, March 2010. - http://www.galvinfo.com/ginotes/GalvInfoNote_1_10.pdf.

Garrain D. [et al.] LCA of Thermoplastics Recycling [Online]. - 2007. - http://www.gid.uji.es/docs/articles/Garrain_07_00.pdf.

Gjovik L. R. and Baecher R. H. Selection, Production, Procurement and Use of Preservative Treated Wood [Report]. - Madison, Wis. : U.S. Dept. Agric., For. Serv. GTR, FPL-15, 1977. - p. 36.

Hoffman M. H. World Almanac and Book of Facts 1988 [Book]. - 1988.

International Iron and Steel Institute (IISI) Life Cycle Inventory for Steel Products [Report]. - 2006.

International Organization for Standardization (ISO) Environmental Management-Life Cycle Assessment-Principles and Framework [Report]. - Switzerland : [s.n.], 2006. - ISO 14040:2006.

International Organization for Standardization (ISO) Environmental Management-Life Cycle Assessment-Requirements and Guidelines [Report]. - Switzerland : [s.n.], 2006. - ISO 14044:2006..

Johnson A. Dissolved Copper Concentrations in Two Puget Sound Marinas [Report] / Environmental Assessment Program ; Washington State Department of Ecology. - Olympia : Department of Ecology, 2007.

Johnson L. [et al.] Forest Resources-Pacific Northwest and Southeast. CORRIM Phase I Final Report Module A: Life-cycle environmental performance of renewable building materials in the context of residential building construction [Online] / prod. CORRIM. - 2004. - 2009. - http://www.corrim.org/reports.

Johnson L. [et al.] Life-cycle impacts of forest resource activities in the Pacific Northwest and the Southeast United States [Journal]. - [s.l.] : Wood Fiber Sci., 2005. - December : Vol. 37. - pp. 30-46.

Kennedy M Depletion of Copper-Based Preservatives from Pine Decking and Impacts on Soil-Dwelling Invertebrates [Conference]. - Orlando : Florida Center for Environmental Solutions, 2004.

Copyright 2012
Treated Wood Council

Lebow S. T., Lebow P. K. and Foster D. O. Estimating Preservative Release from Treated Wood Exposed to Precipitation. , 40(4), 2008, PP.. [Journal] // Wood and Fiber Science. - 2008. - 4 : Vol. 40. - pp. 562-571.

Limbachiya M Marrocchino E, and Koulouris A Chemical-mineralogical characterisation of coarse recycled concrete aggregate [Online] // Science Direct. - Elsevier, January 11, 2006. - February 10, 2011. - http://www.sciencedirect.com.

Loebenstein J. R. The Materials Flow of Arsenic in the United States [Online]. - U.S. Department of Interior, Bureau of Mines, 1994. - January 20, 2010. - http://pubs.usgs.gov/usbmic/ic-9382/arsenic.pdf.

Mato Yukie [et al.] Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment [Journal]. - [s.l.] : environmental Science & Technology, 2001. - 2 : Vol. 35. - pp. 318-324.

Menard J. F. [et al.] Life Cycle Assessment of a Bioreactor and an Engineered Landfill for Municipal Solid Waste Treatment [Online]. - 2003. - 2008. - www.lcacenter.org/InLCA-LCM03/Menard-presentation.ppt.

Miller J. Personal Conversation // Pressure Treaters in the U.S.. - Washington, D.C. : [s.n.], 2009.

Miner R. The 100-Year Method for Forecasting Carbon Sequestration in Forest Products in Use [Journal] // Mitigation and Adaptation Strategies for Global Change. - [s.l.] : Springer Netherlands, May 22, 2006. - 1381-2386.

National Renewable Energy Laboratory U. S. Lifecycle Inventory Database [Online]. - http://www.nrel.gov/lci/.

NOAA The Use of Treated Wood Products in Aquatic Environments: Guidelines to West Coast NOAA Fisheries Staff for Endangered Species Act and Essential Fish Habitat Consultations in the Alaska, Northwest and Southwest Regions. [Report]. - [s.l.] : NOAA-Fisheries, Southwest Region, 2009.

Panshin A.J. and deZeeuw C Textbook of Wood Technology [Book]. - New York : McGraw-Hill, 1980. - 4th ed : p. 722.

Papp J. F. Chromium Life Cycle Study: Information Circular 9411 [Online]. - U.S. Bureau of Mines, 1994. - http://pubs.usgs.gov/usbmic/ic-9411.

Papp J. F. Commodity Summary 2009: Chromium [Online]. - United States Geological Survey, January 2009. - http://minerals.usgs.gov/minerals/pubs/commodity/chromium/mcs-2009-chrom.pdf.

Platt B., Lent, T., Walsh, B. The Healthy Building Network's Guide to Plastic Lumber. 2nd ed. [Online] // Healthy Building Network / prod. Self-Reliance Institute for Local. - October 2005. - 2010. - www.healthybuilding.net.

Copyright 2012
Treated Wood Council

Rios Lorena M. [et al.] Quantitation of Persistent Organic Pollutants Absorbed on Plastic Debris from the Northern Pacific Gyre's "Eastern Garbage Patch" [Journal]. - [s.l.] : Journal of Environmental Monitoring, December 2010. - Vol. 12. - pp. 2226-2236.

Smith, S. T. Comments Regarding the Economic Alternative Materials Sections of: "Treated Wood in Aquatic Environments: Technical Review and Use Recommendations." - Vancouver, WA : Western Wood Preservers' Institute, 2006.

Song J, Dubey, B, Jang, Y, Townsend, T, and Sole-Gabriele, H Implication of Chromium Speciation on Disposal of Discarded CCA-Treated Wood [Journal]. - [s.l.] : Journal of Hazardous Materials, 2006. - 2/3 : Vol. 128.

Sugiyama T Takahashi S, Honda M, Sakai E Current state of the JSCE standard on test method for leaching of trace elements from hardened concrete [Online] // Special Abstracts. - June 11-13, 2007. - March 2, 2011. - http://www.claisse.info/special%20papers/sugiyama_full_text.pdf.

Townsend T., Stook, K, Ward, M., and Solo-Gabriele, H. Leaching and Toxicity of CCA-Treated and Alternative-Treated Wood Products: Report #-2-4 [Report]. - Gainesville : Florida Center for Solid and Hazardous Waste Management, 2003.

US Navy Navy Wood Survey Summary, Special Publication SP-2042-SHR - Naval Failities Engineering Service Center. Theresa Hoffman and David Pendleton. - June 1998.

USDA Forest Products Service, Forest Products Laboratory Wood Handbook-Wood as an Engineering Material General Technical Report FPL-GTR-190 [Book]. - Madison : [s.n.], 2010. - p. 508.

USEPA Construction and Demolition Materials [Online]. - U.S. Environmental Protection Agency, 2008. - http://www.epa.gov/CDmaterials.

USEPA Environmental Fate and Transport Assessment of CCA-C for Reregistration Eligibility Decision (RED) Process [Report]. - Washington, D.C. : USEPA, 2008b.

USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2007: Report No: EPA 430-R-09-004 [Report]. - Washington, D.C. : U.S. Environmental Protection Agency, 2009.

USEPA National Recommended Water Quality Criteria [Report]. - [s.l.] : USEPA-Office of Water, 2009.

USEPA Plastic Pellets in the Aquatic Environment, Sources and Recommendations, Final Report [Report]. - 1992. - Conducted by the Oceans and Coastal Protection Division, Contract No. 68-C8-0105.

USEPA Reregistration Eligibility Decision for Chromated Arsenicals [Report] / Office of Prevention, Pesticides and Toxic Substances. - [s.l.] : USEPA, 2008a. - EPA 739-R-08-006 - Case No. 0132.

Copyright 2012
Treated Wood Council

USEPA Solid Waste Management and Greenhouse Gases, A Life Cycle Assessment of Emissions and Sinks, 3rd Edition. [Report]. - Washington, D.C. : U.S. Environmental Protection Agency, 2006.

USEtox USEtox—the UNEP-SETAC Toxicity Model: Recommended Characterization Factors for Human Toxicity and Freshwater Ecotoxicity in Life Cycle Impact Assessment. . USEtox web site: www.usetox.org. [Online] / prod. 532-546 Int. J Life Cycle Assess (2008) 13: Pages. - 2008. - www.usetox.org.

USGS Water Science for Schools: Water questions and answers: Water use [Online]. - 2009. - http://ga/water.usgs.gov/edu/qausage.html.

Vlosky R. Statistical Overview of the U. S. Wood Preserving Industry: 2007 [Report]. - 2009.

Webster M.T. and Loehr, R.C. Long-Term Leaching of Metals form Concrete Products [Journal]. - [s.l.] : Journal of Environmental Engineering, 1996. - August.

Western Wood Preservers Institute Best Management Practices (BMPs) [Report]. - 2006.

Ytreberg E., Karlsson J. and Eklund B. Comparison of Toxicity and Release Rates of Cu and Zn from Anti-fouling Paints Leached in Natural and Artificial Brackish Seawater [Journal] // Science of the Total Environment. - [s.l.] : Elsevier, May 15, 2010. - 12 : Vol. 408. - pp. 2459-2466.

Internet References:

www.wikipedia.com (Wikipedia Searches):
- Horsepower
- Arsenic
- Chromium
- Copper
- HDPE

NREL. National Renewable Energy Laboratory, U.S. Life Cycle Inventory Database, web site www.nrel.gov/lci/.

NREL U.S. LCI Database: Chemical Manufacturing. HDPE resin at plant.

NREL U.S. LCI Database: Chemical Manufacturing. Ethylene production, at plant.

NREL U.S. LCI Database: Chemical Manufacturing. Natural gas, processed, at plant.

NREL U.S. LCI Database: Chemical Manufacturing. Polyethylene terephthalate resin production.

NREL U.S. LCI Database: Rail Transportation. Transport, train, diesel powered.

Copyright 2012
Treated Wood Council

NREL U.S. LCI Database: Truck Transportation. Transport, combination truck, diesel powered.

NREL U.S. LCI Database: Forestry and Logging. Softwood logs with bark, harvested at average intensity site, at mill, US SE.

NREL U.S. LCI Database: Utilities. Anthracite coal, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Bituminous coal, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Diesel, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Diesel, combusted in industrial equipment.

NREL U.S. LCI Database: Utilities. Electricity, alumina refining regions.

NREL U.S. LCI Database: Utilities. Electricity, aluminum smelting and ingot casting regions.

NREL U.S. LCI Database: Utilities. Electricity, anthracite coal, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, at grid, Eastern US.

NREL U.S. LCI Database: Utilities. Electricity, at grid, Texas US.

NREL U.S. LCI Database: Utilities. Electricity, at grid, US.

NREL U.S. LCI Database: Utilities. Electricity, at grid, Western US.

NREL U.S. LCI Database: Utilities. Electricity, bauxite mining regions.

NREL U.S. LCI Database: Utilities. Electricity, biomass, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, bituminous coal, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, diesel, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, lignite coal, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, natural gas, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, nuclear, at power plant.

NREL U.S. LCI Database: Utilities. Electricity, residual fuel oil, at power plant.

NREL U.S. LCI Database: Utilities. Gasoline, combusted in equipment.

NREL U.S. LCI Database: Utilities. Lignite coal, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Liquefied petroleum gas, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Natural gas, combusted in industrial boiler.

Copyright 2012
Treated Wood Council

NREL U.S. LCI Database: Utilities. Natural gas, combusted in industrial equipment.

NREL U.S. LCI Database: Utilities. Residual fuel oil, combusted in industrial boiler.

NREL U.S. LCI Database: Utilities. Wood waste, unspecified, combusted in industrial boiler.

NREL U.S. LCI Database: Water Transport. Transport, barge, residual fuel oil powered.

NREL U.S. LCI Database: Water Transport. Transport, ocean freighter, residual fuel oil powered.

NREL U.S. LCI Database: Forestry and Logging. Roundwood, Softwood, US SE.

USGS, 2009. Water Science for Schools: Water questions and answers: Water use. Web site: http://ga/water.usgs.gov/edu/qausage.html.

Copyright 2012
Treated Wood Council

APPENDIX 1

PROJECT GOAL AND SCOPE

APPENDIX 2

EXAMPLE OF THE TREATER SURVEY

APPENDIX 3

U.S. ELECTRIC ENERGY GRID LIFE CYCLE INVENTORY CALCULATIONS

APPENDIX 4

LIFE CYCLE INVENTORY CALCULATIONS

APPENDIX 5

LIFE CYCLE INVENTORY SPREADSHEET

APPENDIX 6

ASSUMPTIONS

APPENDIX 7

SENSITIVITY ANALYSIS RESULTS

APPENDIX 8

CRITICAL REVIEW REPORTS AND RESPONSES

REAL ESTATE
UNIVERSITY of WASHINGTON

U.S. FISH & WILDLIFE SERVICE
WFWO
DEC 05 2014
LACEY, WA
RECEIVED

December 3, 2014

VIA EMAIL - WFWOComments@fws.gov

Tim Romanski
U.S. Fish and Wildlife Service
510 Desmond Drive SE, Suite 102,
Lacey, WA 98503

Scott Anderson
NOAA Fisheries
10 Desmond Drive SE, Suite 103,
Lacey, WA 98503

Re: Proposed Aquatic Lands Habitat Conservation Plan

Dear Mr. Romanski and Mr. Anderson:

Thank you for the opportunity to comment on 1) the Washington State Department of Natural Resources (DNR) proposed Aquatic Lands Habitat Conservation Plan (August 2014) (proposed DNR HCP) and 2) the Draft Environmental Impact Statement to Analyze Impacts of Issuance by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) of Two Incidental Take Permits under Section 10 of the Endangered Species Act for Implementation of the Washington Department of Natural Resources' Aquatic Lands Habitat Conservation Plan (August 2014).

The University of Washington (UW) appreciates the hard work of DNR aquatic staff, in collaboration with representatives from USFWS and NMFS, in producing this HCP. UW supports the DNR's goals and objectives of developing an HCP that formalizes the agency's efforts to conserve and enhance the State's aquatic lands, and provides a stable management framework grounded in science and based on the principles of sustainability.

With that in mind, the UW is primarily concerned about the application of the proposed DNR HCP conservation measures to our existing overwater structures. We request that the DNR HCP include a project specific review for existing overwater structures owned and operated by public agencies. As an example of the issue we would like addressed, we will use the dock at UW Friday Harbor Laboratories (UW-FHL).

Campus Box 359446 Seattle, WA 98195-9446
206.616-3400 fax 206.685-1547 uwreo@u.washington.edu http://www.washington.edu/admin/reo/index.php

Founded in 1904, UW FHL is a marine biology field station of the University of Washington, located in Friday Harbor, San Juan Island, Washington. Friday Harbor Labs offers intensive summer classes to undergraduate and graduate students in various fields of marine biology and other marine sciences, including Marine Algae, Marine Invertebrate Zoology, Comparative Invertebrate Embryology, Marine Conservation Biology, Functional Morphology and Ecology of Marine Fishes, Invertebrate Larval Ecology, Experimental and Field Approaches in Biology and Paleontology, and other current topics in marine science and oceanography. In addition to serving students, Friday Harbor Laboratories has a small resident scientific staff and offers year-round laboratory, library, and housing accommodations for visiting researchers.

UW-FHL operates its dock as part of its marine science teaching/educational outreach and research programs. The dock is used annually by 150 enrolled students at UW-FHL, in addition to K-12 Marine Science Outreach Program, 100 visiting independent graduate students, and 10-15 visiting classes from a variety of educational institutions across the country. The dock is used for moorage of the 58' Research Vessel *Centennial*, as well as three to six small boats. The dock also has a dive locker for scuba divers to dress and store equipment in, a scuba compressor, a shed for Remotely Operated Vehicle (ROV) as well as an instrumentation room with meteorological equipment owned by National Marine Fisheries Service (NMFS). On occasion, UW-FHL has allowed moorage to other governmental agencies conducting research in the San Juan Islands, These agencies include US Fish and Wildlife, the Whale Museum, the Marine Mammal Stranding Network, and NMFS.

The UW-FHL dock is located on DNR managed aquatic lands leased from the state of Washington. As currently drafted, the DNR HCP is unclear regarding how the overwater structure conservation measures (described in DNR HCP Section 5.2.1) would be applied to existing structures. If the DNR HCP required absolute compliance with these overwater structure conservation measures as a condition of a new long term aquatic lease for the UW-FHL dock, several of these conservation measures (such as the buffer distance requirements, 100 grating requirements, and near shore building requirements) are not suitable to the UW-FHL dock and would likely require the UW to make major (and potentially impossible) modifications to the dock. The UW does not believe that these conservation measures should be applicable to the existing structures at UW-FHL.

While the DNR HCP does allow the applicant to propose counterproposals (see DNR HCP Section 5.2 at page 5-9), the counterproposal approval process as currently drafted is vague and appears unworkable. This approval process appears to impose a default obligation upon the leaseholder to comply with the overwater structure conservation measures, instead of allowing the parties to engage in a collaborative process to develop a suitable suite of conservation measures.

For this reason, the UW requests that the DNR HCP include a project specific review for existing overwater structures owned and operated by public agencies. This project specific review should allow for flexibility in the development of site specific conservation measures suitable for the existing overwater structure. This review should balance: 1) the site specific environmental impacts of the existing structures, 2) the site specific conservation benefits of complying with overwater structure conservation measures, 3) the costs associated with

compliance with conservation measures, and 4) the public interest considerations with respect to the facility.

The UW again appreciates the opportunity to comment on the DNR HCP and the significant effort of DNR, USFWS, and NMFS in developing this HCP. The UW also looks forward to working with DNR, USFWS, and NMFS in finalizing the HCP and addressing the UW comments outlined in this letter.

Sincerely,

Jeanette Henderson
Executive Director
UW Real Estate

WFWOComments, FW1 <wfwocomments@fws.gov>

WDNR Aquatic Lands HCP DEIS

1 message

Dallin Brooks <dallin@wwpinstitute.org> Wed, Dec 3, 2014 at 11:28 AM
To: WFWOComments@fws.gov
Cc: david.palazzi@ddnr.wa.gov, lalena.amiotte@dnr.wa.gov, eric@wwpinstitute.org

Tim Romanski, U.S. Fish and Wildlife Service

Scott Anderson, NOAA Fisheries

Cc David Palazzi, DNR

Cc Lalena Amiotte,DNR

Cc Eric, WWPI

Attached you will find 4 documents.

1. A letter with comments on chapter 5 of the proposed Aquatic Lands Habitat Conservation Plan.

2. A Full Life Cycle Analysis of the environmental impacts of preserved wood in marine use compared to steel and concrete.

3. The screening level assessment, recommended by NOAA Guidelines, to support consistent, objective decisions in assessing the potential effects of proposed applications of treated wood in aquatic environments.

4. The detailed site-specific risk assessment worksheets for use when planning and selecting preserved wood to determine if there is an environmental impact.

We would appreciate your consideration of our position and look forward to consulting with you on how best to ensure that preserved wood is used in an environmentally responsible way.

Best Regards,

Dallin Brooks

Executive Director

Western Wood Preservers Institute

www.wwpinstitute.org

Administrative Vice President

North American Wood Pole Council

www.woodpoles.org

360-693-9958 Cell 360-823-3898

---

4 attachments

WWPI Response Letter .pdf
233K

LCA CCA Marine Piling Final copy 9 28 12.pdf
1348K

FinalDraft_Screening Level Assessment 07 27 11.pdf
2208K

General Risk Assessment Model Aquatic Guide April 2010 (2).xls
3049K

WESTERN
WOOD PRESERVERS
INSTITUTE

December 2, 2014

Washington State Dept. of Natural Resources
Aquatic Resources Division
1111 Washington St. SE
Olympia, WA 98504-7027

Subject: Draft Aquatic Lands Habitat Conservation Plan

To Whom It May Concern:

Western Wood Preservers Institute (WWPI) is a non-profit trade association based in Vancouver, Washington. WWPI serves the interests of the wood preserving industry in western North America so that renewable resources, exposed to the elements, can maintain favorable use in aquatic, building, commercial and utility industries.

This letter is in response to a meeting held with David Palazzi and Lalena Amoitte of the DNR on October 21, where the draft Aquatic Lands Habitat Conservation Plan was discussed. We take notable exception to the draft plan and the attitude expressed by the DNR that preserved wood is a liability to the environment. In particular, we take issue with statements such as the following from Chapter 5 (pg. 5-29) of the plan:

> *"No exposed treated wood may be used as part of the decking, pilings, or other components of any in-water structures, such as floats, docks, wharves, piers, marinas, rafts, shipyards, and terminals."*
>
> *"During maintenance that involves replacing treated wood, the existing treated wood must be replaced with alternative materials, such as untreated wood, steel, concrete, or recycled plastic."*
>
> *"Treated wood leaches harmful chemicals into the aquatic environment, degrading water and sediment quality. Chemicals in treated wood can be absorbed or ingested by covered species and may cause biological dysfunction. Many of these chemicals can bioaccumulate in higher trophic levels through food web dynamics, impacting health and reproduction."*

These statements are wholly without scientific merit and they ignore the fact there are several options in preservatives as well as applications that are safe for use in aquatic environments. The language in the plan is effectively a ban on the use of preserved wood, which is entirely unacceptable as an across-the-board solution to water quality issues in the state of Washington. The unsupported statements in the plan are contrary to how preservative treated wood is safely used in aquatic applications today, per the following reasons:

1. **Science has clearly indicated that wood preservatives are not the contributor** to Puget Sound water quality issues as has been claimed. There are numerous scientific studies available showing that plants and aquatic life are able to thrive on preserved wood pilings and the migration of preservatives into water, in most cases, have a negligible impact on the environment.

12503 SE Mill Plain Blvd. • Suite 205 • Vancouver, WA • 98684
360-693-9958 • Toll Free 888-693-9958 • www.WWPInstitute.org

2. **Not all preservatives are alike**. There are two classifications of preservatives: oil borne and water borne. Each of these classifications has different options of preservatives for different applications. For instance, the use of carbon-based waterborne preservatives are allowed for decking above ground, however these are not appropriate for in-ground contact. Wood preservatives have long been approved for use by the U.S. EPA for certain applications. Standards set under a national consensus by the American Wood Protection Association guide how much of each preservative should be used for each exposure condition. Therefore, the one-size-fits-all approach belies established facts concerning accepted uses.

3. **Best Management Practices** (BMPs) developed by WWPI to guide the specification and use of preserved wood in aquatic and sensitive environments are available when a preservative is selected. These BMPs are the industry's best available science to prevent the movement of preservative from the wood into the environment. Many users of preserved wood (such as the U.S. Forest Service, port and marinas) specify BMPs as part of their standard procedures.

4. **Risk assessment models that have been approved by NOAA Fisheries** are available to conclusively determine if there will be an impact from using preserved wood. Developed in partnership by WWPI and Oregon State University, the risk assessment models are available at no charge and can predict if the movement of preservatives into the water and soil will cause unacceptable environmental risk. These models allow users to take a site-specific approach to the piling, decking, water flow, soil type, background levels and other criteria on a case-by-case approach. Similar risk models are not available for alternative materials that would replace preserved wood, thus allowing an unknown risk to replace a known and controllable risk.

5. **Life Cycle Assessments** (LCAs) conducted under international standards shows that wood is far better for the environment than alternatives. By banning preserved wood, the DNR is taking a "NIMBY - Not In My Backyard" approach to the environment. This effectively ignores the larger impacts of the production of steel, concrete and plastics on the environment due to their higher fossil fuel use, GHG emissions, water use, smog, eutrophication and ecotoxicity.[1] While these alternative may be more inert as a finished product, their production still has significant impacts on the environment that should not be overlooked.

6. **Economics also play a role**, as alternatives such as steel are more expensive and come from out of state, which does not create local jobs and tax receipts that the preserved wood industry contributes to here in Washington state. This rule will have a direct detrimental effect on Washington's economy and more should be done to understand the economic impact of this regulation.

7. **Nothing is without risk.** The approach from the DNR that 0% risk is all that is acceptable is naïve and unfounded. It is clear the DNR intends to pick on the preserved wood industry as "low-hanging fruit" to create a perception of cleaning up the Puget Sound. In reality, eliminating the use of preserved wood only removes a negligible source of potential contaminants, while significant sources of these same

[1] Journal of Marine Environmental Engineering, http://www.oldcitypublishing.com/JMEE/JMEEcontents/JMEEv9n3issuecontents.html.

contaminants are completely ignored as contributing factors to water quality.

All products have risk, including alternatives to preserved wood. Galvanized treated steel has a sacrificial layer to protect the steel from rusting, a layer that can migrate into the environment when disturbed. Concrete has additives in it that can migrate into water, while spalling in concrete products reveals rusting rebar and the corresponding environmental impacts from that exposure.

In addition, recommending the use of untreated wood creates the risk that a construction project may need to be reconstructed every 4 or 5 years. Each reconstruction doing more damage to the surrounding soils and waters. Using properly treated wood for construction would mitigate that risk.

8. **The plan language is outside the scope of enabling statute.** A rule with such a sweeping effect of this magnitude is outside the scope of the agency's rulemaking authority. This proposed type of drastic change should be considered by the state legislature, not imposed arbitrarily by agency fiat.

Preserved wood has a long record of safe and effective use in aquatic uses, backed by scientific data that affirms it can be used in an environmentally responsible way. We believe the draft Aquatic Lands Habitat Conservation Plan unnecessarily restricts the use of preserved wood. These restrictions are tantamount to dismantling an entire industry based on misleading information. Adopting a rule of this magnitude without further consideration of the underlying assumptions is counterproductive to the state's efforts to protect the aquatic environment.

As such, WWPI proposes the DNR take a more nuanced, informed approach by using a preservative treated wood risk assessment model on a case-by-case basis. We believe the DNR can meet its goal of protecting the environment by amending the wording in Chapter 5, page 5-29 of the plan by wholly replacing the language under the section "Treated wood" with the following:

> *"Before using treated wood products on a new project, such as floats, docks, wharves, piers, marinas, rafts, shipyards, terminals, decking, pilings, or other components of any in-water structures an approved risk assessment model must be applied to determine if there is any negative impact on the environment. This model is available free of charge from Western Wood Preservers Institute at www.wwpinstitute.org."*

Keeping all options open is a win-win for the environment, the preserved wood industry and the end users who may choose to utilize wood. Those who are willing to utilize a risk assessment and obtain the necessary permits should not be arbitrarily excluded from having the option to use preserved wood in their construction project near an aquatic environment.

We appreciate your consideration of our position and would be happy to discuss with you further. Please see enclosed screening level assessment worksheets and full risk assessment model worksheets.

Sincerely,

Dallin Brooks
Executive Director
Western Wood Preservers Institute

General Model for 11 types of commonly used treated wood

Site	
Project	
Date	
Evaluator	

User Inputs. **Those highlighted in blue will generally require site specific inputs**

Piling

1. Piling Retention (kg/m^3)	40
2. Number of piling in a row paralleling the currents	2
3. Number of piling bents	4
4. Average piling radius (cm)	15
5. Distance between piling in a row paralleling the currents (cm)	300
6. Receiving water channel width (cm)	10000

Immersed Lumber

7. Surface area of cases lumber that is immersed at Mean High Water (MHW) (cm^2)	200
8. Immersed Lumber Retention (kg/m^3)	4

Rainwater exposed lumber and piling

9. Surface area of cases lumber and piling above MHW exposed to rainfall (cm^2)	200,000
10. Above water lumber retention (kg/m^3)	4

Box dimensions

11. Box width or width of a stream channel under an overhead structure (cm)	1,500
12. Box length paralleling the currents (cm)	600
13. Mean water depth in the box (cm) (measured so the depth at MHW in tidal systems)	200
14. Maximum tidal current speed or V_{tidmax} (cm/sec)	15
15. Steady State Current Speed or V_{ss} (cm/sec)	10
16. Model speed or V_{model} (cm/sec)	10

Water characteristics

17. Average annual water temperature (degrees C)	12.5
18. Freshwater pH	8.0
19. Water Hardness (mg CaCO3/L	50.0
20. Salinity (PSU or parts per thousand)	0.0
21. Background dissolved copper concentration (µg Cu/L)	1.5
22. Background dissolved arsenic concentration. (µg As/L)	1.2
23. Background dissolved chromium concentration (µg Cr/L)	0.5
24. Background dissolved zinc concentration. (µg Zn/L)	2.2
25. Background dissolved pentachlorophenol concentration (µg pentachl/L)	0.0

Rainfall characteristics

26. Annual Rainfall (cm/year)	100.0
27. Steady State Rainfall rate (cm/day)	0.274
28. Storm event (cm/hour)	0.000
29. Duration of the Storm event (hours)	0.000

Sediment characteristics

30. Sediment Total Organic Carbon (percent)	1
31. Sediment density (g/cm^3)	2.5
32. Sediment porosity (unitless) (n/1-n) for porosity at depth of the RPD for crustacean (cm)	2
33. Background sediment copper concentration (mg/kg)	15
34. Background sediment arsenic concentration (mg/kg)	2.0
35. Background sediment chromium concentration (mg/kg)	0.1
36. Background sediment zinc concentration (mg/kg)	18.5
37. Background sediment pentachlorophenol concentration (mg/kg dry)	0
38. Background sediment PAH concentration (mg/kg)	0

Other

39. Days since construction for determining contaminant concentrations in water	0.1
40. Settling velocity (0.05 cm/sec for creosote and 0.005 cm/sec for other contaminants)	0.005
41. Anti-tusted lifetime of the project. Default is 30 years with a minimum of 10 years	30.00
42. Half angular increase in width of the sediment deposition zone downstream & offshore	0.25
43. Channel Width (cm)	2000000.00

Note: To convert retention from pounds per cubic foot to kg/m^3, multiply pcf by 16.03

Preservative: **ACQ-B or C** | **3** ← **Enter numeric codes from column P in Cell K1**

NA

Table 4. Preservative loss rates from immersed treated wood

On day 0.5

Contaminant	Migration Rate (µg/cm^2-day)
Copper	44.054
Arsenic	0.000
Chromium	0.000
Zinc	0.000
TEB	0.000
PROP	0.000
IMID	0.000
Creosote (PAH)	0.000
PENTA	0.000
DDAC	0.000

Table 5. Preservative concentrations in rainwater runoff

Contaminant	Concentration (µg/L)
Copper	13779.578
Arsenic	0.0
Chromium	0.0
Zinc	0.0
TEB	0.0
PROP	0.0
IMID	0.0
Creosote (PAH)	0.0
PENTA	0.0
DDAC	0.3

Table 6. Dilution Water Volume Factors

Volume of rainwater runoff from pressure treated wood (L/d)	34.76
Dilution water passing through the box with steady state currents (L/d)	328,320,000
Dilution water in the box within 12 hour of slack tide (L)	NA
Rainwater dilution (20 cm deep) water moving through the box with steady state currents (L/day)	32,832,000
Rainwater dilution (20 cm deep) within 12 hour either side of slack tide (L)	NA

Table 7. Dissolved contaminant concentrations leaving the box (µg/L)

Contaminant	Background	From Immersed	From Rain	Total	Acute Benchmark	Chronic Benchmark
Copper	1.50	0.000	0.006	1.50	8.936	6.278
Arsenic	1.20	-	0.000	1.20	360.00	190.00
Chromium	0.20	-	0.000	0.20	311.04	100.00
Zinc	2.80	-	0.000	2.80	65.61	58.09
TEB	0.00	-	0.000	-	32.00	18.50
PROP	0.00	-	0.000	-	51.00	9.30
IMID	0.00	-	0.000	-	27.3/~10 cm/sec	17.00
Creosote (PAH)	0.00	-	0.000	-	3.000	1.000
PENTA	0.00	-	0.000	0.00	26.78	15.64
DDAC	0.00	-	0.000	0.00	NA	49.00

Box Model for predicting sediment accumulation of contaminants from pressure treated wood (mg/kg)

Table 8. Predictions of the area of sediment contamination (cm^2)

	Minimum	Maximum	Area (cm2)
Effective width of sediment footprint (cm)	1.900	17681.8	
Distribution downcurrent for rainwater contaminants (cm)	300000	400,000	887,510,171
Distribution downcurrent for contaminants from immersed wood (cm)	0.0	400,000	3,922,230,098
Maximum width of the sediment footprint (cm)	1.900	17681.8	

Table 9. Surface areas (cm^2) of pressure treated wood for determining total contaminant loading

Immersed treated wood (cm^2)	226,280
Rainwater exposed wood (cm^2)	200,000

Table 10. Maximum contaminant sediment concentration (mg/kg)

Contaminant	Background	From Immersed	From Rain	Total (mg/kg)	Sediment Quality Criterion (mg/kg)
Copper	15.00	0.00	0.04	15.00	80.000
Arsenic	2.00	-	-	2.00	20.000
Chromium	0.50	-	-	0.50	95.000
Zinc	12.40	-	-	12.40	140.000
TEB	0.00	-	-	-	NA
PROP	0.00	-	-	-	25.000
IMID	0.00	-	-	-	NA
Creosote (PAH)	0.00	-	-	-	37.000
PENTA	0.00	-	-	-	0.400
DDAC	0.00	0.0000	-	0.00	50.000

Table 11. Dissolved contaminant in water during a storm event

Contaminant	Concentration (µg/L)
Copper	0.00000
Arsenic	0.00000
Chromium	0.00000
Zinc	0.00000
TEB	0.00000
PROP	0.00000
IMID	0.00000
Creosote (PAH)	0.00000
PENTA	0.00000
DDAC	0.00000

Table 1. Loss rates of wood preservative active ingredients

Preservative	Code	Metal loss from immersed wood (µg/cm2-day)				Metal in rainwater (µg/l)				Organic C Compounds: From Immersed Wood (µg/cm2-day)			Organic C Compounds: Organic in Rainwater (µg/L)					
		Copper	Arsenic	Chromium	Zinc	Copper	Arsenic	Chromium	Zinc	PAH (Cran)	PENTA	TEB	PAH (Cran)	PENTA	PROP	TEB	IMID	DDAC
CCA-C	1	NA	NA	NA		NA	NA	NA										
ACZA Marine	2M	NA	NA		NA	NA	NA		NA									
ACZA Freshwater	2F	NA	NA		NA	NA	NA		NA									
ACQ-B or C	3	44.054				13779.58												0.300
CA-B	4	NA				NA						NA				NA		
Wolman Dispersed CA-C	5					NA									NA	NA		
Osmose Smartscence	6					NA										NA		
Reserved	7					NA												
Copper Naphthenate	8	NA				NA												
Wolman AG	9														NA	NA	NA	
Creosote	10									NA			NA					
Pentachlorophenol	11										NA			NA				

Table 2. Maximum accumulation of wood preservative active ingredients in sediments

Preservative	Code	Max metal accumulation from immersed wood (µg/cm2)				Maximum metal accumulation - rainwater runoff (µg/cm^2)				Max accumulation Immersed - (µg/cm^2)			Maximum accumulations of organics from rainwater runoff (µg/cm^2)					
		Copper	Arsenic	Chromium	Zinc	Copper	Arsenic	Chromium	Zinc	PAH (Cran)	PENTA	TEB	PAH (Cran)	PENTA	PROP	TEB	IMID	DDAC
CCA-C	1	NA	NA	NA		NA	NA	NA										
ACZA Marine	2M	NA	NA		NA	NA	NA		NA									
ACZA Freshwater	2F	NA	NA		NA	NA	NA		NA									
ACQ-B or -C	3	5,439.0				8653.002												
CA-B	4	NA				NA						NA				NA		
Wolman Dispersed CA-C	5					NA												
Osmose Smartscence	6					NA												
Reserved	7					NA												
Copper Naphthenate	8	NA				NA												
Wolman AG	9														NA	NA	NA	
Creosote	10									NA			NA					
Pentachlorophenol	11										NA			NA				

Table 3. Benchmarks for assessing active ingredients

	FW Acute Dissolved Freshwater	FW Chronic Dissolved	Marine Acute Dissolved Marine	Marine Chronic Dissolved Marine	Marine Sediment	Freshwater Sediment	
Copper	8.9	6.3	4.8	3.1	390.0	80	
Arsenic	360.0	190.0	69.0	36.0	57.0	20	
Zinc	65.6	58.1	90.0	81.0	410.0	140	
Chromium	311.0	100.0	110.0	50.0	260.0	95	High this in sediments (days)
PAH	$\sum$ TU=0.186	$\sum$ TU=0.186	$\sum$ TU=0.186	$\sum$ TU=0.186	13.3	37.0	409.79
Pentachlorophenol	24.78	15.64	13.00	7.90	0.36	0.4	144.934
PROP	51	9.3	6.3	NA	-	25	11.1
TEB	32	18.5	NA	NA	NA	NA	46
IMID	27.3/~10 cm/sec	12	30.8	15.4	NA	NA	146
DDAC	NA	49	NA	49	10	10	

Notes: 1) Acute criteria are one-hour average concentrations

2) Chronic criteria are four day averages that are allowed once every three years

3) Marine saltwater copper quality criteria from, Ambient Water Quality Criteria - Saltwater Copper Addendum (DRAFT) April 14, 1995.

4) Water Quality Criteria for metals from WAC 173-201

5) Marine SQC for metals and PAH from WAC 173-204

6) Freshwater SQC for metals, PAH and Penta estimated using WDOE (2003)

Note that these are values presented by the authors that have not been adopted by Ecology on the date of the publication.

7) 3.0 µg TPAH/L is a threshold below which photosenhanced PAH activity has not been observed. Users can also use the $\sum$TU=0.18 method of Swartz *et al.* (1999) by assuming that PAH are released from creosote in the proportion as they are found in expressate from treated wood.

8) Sediment quality criteria for Marine PAH and Freshwater Penta are Organic Carbon Based. Values are correctal for the percent TOC recorded in sediments and entered in SES48 by the user.

9) NA = Not Determined