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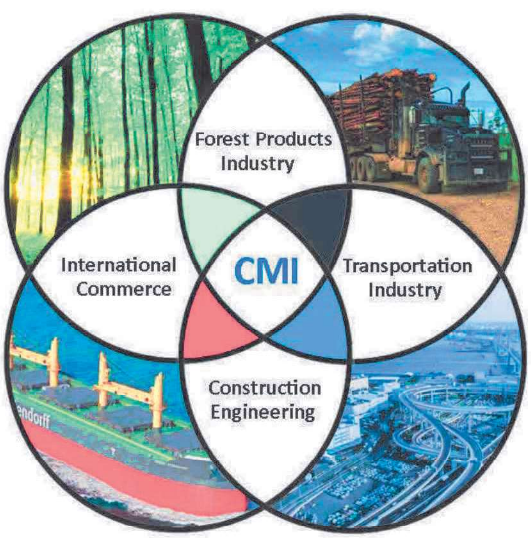

February 1, 2024
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PIPELINE HYDRO-TRANSPORT OF WOOD CHIPS: *Connecting Perry, to the Port of Eastport, Maine with a Continuous Flow of Wood Chips for Export.*

March 8, 2023, revised December 15, 2023

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Abstract
A process is offered in this study for optimizing an economic model of a pipeline network envisioned to transport woodchips hydraulically, as an alternative to traditional transportation, by heavy over the road trucking. Transportation of wood chips by pipeline is an environmentally sound, socially responsible, and economically viable paradigm shift for; invigorating and sustaining Maine's forest products industry, the enactment of meaningful international trade opportunities, enhancing local workforce development opportunities for economically disadvantaged, disenfranchised, and Native American communities, fully utilizing the deep-water port of Eastport, while dramatically reducing the carbon emission footprint and costly highway infrastructure expenditures by excluding truck transportation along Route 190, which traverses the Passamaquoddy Tribal Community through Pleasant Point.

Introduction

Wood chip feedstock supply is heavily impacted by a level of transport efficiency or by its negative effect on environmental exigencies, when predominantly associated with heavy over the road, truck-based transportation. This paper examines an alternative transport process for movement of wood chips from Perry, Maine to Port of Eastport, for subsequent loading to a vessel. Pipeline hydro-transport of wood chips is an economically viable means of delivering large volumes of wood chips, and "can replace conventional modes of transport (*e.g.,* truck transport, or rail transport)"[1] to reduce the intrinsic costs associated with supply chain logistics, to reduce or eliminate barriers negatively impacting export supplies, and to support fiberboard, plywood, and furniture manufacturers, as well as establishing sustainable sources of renewable energy to wood chip biomass facilities globally.

This paper reviews extant studies and publications produced by various segments within the forest products and transportation industries regarding traditional means and methods of transportation, and onshore pipeline transport of wood chips in water mixed (slurries). The aim is to: identify challenges and structural barriers to hydro-transport; apply appropriate mechanical and construction related performance equations necessary to support this assessment; facilitate a business environment built around the practical regulations and transparency necessary to ensure sustainable, ethical, and responsible business practices to implement and guide hydro-transport processes through lenses of Corporate Social Responsibility (CSR).

Beyond the expansive financial costs of truck transport, there are existential threats to our regional and global environment - intensified by transportation, not only by truck transport but, also by rail. Industrial and commercial transport is inextricably associated with

[1] Vaezi, M., Kumar, A., Experimental Programs, Empirical Correlations, and Economic Assessments, Accessed at: https://www.sciencedirect.com/science/article/abs/pii/S0961953415300155

high carbon emissions, CO_2 contamination of the atmosphere. Overland truck transportation is viewed in comparison to other forms of on land bulk transport modes such as rail.

Transportation in this review includes pipeline hydro-transport versus heavy over-the-road truck transport. All transport is hereinafter referred to as 'onshore' transportation. This assessment explores an alternative onshore pipeline hydro-transport option for the movement of wood chips. Transporting wood chip by pipeline is not a new concept, which has been successfully utilized in Maine for effective and efficient transport of wood chips and residual materials, however it is examined anew here as a paradigm alternative to truck or rail transport. We discuss a pipeline scenario that would supplant the reliance upon truck transport with its heavy toll upon society in the social, economic, and environmental context.

Previous utilization and successes of hydraulic transport of wood chips by pipeline
In the 1920s Fraser Paper Ltd. of Toronto, opened a significantly large paper mill in Madawaska, Maine. This facility, as well as International Paper's kraft mill at Van Buren, consumed large amounts of pulp wood at the time, preceding the Great Depression era circa 1930. Another large mill at Edmunston, N.B., CA supplied the paper machines at Madawaska with pulp via a pipeline which ran across the St. John River.[2] The current owners of this pipeline, Twin Rivers Paper Company ("TRPC") of Toronto, have sought permits to reposition, and or make necessary modification to the pipeline, still used to transport wood chip commodities between its pulp mill in Edmundston, NB, Canada and Madawaska, ME, USA.[3] The pulp is pumped over, utilizing a pipeline under and across the St. John River, feed stock and water are separated through a filter and the water is resent to Edmundston through a return pipeline.

In August of 1907, the Town of East Millinocket's mill produced its first, using groundwood that was transported in a pipeline from Dolby.[4] Another pipeline received its operating license in East Millinocket, Maine in 1975 serving the pulp and paper industry. It was known as the Dolby I Landfill. This pipeline transported forest product residuals, "wastewater sludge, woodroom/woodyard waste, wood ash, and general forest related rubbish from the Millinocket and East Millinocket mills. Waste was hauled to Dolby I between 1975 and 1979 and a final soil cover was placed over Dolby I in 1980-81. The East Millinocket mill received sulfite pulp from Millinocket through a nine-mile-long pipeline.[5] Dolby stopped receiving and handling forest related waste in approximately 2012, when papermaking operations in Millinocket and East Millinocket were terminated. Over the last 10-years of operation, the pipeline transported an average of 60 million gallons of slurry mixture per year (MG/yr) or roughly 164,000 Gallons per day (*gpd*). The pumps could operate 24-hours per day, 7-days per week.[6]

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[2] Clark, J., *The Emergence of The Paper Plantation: Historical Geographies of the Pulp and Paper Industry in Maine, 1880 To 1930*, A Thesis in Geography, The Pennsylvania State University, The Graduate School, College of Earth and Mineral Sciences Accessible at: https://etda.libraries.psu.edu/files/final_submissions/2691

[3] Twin Rivers Paper Company *Application for the Approval of the Relocation of Pulp and White Water Pipelines*, January 6, 2023, Accessible at: Paper

[4] Danforth, Wayne, *"History of East Millinocket Maine"* Page 60, (2019). Maine History Documents. 185. Accessible at: https://digitalcommons.library.umaine.edu/mainehistory/185

[5] McCann, Paul K., "History of the Great Northern Paper Company in the 1970s and 1980s" (1992). Great Northern Paper Company Records. 161. Accessible at: https://digitalcommons.library.umaine.edu/great_northern/161

[6] Study to *Assess Treatment Alternatives for Reducing PFAS in Leachate from State-Owned Landfills* Accessible at: Paper

The Pulp and Paper Research Institute, of Canada began its pipeline transport research in 1957, with a preliminary experimental line of roughly 5-centimeters (roughly 2") in diameter, which proved wood chips could be hydraulically transported in this manner. The concept seemed too radical a departure from conventional practices of sending the wood … by truck or rail.[7] Afterward, the institute installed at its new laboratories at Pointe Claire, Quebec, a prototype loop of aluminum pipe 20.3 centimeters (8") in diameter and 0.16 kilometer (525 LF) in length. Using conventional wood chips, supplied from a nearby mill and sent through this pipeline at varying velocities and in varying mixtures with the water. The velocities used ranged from 1.2 to 3 meters (3.9ft to 9.85ft) per second and the mixtures ranged up to 48 percent by volume of wood.[8] At this high concentration of wood chips, a 20-centimeter diameter pipeline would be capable of transporting approximately 800 tons bone-dry of wood per day from forest to mill at a flow rate of 1.8 meters per second, and a pipeline 88 kilometers in length would empty itself in approximately 24 hours. Hence, there would be no strong requirement for a large pile of chips at the mill or at the feeder end of the pipeline. Thus, year-round operations would be possible and it was estimated that 900,000 cubic meters of wood would be necessary to feed such a line on a continuous basis the year round. Moreover, it was established that the chip-water slurry could be passed through an ordinary centrifugal pump without damage and, indeed, that the damage to the wood for pulp or papermaking was really negligible after it had been given the equivalent of hundreds of kilometers of transportation in the pipeline.[9]

The Georgian Research Institute (GRI) of Forest Industry contemplated studies of a steel pipeline system; using a 300 mm (11.8") diameter over an 80-120 km (roughly 49.7 – 74.6 mile) length, for the transport of wood chips, utilizing an experimental velocity of 1.6 meters (5.25 feet) per second. However, to precisely study the technical and economic feasibility of the project, GRI built a prototype pipeline system; using a 150 mm (6") diameter over a 48-meter (roughly 157.5 feet) length, for the transport of wood chips, utilizing experimental velocity ranging from 1.0 to 2.5 meters (3.28084 to 8.2 feet) per second. This research experiment concluded that "pipelines are fully suitable for the transport of wood chips in water suspension."[10]

25-Benefits and predictions related to a hydro-transport wood chip pipeline

1. Low unit transportation costs. (*In this study, Perry to Eastport unit costs will vary between a 300,000 and 600,000 annual export volume of wood chips, over a 10-mile pipeline versus a pipeline of up to 50-miles deeper into the wood basket*).

2. Operation of a pipeline is a low labor intensity activity. This is also a minor cost item in the overall budgeting process and will change only by the approximate index associated with a cost of living in the region. There should therefore be only a minor increase in transportation costs over a predicted 20-year pipeline lifecycle.

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[7] Thiesmeyer, L., A paper prepared for the Conference on Pulp and Paper Development in Africa and the Near East, Cairo, 8-20 March 1965. This conference was organized by FAO, the Economic Commission for Africa, and the United Nations Bureau of Technical Assistance Operations, *Hydraulic transportation of wood chips by pipeline*, Accessible at: https://www.fao.org/3/21636e/21636e05.htm

[8] Id.

[9] Id.

[10] Vaezi *Supra*, Footnote 1

3. Low annual depreciation charges associated with a buried pipeline, alongside and within the state right-of-way along Route 190, as compared to new rail or continuous new road construction or reconstruction.

4. A continuous-flow hydro-transport system will significantly reduce, if not eliminate the need for large volumes of wood chip stockpiling and inventories.

5. Continuous pipeline operation will adequately feed scheduled monthly arrivals of wood chip carriers and other transport vessels, on a consistent volume thus, assuring annual off-take volumes are sustained.

6. All transported wood chips arrive to the port facility with no shrinkage, degradation, and are environmentally shielded from contaminants at all times.

7. Greater utilization of small-diameter wood (tree-tops and branches), considered to be forest residuals of low value, which are now largely wasted.

8. Safeguarded from regional weather and terrain conditions, which is principally significant in the northern regions of the US and particularly the farthest eastern coastal port town of Maine, bordering on Canada.

9. Slurry water can be recycled through a return feed pipeline, and filtered consistently to remove forest product fines and avoid water spillage into the coastal waters of Eastport.

10. The return pipeline can be utilized as a pressurized water supply for fire-fighting in an emergency, with a predetermined spacing of permanent fire hydrants at vital locations.

11. Possible ownership and management of the pipeline system can be placed with the Passamaquoddy Tribal Community through Pleasant Point.

12. Significant funding opportunities are likely to be readily available to the Passamaquoddy Tribal Community, through the issuance of various government agencies, federal funding platforms, and other such financial entities.

13. Conceivable numerous uses of the pipeline for alternate species and end-user specifications of wood chips available in the same forest areas.

14. A pipeline system can be established as a singular and independently controlled supply chain entity, designed to receive wood chips from trucking firms at a receiving yard in Perry. This section of the supply chain is responsible for moving the wood chips through the pipeline, from receipt of the chips to the dispensing of wood chips at the port facility.

15. A raw fiber receiving, sorting, classification, and aggregation yard can be owned and operated by another firm, with specific duties and responsibilities to ensure adequate arrival of, quality and quantity of wood chips, for feeding into the loading hopper of the pump station, owned and operated by others.

15. A hydro-transported wood chip volume will be received, handled, and loaded to vessel, where this operation can be owned and operated by another firm, with specific duties and responsibilities to ensure adequate arrival of, quality and quantity of wood chips, for timely and adequate loading of wood chips to the vessel(s), where the pipeline operation is independently owned and operated by others.

16. Potential off-take contracts, which are already significantly under preliminary discussion, with top tier international buyers, can total roughly 600,000 to 660,000 Metric Tonnes of fiber, of various species and specifications, for alternative end user purposes.

17. Off-take contracts can be established with either one or any combination of participants in this pipeline process.

18. Rapid pipeline clean-out sequencing can provide for various wood chip species, specifications, and end-user demands to be met, thus lending the pipeline operation to be beneficial to each and/or all participants depending upon the off-take contract arrangements.

19. Independent, third-party pipeline monitoring and inspection services, via integrated computerized oversight will provide quantity, quality, and performance assurance static reports for financial monitoring and reporting agencies, and to monitor specifically mandated temperature and duration requirements for the export of wood chips to anywhere in the EU from the continental boundaries of North America.

20. Additional pipeline routes can be established from deeper within the forest feedstock regions, thereby allowing for feedstock to be transported by pipeline-to-pipeline systems with minimal reliance upon truck traffic.

21. By having a network of strategically positioned pipeline system for movement of wood chips; foresters and trucking firms can produce and deliver more loads per day, as a direct benefit of having to travel shorter distances to their respective delivery sites. This is similar to being able to off-load three trucks per day, for a total of two freight rail cars or about 75 – 80 tons per day, versus delivery of one or at most two loads per day to a farther away destination on a daily basis.

22. The installation and utilization of a pipeline hydro-transport system for wood chips will reduce the carbo footprint emissions along that route by a factor of 84% or more by eliminating truck traffic.

23. An example of the elimination of truck traffic along a 10-mile stretch of Route 190 via the Passamaquoddy Tribal Community through Pleasant Point, is as follows. To transport 300,000 metric tons (330,000 short tons) of wood chips to the Port of Eastport by truck traffic, with individual payloads maximized at 30-tons per truck, will require about 11,000 truckloads per year, or 917 loads per month, or 153 loads per week (on a 6-day week). That is 26 loads per day, and if the roads are open for 12-hours per day that is a minimum of 2.1-loads per hour. That is only the one-way fully loaded trip, which is doubled when trucks have to return to their originations.

24. An example of the elimination of truck traffic along a 10-mile stretch of Route 190 via the Passamaquoddy Tribal Community through Pleasant Point, is as follows. To transport 600,000 metric tons (660,000 short tons) of wood chips to the Port of Eastport by truck traffic, with individual payloads maximized at 30-tons per truck, will require about 22,000 truckloads per year, or 1,834 loads per month, or 306 loads per week (on a 6-day week). That is 52 loads per day, and if the roads are open for 12-hours per day that is a minimum of 4.2-loads per hour (every 15-minutes). That is only the one-way fully loaded trip, which is doubled when trucks have to return to their originations.

25. By eliminating heavy truck traffic required for wood chip transport, the above-mentioned benefits will be realized, along with the reasonable reliance upon additional types of export materials remaining available to travers the Route 190 corridor without impeding normal traffic flow, and thereby enhancing the potential export viability of the port facility.

The economic advantages of pipeline transportation are quite attractive[11]

Automation: Pipelines have been automated for approximately twenty years. Once the wood chips are fed into the mixing tower, and the proper ratio of water to wood chips has been

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[11] Hoffman, I., *A method for optimizing a network of pipelines for transporting woodchips*, Pg. 2, Accessed at: https://scholarworks.montana.edu/xmlui/bitstream/handle/1/5393/31762100143401.pdf?sequence=1

reached, the slurry mixture is introduced into the pipeline and left unattended until the next input juncture or until it is discharged. Pumping stations are controlled automatically from a central master station, and various monitoring controls can be installed at predetermined locations or junctions along the way.

Dependability: The dependability of pipelines has been proven. The Gil Sonite pipeline in Utah has been operating for seven years.[12] The Consolidated Coal Company operated a 108-mile pipeline in Ohio without a shutdown for three years (evidencing a flow of solid materials harsher than wood chips).

Operating Costs: Operating costs are low; other costs are mostly fixed and remain nearly constant over the life of the installation, which is typically estimated to have a 20-year life-cycle. Other transportation systems have higher operating costs and are more easily affected by the fluctuating and generally rising costs of labor and personnel.

Maintenance Costs: Maintenance costs are low since pumping stations have few moving parts and the pipeline is buried and subject to little wear.

Inadvertent Attributes of Pipeline Installation and Hydro-Transport of Wood Chips
A financially significant, capital cost containment, benefit to the construction of a pipeline along Route 190 is that it is the most sensible route because the path is already-cleared, graded, protected and is an easily-accessible right-of-way along the state highway. This is the same type of benefit that inures to the construction of a pipeline along a railway, for long-distance pipelines. Where a pipeline route could be seen as a substitute transportation alternative for those moving wood chips over long distances; rail companies could become joint owners and or entirely own a wood chip hydro-transport system to retain clientele and move substantial quantities of commodities, at a much lower price per ton rate, while recognizing a slightly larger profit margin, on the pipeline transport method, while keeping transportation costs low for the client.

Another benefit to a pipeline transportation system is that it could have a positive and unintended advantage in advancing and accomplishing the EU requirement, that all wood fiber from North America, must meet Phytosanitation Guidelines that mandate wood chips be heat treated to a temperature of 56°C (approximately 132°F), heated to the core of the chips, for a minimum duration of 30-minutes. This Phytosanitation process has been a stumbling block or barrier to wood chip exports since 2015. This author was the first person (*entity*) to achieve and be provided a full approval, for its full cycle, successful shipment of Heat-Treated Kraft Quality Paper Wood Chips to the EU in September 2014. The shipment went to Mercer International Paper Company in Germany. The shipment originated from the harvesting of fiber, wood chips, from Searsport, Maine. This attribute, or benefit that can be derived from a pipeline hydro-transport operation, is likely to be accomplished by a modification to the pipeline system through the introduction of a smaller diameter section of piping, along a designated portion of the journey, and by utilizing a strategically positioned, higher pressure pump at the start of the smaller diameter pipe. The concept here, is the subject matter of an ongoing application for research funding, which will be conducted by CM Institute of Maine, and will attempt to prove that enough physics and natural activity of a reduction in pipe size,

[12] Colorado School of Mines Research Foundation Inc., *The Transportation of Solids in Steel Pipelines*. 1963 Accessible at: https://repository.mines.edu/bitstream/handle/11124/14589/Apt_10781929.pdf?sequence=1

and an increase of pressure in the smaller pipe area, will move the wood chips faster through the Venturi portion of the pipeline, thus increasing friction and resulting in an increase of temperature sufficient to reach and or exceed the requirement of approximately 132°F, for a period of 30 minutes. The length of the reduced diameter pipe will be determined by experiment, and will dictate the required length of the reduced pipe section, to reach and maintain a 30-minute duration, held at approximately 132°F. A minimum development budget for the construction of a heat treatment system, used solely to satisfy the EU mandate, is estimated to be between $9 and $13 million. The modification to a pipeline, intended to solve this EU mandate, especially if installed during the initial construction of the pipeline, together with the third-party, independent monitoring systems that would have to be installed as well, is estimated to be under $1 million.

Potential Origination Locations of a Pumping Station for Hydro-Transport
Maine forests are classified as 'Temperate' where they cycle through all four seasons and depending on the regions throughout Maine, "you can find coniferous forests full of evergreen trees that have leaves year-round; deciduous forests with trees that shed their leaves every year; and some forests with a mix of everything."[13] We make no distinction between any particular species of wood-chip feedstock, whether its end-use is destined for paper production,[14] manufacture of medium density fiber (MDF),[15] oriented strand board (OSB),[16] or high energy densified biomass (E=MC3).[17]

We explore pipeline distances, which would serve two distinct scenarios requiring independent examination. (Exhibit "A") Both scenarios rely on a constant supply source whereby the pipeline would move wood chips on a continuous 24/7/365 supply schedule, with very little truck movement required. The first scenario would provide a pipeline system with an approximate distance of just under 20-miles from within the Meddybemps region, and only 10-miles if from the Perry where a pipeline receiving station or facility could be constructed and the wood chip materials could be transported directly to the Port of Eastport, Maine. The alternative scenario region, would extend up to approximately 50-miles, from within the heavily wooded forests of the Native American 'Passamaquoddy Tribal Land Trust', and it would terminate at the deep-water Port of Eastport, Maine. This 50-mile pipeline would include the 10-miles of Route 190 thus the additional pipeline distance is 40-miles longer than the second option.

Barriers to Increased Utilization of Port of Eastport Facility
Roads – Highway Constraints
State Route 190 (SR 190) is a 7.1-mile (11.4 km) state highway that travels from Water Street in Eastport to U.S. Route 1 (US 1) in Perry.13 Route 190 serves as the connector route to Eastport from the mainland. (Exhibit "B") Route 190 continues as the primary transportation corridor serving the island city and the Port of Eastport. Route 190 traverses through Passamaquoddy Tribal Community territory and presents a naturally understandable barrier

[13] What's a boreal forest? And the three other types of forests around the world. Accessed at: https://www.worldwildlife.org/stories/what-s-a-boreal-forest-and-the-three-other-types-of-forests-around-the-world
[14] Northern Bleached Softwood Kraft Pulp Paper Chips, Accessed at: https://www.atcowoodproducts.com/wood-chips
[15] Wikipedia, Medium Density Fibreboard, Accessed at: https://en.wikipedia.org/wiki/Medium-density_fibreboard
[16] Wikipedia, Oriented Strand Board, Accessed at: https://en.wikipedia.org/wiki/Oriented_strand_board
[17] Phytosanitized - Heat Treated and Densified Wood Chips for CHP, Accessed at: https://www.arthurhouse.com/e-mc3.shtml

due to the necessity of, and reliance upon this small 7.1-mile path of State Road, to support an extraordinary use of heavy trucks loaded with wood chips for export.

According to a study for transport of windmills, conducted by Sewall, the adjoining Route 1 at the intersection of Route 190 is typically a "50 mph route and slower toward Calais on Rt-1 and presumptively toward Eastport on Route 190. Pavement is roughly two twelve-foot lanes with 6-foot shoulder for a total of 36-feet."[18] Truck traffic would drop to approximately 35 mph as it traverses the road through the village and community. While the proposed pipeline from Perry to the port facility is approximately 10-miles in total, the portion of Route 190 going through the Passamaquoddy Tribal Community territory is 7.1-miles. At 35-mph, and with a minimum of 4.2 truckloads per hour going over Route 190, there is literally no time, during the 12-hour period allowing truck transport, that a truck or more is not actively moving on the road through the Community.

Route 190 Heavy Truck Traffic Calculations

Annual Volume: Wood Chips (by truck)	***Metric Tonnes***	***US Tons***
Volume	300,000	330,000
Average legal truck GVW (pounds)	72,000	80,000
Avergae legal truck GVW (tonnes/tons)	36	40
Average truck/trailer weight	9	10
Average payload	27	30
Annual inbound volume of truck traffic	11,000	11,000
Monthly inbound truck trafic	917	917
Estimated weekly inbound truck traffic	229	229
Estimated weekly hours of truck traffic on Rt. 190 *		72
Hourly inbound traffic to port facility		3.2
Hourly outbound traffic from the port facility		3.2
Total hourly truck traffic over Rt. 190		6.4
Annual GVW Inbound (Truck/Trailer/Cargo)		330,000
Annual GVW Outbound (Truck/Trailer/Empty)		110,000
Total annual weight over Rt 190		440,000

* Assuming 12 hours per day and 6 days per week

To support the "steady stream of shipments that averaged 300,000 [metric] tons a year and provided consistent work for about 70 direct and indirect workers"[19] there is a requirement for 11,000 truckloads annually, or a minimum requirement of 917 truckloads of wood chips to be delivered monthly – and a return traverse over the same road, by empty truck. For immediate clarity, export volume is measured in metric tonnage. The equivalent of 300,000 metric tonnes is 330,000 US tons. Legally authorized payloads of wood chips, per truck is 30-US tons. This volume would require 11,000 fully loaded trucks per year to traverse Route 190. This accounts for inbound traffic only and is doubled to 22,000 passages, to account for the return trip outbound from Eastport.

Maine truck weights allow for a fully loaded rig to be 80,000 pounds (40-US Tons) gross vehicle weight GVW comprised of tractor/trailer and payload. On Interstate Systems, there can be exceptions granted to increase the GVW up to 100,000 pounds. Not accounting for overweight loading permits, the standard GVW inbound to the port will be 80,000 pounds (40-US Tons), and the outbound GVW will approximate 20,000 pounds (10-US Tons).

[18] Sewall, Transportation Route Assessment Report: Bowers Mountain wind Project, Accessed at: https://www.maine.gov/dacf/lupc/projects/windpower/firstwind/champlain_bowers/Development/Application/Exhibit_7D.pdf

[19] Jackson, L., The Maine Monitor, A Port in the storm: Eastport's historic port navigates new challenges, February 4, 2023, Accessed at: https://www.themainemonitor.org/a-port-in-the-storm-eastports-historic-port-navigates-new-challenges/ or, https://www.newscentermaine.com/article/news/local/eastport-maine-a-port-in-the-storm-eastports-historic-port-navigates-new-challenges/97-cc76e5c9-43b3-474a-88d4-ed

Considering reasonable hours for heavy truck traverse across Route 190 may be between 6 AM and 7 PM (13-hours per day), Monday through Friday plus partial day on Saturday (75-hours per week); the monthly inbound traverse of 917 trucks would roughly equal 229 trucks per week traffic, to require three (3) trucks per hour – each way or six (6) trucks per hour – hour after hour. Annual US Tonnage of wood chips, related to the minimum contract potential of 300,000 Mt moving over the 7.1-mile stretch of Route 190 would be 440,000 US Tons per year moved by heavy truck transport.

With the proposed pipeline installed the amount of traffic would be doubled. The pipeline as envisioned would support up to 750,000 to 800,000 Metric Tonnes of export commodity, however, this paper is constrained to the maximum projection of 600,000 Metric Tonnes (660,000 US Tons) per year.

The above numerical estimates reflect truck traffic required only for wood chip movement, there is no observance for additional truck traffic required to support any other port-related services, no accounting for trucking needs to serve downtown business operations or any other service, and there is no accounting for traditional private or personal vehicular traffic to support work related transportation for remote employment. Route 190 cannot sustain truck transport to support the lowest prediction of 330,000 US Tons per year, much less support an increase in wear and tear on Route 190 should the export volume of wood chips meet desired expansion volumes per year reaching 660,000 US Tons per year.

Rail Service – Lack of Existence – Consideration of Restoring Rail Line

One does not need to be an economic development professional to have an appreciation of the effect various transportation modes have on the economic vitality of a city. Eastport lost its rail connection in 1978 when Maine Central Railroad abandoned the 15.5-mile line out of a financial necessity. In 1980 the track and its infrastructure were removed. "Eastport is just about the only port without a rail connection in the country."[20]

Assuming there was available land for a restoration of the line, and adequate funding for the project was obtainable; the rail would not go directly to the port, but it would likely terminate in Perry. Terminating in Perry would create the need for transshipping facility to offload rail cars, and load wood chip hauler trucks, in a similar manner as was performed in South LaGrange, during the height of the paper mill production days. The 60-acre rail-siding in South LaGrange afforded a 40-railcar spur, on approximately a ½ mile rail siding, holding approximately 75-tons of wood chips each (estimated but slightly higher than an average of 70-US tons). One rail movement per week to Perry would provide 3,000 US tons per week – two rail movements would provide 6,000 US tons per week. We base this action on the two rail movement statistics. The maximum weeks that an active delivery schedule could produce is 52-weeks per year. This is unrealistic due to circumstances out of the control of any major rail service. Weather plays a major part in delivery, breakdowns or routine maintenance cuts into the schedule, and rail operation and management are not perfect. A probability of continuous service can reasonably be set at an 85% productivity rate, which provides for 44-weeks of productive rail capacity. This schedule can produce 265,200 US tons per year, and a

[20] Tierney, J., When Rails Make the Difference, From Down East to the Southwest: The loss of rail service into a small Maine town has been crippling, The Atlantic Newsletter, December 16, 2013, Accessed at: https://www.theatlantic.com/national/archive/2013/12/when-rails-make-the-difference-from-down-east-to-the-southwest/282359/

short fall of 64,800 US tons per year through the facility. Using the 30-US ton per truck capacity, we require 8,840 trucks per year to traverse Route 190 to and from the port and the rail facility. The remaining 64,800 US tons will come by 2,160 trucks, over Route 190 to and from the port. Combined truck requirement is 11,000 truckloads per year.

> *"The end result is that, assuming a rail service was reconstructed to serve Perry, not one single truck is removed from Route 190 in this scenario"*

Cost of Rail Construction

A rule of thumb for new track construction is between $1 Million - $2 Million per mile,[21] depending on who is constructing the track. For a track with an additional rail siding for a 40-car pull, the cost would be closer to the $2 million and as such that number is relied upon for this review. Some rail clients need a lot of track space to handle the movement, housing, and operations of a rail system. The basic planning budget for rail and track only, for the 15.5 miles to be rebuilt equals upwards of $31 million before rail cars and engines are acquired and before a transloading system is purchased and set in place. For a 40-car pull, each car is estimated to cost on average, "between $100,000 and $200,000".[22] For 40-rail cars, we use the lower end of the scale, and estimate the cost of $4 million. An efficient use of a rail siding and 40-cars would be to have 40-cars sitting in Perry, with 40- cars in the originating yard (such as Millinocket), and another 40-cars in transit at all times. This would provide for the two trips per week schedule. A 120-rail car purchase is estimated to be $12 million. Acquisition or relocation of South LaGrange transloading system would cost approximately $1 million new and $500,000 used with transport to Perry. Finally, we need to purchase a locomotive engine. That acquisition could mirror a recent purchase by Union Pacific where they bought "ten more all-electric locomotives…from Caterpillar Inc.'s Progress Rail, investing over $100 million in total."[23] That would average a $10 million purchase for the locomotive alone.

Rail Infrastructure and Equipment to Restore Eastport Rail Service

	Per Unit $	*Units*	*Budget*
Estimated construction cost for a 40-rail car facility *	$ 2,000,000	15.5	$ 31,000,000
Acquistion of wood chip gondola rail cars **	$ 100,000	120	$ 12,000,000
Acquisition of Electric Locomotive Engine ***	$ 10,000,000	1	$ 10,000,000
Construction/Installation of Rail Car Unloading System (Gantry)	$ 500,000	1	$ 500,000
Estimated budget to support rail construction			$ 53,500,000

* https://www.acwr.com/economic-development/railroads-101/rail-siding-costs
** https://railcardeals.com/#:~:text=On%20average%2C%20a%20train%20car,to%20get%20the%20best%20deal
*** https://electrek.co/2022/01/31/union-pacific-buys-ten-more-all-electric-locomotives-this-time-from-caterpillar-inc-s-progress-rail-investing-over-100-million-in-total/

Wood chip Transportation Costs by Truck – Current Estimated

Average costs of truck transport of wood chips, per short ton, within a range of 20-miles to the port, is currently estimated to be $8.50 per US Ton, and alternatively if delivered from within a 50 to 75-mile range, the delivery cost per US Ton is currently estimated to be $15.00 per US Ton. To accommodate an export volume of 330,000 US Tons (300,000 MT) from the 20-mile distanced facility, the annual approximate delivery cost is $2,805,000. Alternatively, if delivered from the 50 to 75-mile range to the facility, the delivery cost is approximated to be $4,950,000 annually.

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[21] Paul Hoben, the Director of Business Development the Aberdeen Carolina & Western Railway Company, Costs of a Rail Siding, Accessed at: https://www.acwr.com/economic-development/railroads-101/rail-siding-costs

[22] Rail Cars For Sale Are Here! Train cars, Freight and Cabooses! Accessed at: https://railcardeals.com/#:~:text=On%20average%2C%20a%20train%20car,to%20get%20the%20best%20deal.

[23] Accessed at: Union Pacific buys ten more all-electric locomotives, this time from Caterpillar Inc.'s Progress Rail, investing over $100 million in total | Electrek

This paper's primary goal is not to examine ways to reduce the cost of transport of raw materials to the port but, rather substitute and potentially eliminate the transportation of wood chips to the port by truck. End user procurement prices are set by market conditions so are not discussed. The focus is to examine the best method of delivery to the port to make an export contract possible. Thus, even if transport costs to the port via pipeline, is equivalent to the cost of trucking, the global initiatives, and corporate social responsibility challenges are met. Where the end user cost may not be appreciably affected the utilization of a pipeline for wood chip transportation continues to be fully justified.

Tangential Matters

Another ominous transportation cost for trucking of wood chips will be significantly impacted by the politically driven transition agenda toward electric vehicle use in Maine over the next several years. EV purchases in Maine are roughly 2% of total vehicle sales but are expected to surpass 30% of sales within ten years. The average increase in individual EV weight is 35% and there is a push to replace current tractor and cab equipment with electric trucks and cabs.

Legal weight of a fully loaded tractor and trailer on State Roads is 80,000 gross vehicle weight GVW. That is roughly 40-tons total, with 30-tons of cargo and 10 tons of equipment. If the weight is increased by even 30% then the weight of the equipment will approximate 13-tons. A three-ton increase in equipment reduces the cargo load capacity by a comparable weight, dropping the cargo weight from 30-tons to 27-US Tons. That translates into more truck trips required, with lighter payloads, a higher per US Ton cost, and more wear and tear on the roads. An increase of truck reliance with EV mandates will mean 12,222 truckloads will be required instead of the estimated 11,000 loads. For a round trip traverse over Route 190 there is an increase of 2,400 truck movements per year.

Road repair or reconstruction to support 22,000 truck passes over Route 190 will be a constant obligation. Currently Maine DOT is scheduled to seek pricing proposals, in a planned advertisement on 4/5/2023, for Project WHITING-EASTPORT, ROUTE1/ROUTE 190 #026630.04, which entails 'Highway Preservation Paving' of Route 1: Beginning at the Pleasant Point town line and extending south 3.97 miles. [Route 190: Beginning 0.02 of a mile west of Gardner Lake Road and extending east 3.77 miles. FHWA INFRA Grant recipient.][24] With heavy truck traffic required to support the port operations, the next MaineDOT project might include 'Highway Construction/Rehabilitation' at about $450,000 per mile or roughly $3.3 million for the 7.1-mile stretch. This would be a recurring cost brought on by heavy traffic and wear and tear.

Environmental – Carbon Emission Concerns Related to Heavy Trucks

According to the Natural Resources Council of Maine, "Trucks have an outsized impact on climate change in Maine. The transportation sector is responsible for 54% of Maine's carbon pollution, and 27% of those emissions are from medium- and heavy-duty trucks. Reducing emissions from these heavier vehicles is a key part of Maine's Climate Action Plan, which is why the Natural Resources Council of Maine is supporting the Maine Department of Environmental Protection's (DEP) proposed Advanced Clean Trucks (ACT) rule."[25] 21

[24] MaineDOT, Accessed at: https://www.maine.gov/mdot/projects/advertise/schedule/

[25] Shapiro, Jack, NRCM Climate & Clean Energy Director, the Natural Resources Council of Maine, What the Advanced Clean Trucks Rule Means for Maine, November 9, 2021, Accessed at: https://www.nrcm.org/climate/what-advanced-clean-trucks-rule-means-for-maine

The growing bandwagon of clean-truck states also marks progress toward a goal of making 100% of bus and truck sales electric by 2050, as pledged by 15 governors and the mayor of Washington, D.C., in a memorandum of understanding from 2020. Maine has already taken steps to adopt the ACT rule in 2022.[26] At stake here is that trucks will move toward electric power, increasing the cost of trucks exponentially, reducing effective payloads to offset increased weights associated with batteries, the availability of trucks will become scarce, and drivers are already in demand due to the shortage of driver availability – which can only be countered by increased wages for drivers.

Onshore Hydro-Transport Wood Chip Pipeline

Pipeline Hydraulic Transport

Pipeline transportation of solids in a slurry mixture is not a new concept. Early research on solid mixture flow is traced back to a 1906 systematic experimentation incorporated the testing of solid liquid mixtures through a horizontal pipeline using centrifugal pump design.[27] During and following the 1960s, significant research was performed on "solid-liquid mixture flow pipelines constructed to hydraulically transport a variety of solids."[28] Both the "technical and economic advantages of pipeline hydro-transport have encouraged various sectors to consider replacing conventional modes of transport, (e.g., road and rail), with pipelines for long-distance transport purposes."[29]

Among the advantages included are: economies of scale in the construction of the pipeline and associated equipment; capacity to transport, in a continual flow, large volumes of solids in slurry; excellent safety record (fewer than two incidents per 10,000 km (6213.7 miles) of pipeline reported per year)[30]; the certainty of - (24/7/365) - continuous operation; substantial reduction of production inventories; consolidated and streamlined labor participation; and, avoidance of interference or interruptions due to seasonal inclement weather, or restraint of the use of roads and highways, or terrain conditions such as are analogous to the temperate forests of Maine.

> *'A fully operational pipeline, with direct transport from a wood chip pumping station, and terminating at to the port of Eastport, will enable the port operators to substantially increase export volume, reduce incremental costs associated with port operations, increase the Town of Eastport's revenue base, enhance the size of its workforce and promote increased wage rates.'*

Hydraulic Operation Principles of Wood Chip Pipeline

Experimental investigations on slurry pipelines for transportation of wood chips has produced a wide range of variables from pipeline materials, diameters, lengths, wood chip dimensions and density characteristics, types of slurry mixtures, and optimal velocities of transport. This paper examines the following physical and hydrological properties. The proposed pipeline is a

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[26] Transport Topics, January 6, 2022, Six States Adopt Clean Truck Rule, Accessed at: https://www.ttnews.com/articles/six-states-adopt-clean-truck-rule
[27] Abulnaga B., Slurry Systems Handbook, New York, NY, USA: McGraw-Hill; 2002, Accessed at: https://civilnode.com/download-book/10201696075312/slurry-systems-handbook
[28] Vaezi, M., Kumar, A., Experimental Programs, Empirical Correlations, and Economic, Pg. 2, Accessed at: https://www.sciencedirect.com/science/article/abs/pii/S0961953415300155
[29] Id.
[30] Petroleum pipeline transport, April 2013, How pipelines work! Accessed at: http://www.trapil.fr/uk/comcamarche4.asp

single line, without a return line for water reclamation, with an 8" diameter (~200 mm) steel pipe, with test experimental lengths of 50-miles, and 20-miles respectively. Wood chips are both coniferous (35-lbs/cf) and deciduous (40-lbs/cf) with dimensions of thickness: 3-10mm 85% Min. Width: Size 48 mm up < 5% Size 9.5 – 45.0 mm > 80% Size 4.8 -9.5 mm < 12%.

The optimum slurry of solids mixture is between 30% to 45% (conservative use of 30%) wood chips to water content in the slurry mix. Wood chip transport velocities have been studied from .5-meters to 5-meters per second, however there is wide consensus that the actual range of velocity should be between 1.5-meters and 2-meters per second. To predict conservatively, and under estimate pipe-flow performance, we use the 1 meter per second velocity flow rate. Wood chips, dry weights are 0.38 gram per cubic centimeter or 380 kilogram per cubic meter, i.e. density of wood chips, dry is equal to 380 kg/m³.27 In Imperial or US customary measurement system, the density is equal to 23.72 pound per cubic foot or 0.22 ounce per cubic inch. These weights are calculated at bone dry moisture content (MC) however, the wood chips would enter the system at closer to 45% to 50% MC – which provides for an approximate weight of 35-pounds per cubic foot.

Utilizing the volumetric formula for a sphere (pipeline) we calculate that $V = \pi r^2 h$ and we conclude there is a volume of 1.39626 cubic feet per 1-foot of pipe – or, (35 lbs X 1.39626 cf = 48.869 lbs per linear foot of pipe). There are 3.28084 linear feet per meter or 160.33 pounds of wood chips per meter. We opt to calculate productivity on a 1-meter per second flow velocity of a rounded volume of 160 lbs/s.

Pounds	***US Tons***	
48.10	0.02	Second(s)
2,886.00	1.44	Minute(s)
173,160.00	86.65	per hour
4,155,840.00	2,079.65	per day
29,090,880.00	14,557.54	per week
126,060,480.00	63,082.66	per month
1,512,725,760.00	756,991.87	per year
85%	643,443.09	Capacity @ 85%

Next, we assign the conservative 30% wood/slurry mixture ratio. In a 1-meter section, we will move ~ 48.1 pounds of wood chips per second. Carry this to its full potential to obtain 2,886 lbs/min or 1.44 US tons p/min; per hour we can achieve 173,160 pounds or 86.58 US tons per hour; 63,293 US tons per month; and 748,449 US tons per year. Factor in a productive capacity rate of 85% and we have a maximum capacity flow of 644,674 US tons of wood chips to the port by pipeline. While export contracts are not in place for 644,674 US tons of wood chips, the pipeline is capable of supporting that volume if ever needed.

"Not one tractor trailer or wood chip hauling truck is required."

Capital Costs for Pump Station 20-Mile Distance (One Way Movement) with Booster Stations as Required

Estimated for a 104 km distance (~ 65 miles)

Item	Cost ($ in 2004)	Cost ($ in 2022)	20-Mile	50-Mile
Pump Station Facilities - Equipment - Infrastructure				
Land (estimated)	19,700.00	30,535.00	30,535.00	30,535.00
Access roads	39,900.00	61,845.00	61,845.00	61,845.00
Conveyor systems	245,300.00	380,215.00	380,215.00	380,215.00
Mixing tank (water and chips)	61,300.00	95,015.00	95,015.00	95,015.00
Piping	405,100.00	627,905.00	627,905.00	627,905.00
Foundations for pumping area	100,000.00	155,000.00	155,000.00	155,000.00
Storage tank for water	769,300.00	1,192,415.00	1,192,415.00	1,192,415.00
Auxiliary Pump (with one redundancy pump)	137,100.00	212,505.00	212,505.00	212,505.00
Power Supply and substation	400,000.00	620,000.00	620,000.00	620,000.00
Communications Lines	40,000.00	62,000.00	62,000.00	62,000.00
Buildings	236,800.00	367,040.00	367,040.00	367,040.00
Road along pipeline	266,000.00	412,300.00	412,300.00	412,300.00
Fire suppression system	65,800.00	101,990.00	101,990.00	101,990.00
Mobile stacker for dead storage	100,000.00	155,000.00	155,000.00	155,000.00
Main Pump for transport (pressure for transport of slurry)	2,678,800.00	4,152,140.00	4,152,140.00	4,152,140.00
Pipeline for transport (furnish and install)	58,863,900.00	91,239,045.00	28,073,552.31	70,183,880.77
Total capital cost Pump Station - Origination	**64,429,000.00**	**99,864,950.00**	**36,699,457.31**	**78,809,785.77**
Booster Station Facilities				
Substation	400,000.00	620,000.00	620,000.00	620,000.00
Booster Pump for mixture	1,283,000.00	1,988,650.00	1,988,650.00	1,988,650.00
Booster pump for water	1,017,500.00	1,577,125.00	1,577,125.00	1,577,125.00
Building	19,700.00	30,535.00	30,535.00	30,535.00
Access roads	4,000.00	6,200.00	6,200.00	6,200.00
Land	700.00	1,085.00	1,085.00	1,085.00
Foundation for pump area	100,000.00	155,000.00	155,000.00	155,000.00
Total capital cost Booster Pump Station - Origination	**2,824,900.00**	**4,378,595.00**	**4,378,595.00**	**4,378,595.00**
Total Project	**67,253,900.00**	**104,243,545.00**	**41,078,052.31**	**83,188,380.77**
	Per mile Cost	***) & 50 Respective***	**2,053,902.62**	**1,663,767.62**

Source: Kumar, A., Cameron, J., and Flynn, P., *Pipeline Transport of Biomass*, Department of Mechanical Engineering, University of Alberta, Edmonton, Canada 2004
https://www.researchgate.net/publication/8647398_Pipeline_Transport_of_Biomass
Costs are reported in USD 2004 Exchange and modified to 2022 by CPI Inflation Calculator, Accessed at:
https://www.bls.gov/data/inflation_calculator.htm

Adjusted budget for a ~ 10-mile pipeline from Perry to the Port facility: $36 million

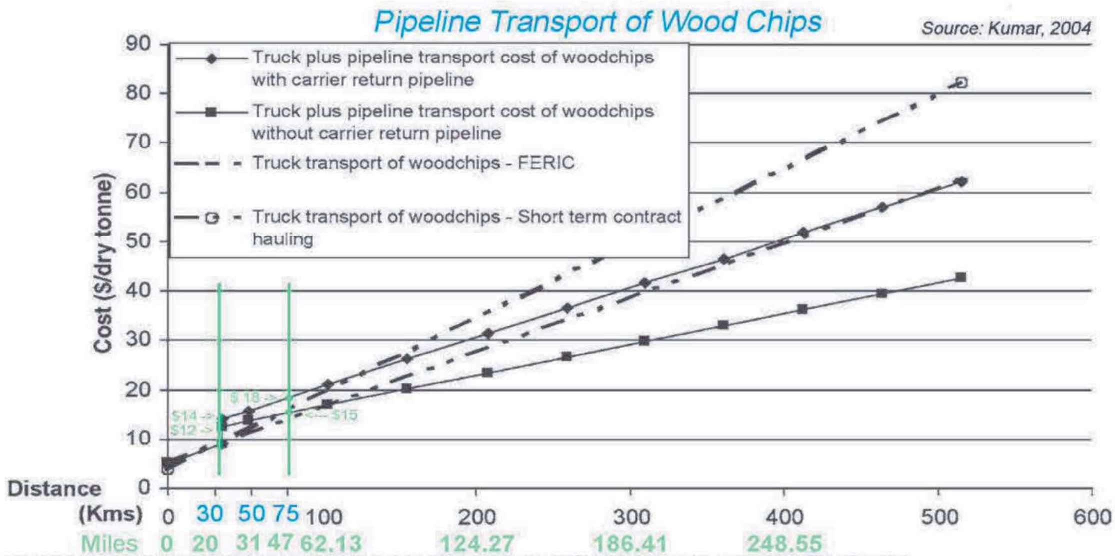
The two scenario processes simplified:
The proposal is to transport up to a minimum of 330,000 US Tons of wood chips to meet the size standards of either MDF or Biomass, through an 8" steel pipeline, in a slurry of 70% water to 30% wood chip, and to pump these wood chips a distance of either 20-miles or 50-miles from a pumping station to the laydown yard at the port of Eastport, without the need for any trucking of wood chips between the points of origination and the port destination.

Pipeline Construction and Per Ton Transport Cost Estimates[31]
Preliminary cost analysis of pipeline construction in 2022 dollars is adjusted from a 2004 detailed cost analysis of a 65-mile single pipe system. We used a CPI Inflation Calculator, as found at: https://www.bls.gov/data/inflation_calculator.htm

The one-line item that is most costly in any scenario is the furnishing and installation of the actual pipeline. Here we adjusted the pipeline cost only from 65-miles to an adjusted 20-mile and 50-mile distance accordingly. The 20-mile distanced facility has an estimated cost of $41,078,052 or roughly $2 million per mile. We adjust, approximating the pipeline from Perry to the Port will not exceed 10-miles; we liberally estimate $36 million (pump station, loading/unloading, all pumps and equipment remain high cost relative to reduced miles of pipeline material). Alternatively, the 50-mile distanced facility has an estimated cost of

[31] CPI Inflation Indicator: https://www.bls.gov/data/inflation_calculator.htm

$83,188,330 or roughly $1.67 million per mile. In the peer reviewed publication[32] we interpolate the projected the cost of transport for the 20-mile system and the 50-mile system respectively. In reliance on the above-mentioned study, by Kumar, et al, the adjustments to the cost of transport of wood chips along the 20-mile one-way pipeline system at $12.00 per bone-dry ton and for the 50-mile system the cost is $15.00 per bone-dry ton respectively. The adjustments to the cost of transport of wood chips along the 20-mile two-way pipeline system at $14.00 per bone-dry ton and for the 50-mile system the cost is $18.00 per bone-dry ton respectively. When converted to GWT and to US ton, the 20-mile one-way system will cost $7.62 per GWT to the port, and the 20-mile two-way system will cost $8.89 per GWT to the port.



Comparison of integrated truck/pipeline transport vs truck-only transport of wood chips at capacity of 2 million dry t/yr.

Case 1: A one-way pipeine, without a carrier fluid return:

	20 miles		50 miles	
BD $ Per Mt	$	12.00	$	15.00
GWT Per Mt	$	8.40	$	10.50
GWT Per USt	$	7.62	$	9.53

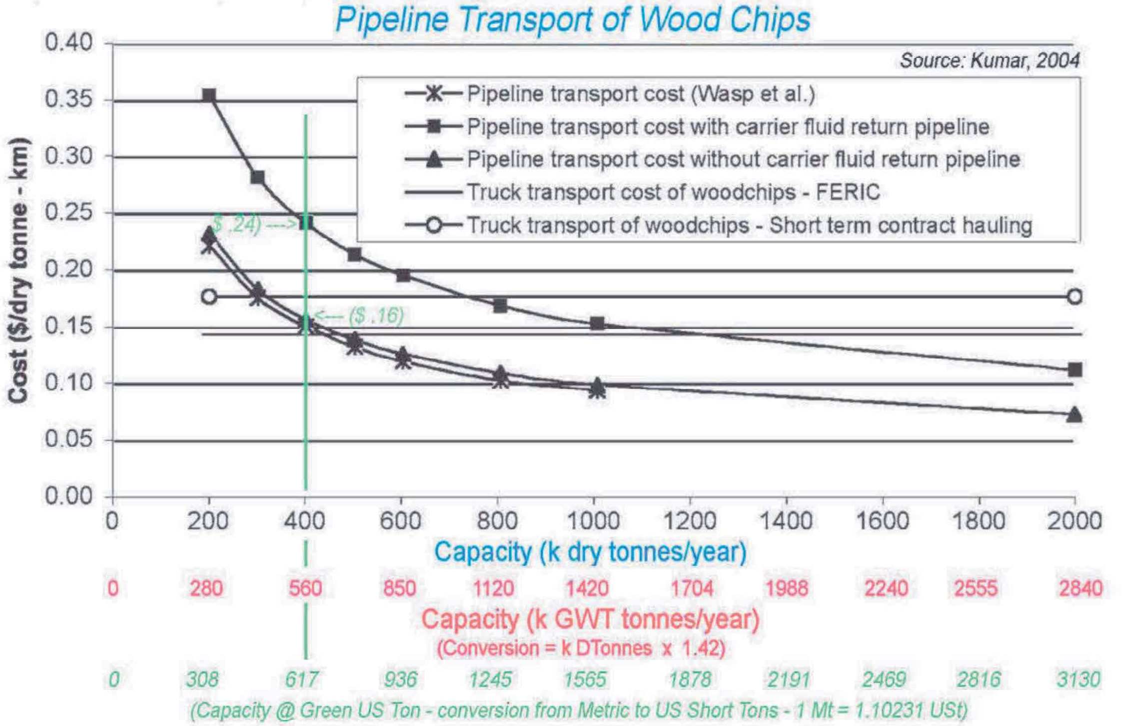
Case 2: A two-way pipeine, with a carrier fluid return:

	20 miles		50 miles	
BD $ Per Mt	$	14.00	$	18.00
GWT Per Mt	$	9.80	$	12.60
GWT Per USt	$	8.89	$	11.43

For the purpose of this paper we adjust weight to the wet ton or (green ton), versus the bone dry tonne weight used in the Kumar research. "A green ton refers not to the color of the ton, but to the moisture content of the wood. When wood is first cut, water constitutes roughly 50 percent of its weight. To account for this weight, foresters distinguish between green tons and dry tons of wood. "Bone dry" wood contains no moisture."[33] The terms wet ton or dry ton considers the different components of a slurry, generally of water and solids, such as coal or anything else immersed in a fluid medium. "The present work is based on 30% biomass by volume in a carrier liquid."[34] A wet ton would refer to the weight of the volume of the slurry while a dry ton

[32] Kumar, A., Cameron, J., and Flynn, P., *Pipeline Transport of Biomass,* Department of Mechanical Engineering, University of Alberta, Edmonton, CA 2004 Accessed at: https://www.researchgate.net/publication/8647398_Pipeline_Transport_of_Biomass
[33] Accessed at: https://urbanforestrysouth.org/products/wood-to-energy/biomass-ambassador-guide/fact-sheets/economic-fact-sheets/FS_Sources_Supply.pdf
[34] Kumar, *Supra*, (2004)

would be the weight of the contained solids after separation from the fluid. The U.S. Energy Information Administration (EIA) "estimates that 590 million wet tons (is equivalent to 413 million dry tons)"[35] of biomass wood chips. Conversion from wet tons (green ton GWT) to dry tons (DT) is (DT/GWT = 70%).



Piepline and truck transport cost of wood chips - sourced at Kumar 2004

Corporate social responsibility: environmental impact

Corporate social responsibility (CSR) can refer to a wide range of actions that businesses may take. One primary focus of CSR is the environment. Environmental CSR aims to reduce any damaging effects on the environment from business processes. Activities in this paper focus primarily on: Reduction of Carbon Emissions. The unmistakable aim in this transition of wood chip transportation by pipeline is to remove as many heavy trucks from the roadways in Maine as possible.

Typical wood chip trailers will haul 30 US ton of wood chips in a single load. As discussed in this paper the minimum volume of wood chips that would require truck transportation is 330,000 US tons or roughly 11,000 fully loaded wood chip hauler trailers.

Considering the two pipeline scenarios studied in this review; the first of which would originate in the Meddybemps/Perry pipeline site is 20-miles from the port facility. This round-

[35]Accessed at: https://19january2021snapshot.epa.gov/sites/static/files/2015-07/documents/biomass_combined_heat_and_power_catalog_of_technologies_2._basic_first_steps_and_considerations.pdf Page 1.

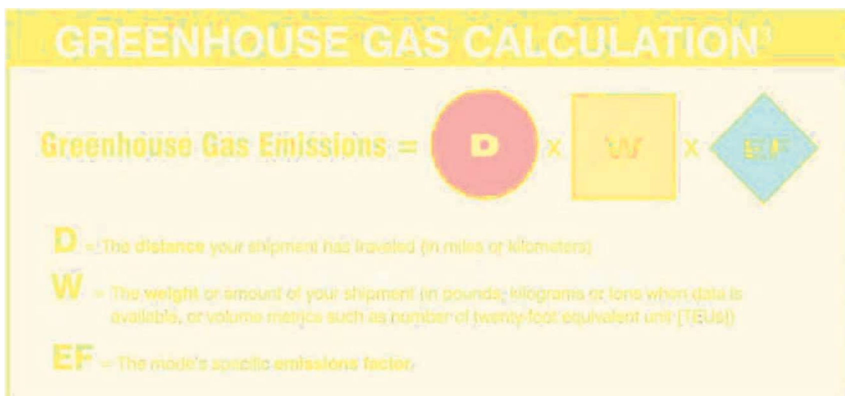
trip process would require 440,000 miles per year with a combination truck/trailer rig of 80,000 GVW. Alternatively, if driving from the Passamaquoddy Tribal Land Trust yard, the same number of trucks would be required however, the round trip per truck is 100-miles. To accomplish the transport to the port from this origination point is 1,100,000 miles per year.

Along with buses and passenger vehicles, trucks are responsible for excessive transportation carbon emissions in the US.[36] 30 A truck CO2 emission per km calculator reveals that an average truck, covering a distance of around 120,000 miles every year, emits 223 tons of CO2 per annum. This is based on an estimated calculation of 400 miles every day over six days per week, and a total of 50 weeks every year. The calculation is also based on 6.5 miles (10.46km) per gallon of fuel (diesel).[37]

In 2020, diesel fuel consumption in the transport sector of the US produced 432 million metric tons of carbon dioxide, which equaled just over a quarter of the total CO^2 emissions of the transport sector. To estimate diesel truck CO^2 emissions per km, a simple calculation can be used. Firstly, 1 liter of diesel equals 835g and consists of 86.2% carbon, which equals 720g of CO^2 per single liter of diesel. Combustion of the carbon to CO^2 requires 1920g of oxygen. The calculation then looks like this: 720 + 1920 = 2640g of CO^2 per single liter of diesel. Consumption of 5 liters per 100 km will then be 5l x 2640 g/l / 100 (per km) = 132g CO^2 per kilometer.[38]

Calculating greenhouse gas emissions from a truck move

Using the formula from above, we can arrive at a simple emissions calculation example for a truck that travels 1,000 miles with 30 short tons of cargo (a short ton is 2,000 lbs). One truck load of wood chips would weigh 30-US tons or 60,000 pounds (cargo only).



<u>*20-Mile Distance from Meddybemps/Perry to the Port Scenario:*</u>
Step 1: Determine the total amount of miles. Multiply 440,000 miles times 30 tons, which gives us a total of 13,200,000 transport miles.

Step 2: The average freight truck in the U.S. emits 161.8 grams of CO^2 per transport mile.

[36] Environmental Protection Agency. (2022, July 14). Fast Facts on Transportation Greenhouse Gas Emissions. Green Vehicle Guide. Retrieved November 19, 2022, Accessed at: https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions
[37] Grace Sharkey. (2021, April 9). What Is the Carbon Footprint of a Truck? Freight Waves. Retrieved November 19, 2022, Accessed at: https://www.freightwaves.com/news/what-is-the-carbon-footprint-of-a-truck
[38] Ecoscore. (2022). How To Calculate the CO2 Emission from the Fuel Consumption? Ecoscore. Retrieved November 19, 2022, Accessed at: https://ecoscore.be/en/info/ecoscore/co2

Step 3: Multiplying this emissions factor with the total transport miles {161.8 X 13,200,000), which gives us a total of 2,135,760,000 grams of CO^2.

Step 4: Convert the total grams into metric tons. Metric tons are the standard measurement unit for corporate emissions of greenhouse gases. There are 1,000,000 grams in a metric ton. To convert our answer from step three we divide it by 1,000,000. This gives us 2,135.76 metric tons of CO^2.

Deduction: The use of a pipeline for wood chip transport from Meddybemps/Perry will reduce the CO^2footprint by 2,135.76 metric tons.

59-Mile Distance from Passamaquoddy Tribal Land Trust yard to the Port Scenario:
Step 1: Determine the total amount of miles. Multiply 1,100,000 miles times 30 tons, which gives us a total of 33,000,000 transport miles.

Step 2: The average freight truck in the U.S. emits 161.8 grams of CO^2per transport mile.

Step 3: Multiplying this emissions factor with the total transport miles {161.8 X 33,000,000), which gives us a total of 5,339,400,000 grams of CO^2.

Step 4: Convert the total grams into metric tons. Metric tons are the standard measurement unit for corporate emissions of greenhouse gases. There are 1,000,000 grams in a metric ton. To convert our answer from step three we divide it by 1,000,000. This gives us 5,339,400 metric tons of CO^2.

Deduction: The use of a pipeline for wood chip transport from the Passamaquoddy Tribal Land Trust yard will reduce the CO^2footprint by 5,339,400 metric tons.

Conclusions

- Hydraulic transportation of wood chips by pipeline is a sound and reasonable alternative to truck transport of wood chips to the Port of Eastport.
- Implementation of a pipeline for wood chip transport will provide the necessary delivery process for the port to reach its full potential regarding the export of wood chips.
- The cost of pipeline transport is appreciably lower than that of truck transport. The environmental benefits of a pipeline over traditional truck transport are substantial in terms of significantly lowering the carbon footprint of transportation.
- A pipeline installed along Route 190, within the easements and right of ways will eliminate the truck traffic along Route 190 and provide for unrestrained transport along a traditionally bottlenecked transport route.
- Building of a pipeline at this time would also reduce the potential for ongoing road repairs and maintenance and also mitigate the future need for a total road reconstruction project along Route 190.
- A pipeline that removes truck traffic associated with wood chips will also open the door to a lesser demanding transport of exportable logs to the port for either container loading or vessel loading.

Other Export Potentials

While biomass grade wood chips have been a primary focus for some time now; other end users of wood chips for MDF, OSB and Paper are interested in Maine. This writer has existing, current contacts that require in excess of 300,000 metric tonnes of fiber each, on an annual basis. A pipeline to the port can bring up to 600,000 metric tonnes of business. A typical client buyer of who have either executed contracts and agreements for wood chips via CMI, or are awaiting a reasonable path for supply includes: Koch Industries of Switzerland, Osman Baris Erdogan (nephew to President Erdogan of Turkey), Yildiz Integre of the US and Turkey, Bord *na* Mona of Ireland, Bee Energy of Belgium (now defunct), Marubeni Canada Ltd., GNT Group of Companies of Canada, Mercer International of Germany, and others.

Log exports to the EU and beyond, can be exported from Eastport. While the relative proximity of ST. John, to Eastport will continue to be a viable export facility, Eastport may accommodate loggers who wish to haul logs to the port facility, in lieu of reduced traffic related to wood chips. Proven markets for log exports have been established. In excess of $23 million per year in containerized log exports has been established (however, due to trade war issues and COVID-19 these trade contracts have been temporarily halted).

This writer had established an extremely cost-effective shipment regime of logs from Searsport to either Boston or direct to Port Elizbeth, NJ. The required minimum volume for the barge service was a minimum of 200-containers per month. The logistics of Searsport is perfect however the pushback by port situated entities stalled the project and then COVID hit then the opportunity stalled. This log export business however, is immediately accessible and can be actionable via Eastport. Eastport can be designated the “Export Fiber Hub of Maine” as Portland is close to its maximum capacity, and Searsport has been and continues to be ill-equipped to handle wood chip export due to loading constraints. Pursuant to a recent spillage of baled waste materials from Ireland, intended for shipment to a local power plant, it is not likely that Searsport will venture into woodchips in the future.

A strategic alliance has been created with one of the world’s leading shippers: Oldendorff. This Internationally Renowned company, has cooperated with CMI to bring vessels to Maine (and New Haven, CT) to move either wood chips in bulk and or in high density baled configuration that solved the long-standing stowage problem regarding wood chips. Typically, wood chips would bulk out a vessel before weighing out. With the heat treated, E=MC3 high density compacted product, the cubic foot stowage of wood chips has met and exceeded the stow value of wood pellets, thus eliminating the most important cost disadvantage previously known to wood chip export. A presentation was made to the International Biomass Conference in Nashville, TN.

For any further in-depth information or follow up questions; CMI can be reached at the below provided contacts.

Arthur T. House, EJD

Researchers and Consulting Companies

The above is a preliminary review and analysis in support of constructing a Hydro-Pipeline transportation system for the transport of wood chips to the Port of Eastport. Substantive work on this proposed program is in progress in cooperation with Northern Illinois University. Mr. House was principally involved in the conceptual planning and the application process and its eventual approval by the USDA in an award of a research grant in the amount of $648,000.

Mahdi Vaezi, Ph.D., Assistant Professor in the Department of Engineering Technology, at the College of Engineering and Engineering Technology (CEET), Northern Illinois University located at 103B Still Hall | DeKalb, IL 60115 Email: mvaezi@niu.edu Dr. Vaezi has been engaged in pipeline research and development for over 12-years, and as he and Mr. House became acquainted in February 2020, at an International Biomass Conference, in Nashville, TN, both as Keynote Speakers, the genesis of this project came together. Collaborating with Co-PIs and consultants, coming from various sectors with expertise in pipeline flow, biomass processing, and bioenergy economy and logistics, helps link the project directly to biomass feedstock collection and preparation, transportation and biorefinery sectors. A significant accomplishment currently within reach is potential off-take contracts that will support between 300,000 and 600,000 metric tonnes of fiber export from Eastport.

Arthur House, EJD is a Forest Products Industry Consultant and Program Developer, Facilitator and Coordinator of significant projects in the Renewable Industry, Construction and Engineering Management Industries. He has been principally engaged in Research and Development, in these overlapping industries, in Maine from his offices in Searsport and Belfast, Maine. Mr. House is President and Founder of Construction Management Institutes ("CMI"), of Maine and Florida – Established in 2001, as a consulting company, with 25-years of experience in biomass, biodiesel and renewable energy research and development. Mr. House anticipates collaborating with substantial industry experts and professional entities, specializing in pipeline and infrastructure projects, forest product production and export, transportation agencies, construction and engineering management firms, and top tier funding groups capable of structuring the type of project and program funding necessary for this project to come to fruition.

Mr. House envisions working with MaineDOT, the Town of Eastport, regional municipalities, and Maineˇ based Universities or Colleges to seek support and funding for these education facilities to undertake their work. A secondary grant is envisioned to study the techno-economic feasibility of constructing the underlying pipeline, the subject matter of this paper. The initial pipeline research grant was considered a top priority study for the USDA. House's additional interest is in expanding upon the potential benefits that a pipeline will have, specifically in Maine, and with regard to satisfying EU mandates, as the motivation for the next grant application – slated to be an entirely Maine emphasis

Potential entities Mr. House envisions working with on this project include but is not limited to: Sevee and Maher Engineers, James Sewall Engineering, Sargent Construction, Cianbro, Treadwell Franklin Infrastructure, Maine Department of Transportation, Maine Port Authority, NIU, U-Maine, Orono, and others.

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