Rachel Catherine Dickson

105 Fox Run Drive
Natchitoches, Louisiana 71457

(318) 792-0058
rcd019@latech.edu

January 31, 2018

Mr. Craig Lichty, Vice President, North American Operations
Evergreen Packaging
5350 Poplar Ave # 600
Memphis, TN 38119

Dear Mr. Lichty:

This research report was composed to recommend a wastewater treatment solution best suited for implementation at the Evergreen Packaging mill in Pine Bluff, Arkansas, in accordance with the requirements of English 303 at Louisiana Tech University.

This report recommends the implementation of a system upgrade to an activated sludge system. Adjustments to the current system would include the addition of an aeration basin, a secondary clarifier, and necessary piping systems. The benefits of this system include improved system operation and control and less climate dependence than the current clarifier system. The temperature control is much greater in advanced sludge systems due to the recycled process sludge. This system would require capital funds to implement, but would allow for improved effluent quality.

Please contact me if you have questions regarding this recommendation report. Thank you for your time and consideration of this report.

Sincerely,

Rachel Dickson

WASTEWATER TREATMENT METHODS IN THE PULP AND PAPER INDUSTRY

Rachel Dickson

WASTEWATER TREATMENT METHODS IN THE PULP AND PAPER INDUSTRY

Written by Rachel Dickson
Chemical Engineering Student
Louisiana Tech University
to fulfill the requirements of English 303

Produced for Craig Lichty
VP North American Operations
Evergreen Packaging

ABSTRACT

A current issue in the pulp and paper industry involves the improvement of effluent (wastewater) treatment processes. Effluent treatment affects communities near industrial sites; therefore, it is not simply an internal step in production, but a vital aspect of mill reputation. Technologies used to treat effluent in a paper mill exist in many different forms and are constantly improving. This report considers the processes of activated sludge treatment, constructed wetlands, and overland flow treatment. These processes are compared based on location constraints, costs, and effectiveness. The three systems researched each utilize a different method of contact for biological treatment. Activated sludge treatment, constructed wetlands, and overland flow utilize the contact methods of aquatic, wetlands, and terrestrial processes, respectively. The three criteria for comparison consist of location constraints of climate and land area, costs of construction and operation, and effectiveness of removal of biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS). The purpose of this report is to recommend the best option to which the mill in Pine Bluff, Arkansas, should upgrade.

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

Environmental regulations today are steadily becoming stricter. With the ever-present growth of industrial technologies to improve production, operational control of waste streams remains a concern. Effluent (wastewater) treatment technologies must adhere to environmental regulations while maintaining inexpensive manageability so that companies can generate profits. This report researches three wastewater treatment processes—activated sludge treatment, constructed wetlands, and overland flow treatment—to determine the most desirable option. The three criteria for comparison are location constraints, cost, and effectiveness of treatment.

When the three proposed solutions are compared against the criterion of location constraints, the most suitable option is the activated sludge process (ASP). This process is most suitable to harsher climates with colder winters. The wetland and overland flow systems both operate more suitably in temperate, warm climates lacking hard winter freezes. The ASP process is small in size; therefore, it has a unique ability to be implemented in locations where land area is scarce. If the land area is available, ASP may not be the best option since it does not utilize the existing resources.

The most suitable option regarding cost is the constructed wetland system. Construction costs range from $250,000 to $10 million depending on the condition of land area available for the system. Despite the large range of construction costs compared to the other types of systems, a constructed wetland costs much less. The operational costs of the three systems can include mechanical equipment maintenance, sludge management, and chemical control. These costs for the three systems are similar in magnitude, but when compared alongside construction costs, constructed wetlands is the most cost-effective solution.

The solution that proves most effective for the effluent treatment is the activated sludge system. This system removes 90% of the biological oxygen demand (BOD) and chemical oxygen demand (COD), as well as nearly all of the total suspended solids in the system. The sludge in the system is effectively settled out of the wastewater and recycled to the system. This process allows for operational control of temperature and is effective in overall treatment of the effluent.

The best overall proposed solution for the Pine Bluff mill is the activated sludge process. This system requires great capital expenditures to implement; however, ASP is widely applicable to any climate and effectively treats effluent wastes. This report recommends implementation of an ASP system, which is widely used in industry today. ASP will allow for accessible control of system operation, independence from climate concerns, and effectiveness of treatment.

INTRODUCTION

Purpose

The pulp and paper industry heavily relies on water for its production. Although the process of paper production depletes, sells, or recycles everything it uses, water used in the process is often heavily contaminated with chemicals and needs to be cleaned before being returned to its nearby source. This report researches three potential solutions for effluent (wastewater) treatment: activated sludge process (ASP), constructed wetlands, and overland flow treatment. The three solutions are compared on criteria of location constraints, cost, and effectiveness of treatment.

History of the Problem

Industry standards of environmental concern have become more prevalent in the past several years. According to Art Haddaway, over half of the water usage in the U.S. can be attributed to industrial applications with approximately 370,000 manufacturing facilities in operation (par. 2). Because paper mills rely so heavily on water usage for production, many mills are built on or near a large river. According to Ronald W. Crites et al., "Serious interest in natural methods for waste treatment reemerged in the United States following passage of the Clean Water Act of 1972" (*Natural* 1). Today the pulp and paper industry is still researching possible natural treatment processes.

Recent Studies of the Problem

The processes researched in this document are prevalently used in industry today. Industrial standards are constantly changing due to ongoing research within the mills that operate these systems. Activated sludge processes are utilized in many mills around the world. ASP systems allow for effective control of temperature and other operating conditions, and ASP is heavily researched and studied for industry due to its prevalence. Constructed wetland systems have been in use for quite some time in municipal waste treatment; however, around the 1980s, the pulp and paper industry began pilot constructed wetlands projects that focused on advancing the practices of wastewater treatment (Knight 1). Overland flow treatment systems operate with a large amount of land area, causing a constant battle to improve the quality of treatment to reduce the land needed. Each of these methods has existed for a long time, but as environmental regulations are constantly being improved and monitored more closely, paper companies will continue to improve the treatment of effluent.

Research Procedures

This recommendation report was compiled using various methods of research. Using databases relating to the pulp and paper industry such as the Technical Association for the Pulp and Paper Industry (TAPPI), I gathered journal articles and other technical information from previous studies of wastewater treatment methods. I also contacted two subject matter experts. The first subject matter expert, Alyssa Martin, is an environmental engineer at International Paper, and she also assisted me with finding source materials and data. The second subject matter expert I contacted was James Ellison, an environmental engineer at

Evergreen Packaging. These two engineers assisted greatly with the information used in this report. Their experiences within two separate companies allowed for the information I received to reflect different perspectives and procedures. Another aspect that allowed for these experts to give individual comparisons was that both of their job sites are in drastically different locations. One job site is located directly on a river and the other nearly thirty miles from the nearest body of water. This difference in location has a direct impact on the views of water treatment methods. The research accomplished for this report established a foundation for a confident recommendation.

Emphasis of the Problem

Effluent (wastewater) treatment in a paper mill is necessary to achieve standards in water quality in order to limit pollution released to the environment. Historically, the regulations regarding quality of water have gone through many levels of rigor, requiring many adjustments in the handling of wastewater in industry. Solutions to water treatment used to meet these standards include activated sludge process (ASP), constructed wetlands, and overland flow treatment. This report uses the criteria of location constraints, cost, and effectiveness to compare these solutions to determine the best overall treatment method.

Introduction of Possible Solutions

Wastewater treatment processes are implemented through three main methods of handling: aquatic, wetland, and terrestrial. Three specific methods compared are activated sludge process, constructed wetlands, and overland flow treatment. In the following section, these methods of treatment are further explained.

Solution 1: Activated Sludge Process

The process of activated sludge utilizes suspended bacteria to treat effluent. The bacteria metabolizes solids and removes biological oxygen demand. This system typically has a primary clarifier followed by an aeration basin and another clarifier. The activated sludge is formed as the metabolized waste builds up in the system; most of this sludge is recycled through the system while some is discarded, as shown in Figure 1. The wastewater is then circulated through more aeration ponds and discharged.

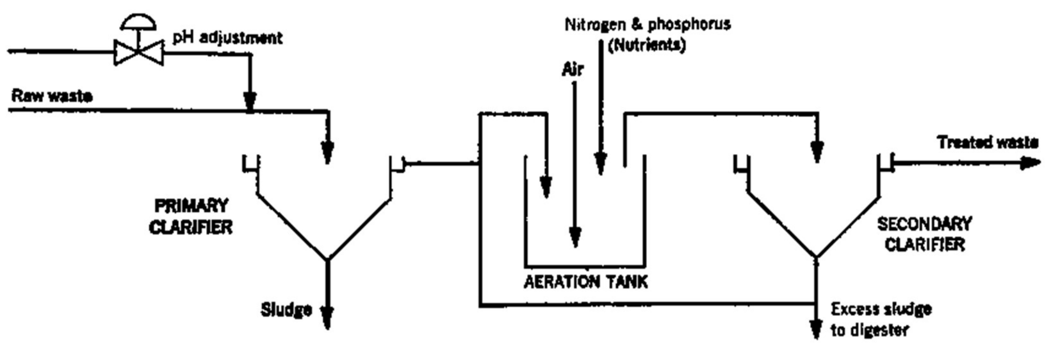

Figure 1: Diagram of activated sludge treatment process (Smook 405).

Solution 2: Constructed Wetlands

Constructed wetland systems use the natural characteristics of wetlands to clean and treat effluents. This type of system allows water to flow down a slope as vegetation and bacteria work to metabolize contamination in the wastewater, as depicted in Figure 2. Weirs (dams) are constructed on either end of the system to allow for volume control in the system. The vegetation used in constructed wetlands is designed to mimic the foliage that occur in natural wetlands.

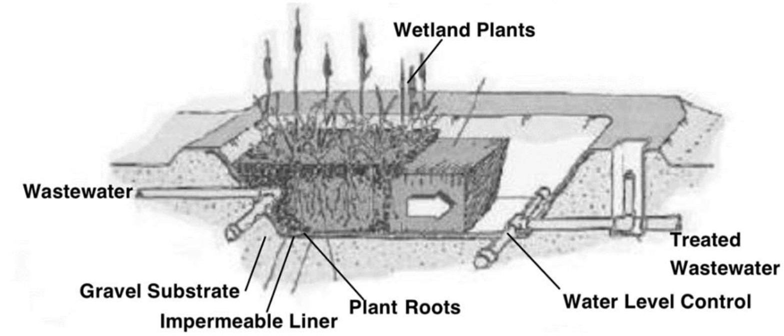

Figure 2: Diagram of constructed wetland treatment system (US EPA, *Constructed* 1).

Solution 3: Overland Flow Treatment

Overland flow treatment applies effluent to slowly permeable soil in order to treat the wastewater. As shown in Figure 3, a sprinkler system spreads the water onto a large field where it is treated by microorganisms in the soil as it runs down a graded slope. The soil filters solid particulates out of the system. The water then runs off into ditches. From the ditches, the water can be recycled for mill use or discharged.

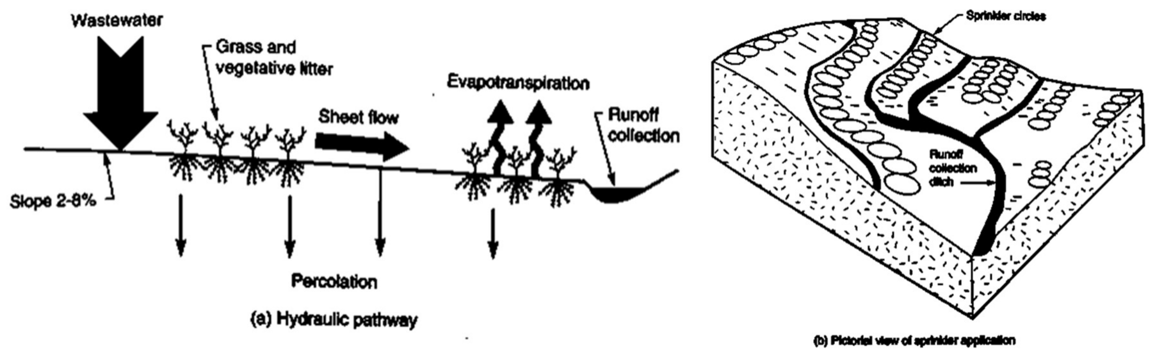

Figure 3: Diagram of overland flow treatment system (Crites et al., *Land* 15).

Introduction of Criteria

The treatment methods of pulp and paper effluent have certain aspects that make them more or less desirable. Several criteria are considered in planning any form of water treatment system. Of these criteria, three are examined in this research: location constraints, cost, and effectiveness.

Criterion 1: Location Constraints

Two factors that greatly constrain an effluent treatment system are climate and land area availability. In a paper mill, these two factors are predetermined by the existing location of a mill. Climate affects temperature control as well as vegetation growth and bacterial activity. Availability of land area determines feasibility of treatment of the water volumes required for a particular mill.

Criterion 2: Cost

In an industrial wastewater treatment system, large capital construction costs as well as maintenance costs are necessary for running the system. Construction costs include equipment, land development, and labor. Maintenance costs include solid removal and equipment upkeep. Compared to the size of construction of a large kraft paper mill, waste treatment is a necessary but rather small percentage of costs. Despite a relatively small effect relative to the overall costs of operating a paper mill, the criterion of cost must be considered because it does have a significant effect on the operation and choice of the system.

Criterion 3: Effectiveness

Treatment methods must be judged quite heavily on their effectiveness which can be determined by the measurements applied and monitored in the given system. According to Alyssa Martin, environmental engineer at International Paper in Mansfield, Louisiana, effluent treatment is typically measured based on environmental permits that set outfall limits to which mills must adhere. These outfall limits most commonly include biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and pH. The ability of a system to maintain these limits is necessary for operation; therefore, effectiveness of treatment is imperative.

Application of Criteria to Solutions

Effluent treatment is determined to best suit an individual mill. The best overall solution can be determined by comparing the three proposed solutions within each criterion. In the following section, each of the criteria will be used to compare the three solutions based on their characteristics.

Application of Criterion 1: Location Constraints

The existing location of the mill is typically taken into account in a comparison of solutions based on location. Location constraints considered are climate and required land area. Due to safety regulations, industrial sites are typically large in acreage because the surrounding communities must be buffered from any hazards involved in industrial processes. This acreage provides a unique benefit to waste treatment systems being considered. Each of the solutions has benefits to operating under specific location constraints.

Location Constraints of Solution 1: Activated Sludge Process

The activated sludge process can be utilized in nearly any climate because it is based entirely on constructed tanks and clarifiers, which allows for control of operating parameters such as temperature. ASP is typically well-suited for cold climates due to the recycling process of the activated sludge. This recycling allows the heat to be conserved within the system as well.

According to James Ellison, environmental engineer at Evergreen Packaging in Pine Bluff, Arkansas, activated sludge systems are typically applied at smaller mills because the system does not utilize as much land space. In other systems, the excess land area is typically used for aeration ponds to follow the clarifier treatment to further aerate the water. However, the ASP system does not generally require many extra ponds in the system.

Location Constraints of Solution 2: Constructed Wetlands

The constructed wetland system is dependent on vegetation growth to process the wastewater. Therefore, the constructed wetland system operates more effectively in regions closer to the equator with warmer climates. Cold northern winters negate the ability for microorganisms and plants to metabolize contamination in effluent. Even in warmer climates, heavy freezing occurring every few years can cause damage to the system.

Land area required for a constructed wetland system is fairly great. International Paper (IP) operates a paper mill in Mansfield, Louisiana, that utilizes a constructed wetland system consisting of six individual wetland areas that operate independently. This allows for one area to be taken out of service each year on a rotating schedule for maintenance (Martin). The area required for this system to process a needed 14-18 million gallons of water a day is nearly 725 acres, over one square mile (Crites et al., *Natural* 16).

Location Constraints of Solution 3: Overland Flow Treatment

Overland flow treatment depends on vegetation, microorganisms, and soil permeability. The system is designed with slowly permeable soils that filter and treat the effluent. The water flows through the soil down a gradual slope. Due to its reliance on vegetation and soil permeability, this type of treatment does not operate well in colder climates. Hard freezes affect the ability of the water to soak into the soil for treatment.

Overland flow systems need the greatest amount of land area because the treatment process occurs more slowly, requiring more space for effluent output. The land requirements for a system that must treat 14-18 million gallons a day are roughly 1,988 acres or just over three square miles (Crites et al., *Natural* 17). This type of system can be designed for storage of water as it is treated; therefore, overland flow is designed specifically for systems that have an abundance of water and a need to recycle that water.

Conclusion

The best option for wastewater treatment regarding location constraints is the activated sludge system. This system requires the least amount of land area and is the most flexible option in climate needs.

Application of Criterion 2: Cost

The costs associated with the systems for effluent treatment are a combination of both capital costs and operating costs. Capital construction costs are typically large due to the extensive work involved in designing and building a wastewater treatment system. The operational costs consist mainly of maintenance to keep the system operational. The total costs are compared to determine overall lifetime cost of the system.

Cost of Solution 1: Activated Sludge Process

The activated sludge system construction consists of primary and secondary clarifiers, an aeration basin, and other equipment such as piping and pumps. The construction cost of a system that processes 20 million gallons a day would be roughly $18.6 million (US EPA, *Construction* 32).

Operational costs for this type of system include maintenance of pumps and piping in the system as well as tank cleaning. These maintenance operations, if completed regularly, can help prolong equipment life and improve operational performance. According to Ellison, most mills have maintenance costs budgeted for every area of operation, so these costs are complex to determine.

Cost of Solution 2: Constructed Wetlands

A constructed wetland system construction involves building inlet and outlet weirs, trucking materials to and from the mill, and heavy dirt work such as grading the land. According to Martin, the system at IP cost about $250,000 when it was built in 2005. Some constructed wetlands projects can be much more expensive depending on the state of the land available. If the land area is entirely flat and needs more development, the costs can be as high as $10 million (Crites et al., *Natural* 326).

Operational costs for the system include maintenance and system additives such as pH control chemicals. Long term maintenance of sludge is necessary because a layer of solids will build up at the bottom of the wetland, hindering plant growth over time. Estimated costs for sludge maintenance range from $10,000 for tilling the sludge, which prolongs the use, to $30,000 to remove all solid materials. Tilling costs are typically accrued every year on a rotational preventative maintenance schedule, while the total solids removal is necessary every 10-15 years (Martin).

Cost of Solution 3: Overland Flow Treatment

Overland flow treatment systems are constructed similarly to the wetland system; however, a major difference is the cost of equipment to create the sprinkler system required to operate an overland flow system. For a system that requires 20 million gallons to be processed per day, the overland flow system has capital costs of $7,000 for the sprinkler system (Crites et al. *Land*

325). This cost is added to similar capital land development costs required for the wetland system.

Maintenance costs for the overland flow treatment system are similar to that of the constructed wetland costs for sludge management. Costs attributed to maintenance of sprinkler equipment add to the operational costs of the system.

Conclusion

According to this analysis, the constructed wetland system is the most cost effective system to implement. While costs for maintenance are high, lower construction costs and natural characteristics allow for operational benefits that outweigh the maintenance and upkeep effort required.

Application of Criterion 3: Effectiveness

Effectiveness of wastewater treatment is the most important aspect in planning wastewater treatment because if the regulations are not met, a company's reputation as well as its profit may be damaged. Effectiveness can be determined by the ability of a system to operate within outfall limits. Outfall limits typically specify the amount of contamination allowed in an output water stream; these limits can include biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and pH. The following sections will compare each solution method on its ability to effectively treat contaminated wastewater.

Effectiveness of Solution 1: Activated Sludge Process

The activated sludge process utilizes clarifiers and aeration techniques to allow microorganisms suspended in the wastewater to metabolize the contaminants. According to Ellison, in an activated sludge system a catastrophic failure or shutdown of the treatment facility is be detrimental to the system by destroying the existing biological sludge.

Typical ASP systems monitor COD and BOD. According to Vipin Sumani and Thomas S. Seguljic, "A properly designed activated sludge system can significantly reduce the BOD and COD by over 90 percent" (39). ASP has the ability to aerate and treat the system at the same time, requiring less overall time for the system to be effective. ASP is specifically designed to remove nearly all suspended solids by settling out the activated sludge. The water removed from the top of the system has no solids remaining, while the activated sludge is reused at the beginning of the system.

Effectiveness of Solution 2: Constructed Wetlands

A constructed wetland system is designed to use natural processes of plants and organisms to metabolize the wastes and reduce the BOD and TSS in the system. Hard freezing during winters is detrimental to the effectiveness of this type of system. Cold weather slows down micro-activity and hinders the ability of the system to treat contamination (Martin).

According to Martin, the IP system operates freely internally, allowing for necessary adjustments; however, the system must adhere to outfall limits for pH, TSS, and BOD. The limit upheld at the Mansfield International Paper mill for BOD is fairly high, requiring less processing, because the Red River, which receives the discharge water, is not clean (Martin). According to Ashutosh Kumar Choudhary et al., constructed wetland systems have a removal efficiency of 85-95%. The TSS removal rate for constructed wetlands is roughly 80%; this translates to an outlet rate ranging between 5 and 50 mg/L (Crites et al., *Natural* 271).

Effectiveness of Solution 3: Overland Flow Treatment

The overland flow treatment system operates through a sprinkler system applying wastewater to a field that filters and treats using natural processes of vegetation and bacteria as well as the permeability of the soil. The overland flow system is rendered ineffective in colder weather similar to the constructed wetland. This type of system is further inhibited when hard freezes occur because the soil becomes less permeable and is unable to treat the effluent.

In this type of system it is estimated that 90-95% of BOD removal occurs through biological oxidation (Crites et al., *Natural* 403). According to Crites et al., "A typical BOD concentration in the treated runoff water is about 10 mg/L" (Crites et al., *Natural* 403). Table 1 lists BOD removal rates for four different locations of overland flow systems for primary effluent treatment. The TSS rate typically found in the outlet stream of an overland flow system is 10 to 15 mg/L (Crites et al., *Natural* 403).

Table 1: BOD Removal in Primary Effluent Overland Flow (Crites et al., *Natural* 404).

Location	Application Rate (gal/ft*min)	Outlet BOD (mg/L)	BOD Removal
Ada, Oklahoma	0.13	8	88.6%
Hanover, New Hampshire	0.17	9	87.5%
Melbourne, Australia	0.32	12	97.6%

Conclusion

Each of the three systems is effective in treating the effluent wastes. Activated sludge processes, constructed wetlands, and overland flow systems all reach 90% BOD removal. Comparing overall contamination removal rates, the best option is the activated sludge system. The activated sludge process is specifically designed to remove BOD, COD, and TSS and does so effectively.

CONCLUSIONS

The activated sludge solution requires little available land area and operates independently of climate constraints. The system capital cost is nearly $18.6 million but is well worth the investment. Maintenance and operating costs depend on the equipment chosen for implementation and can vary greatly depending on frequency of preventative maintenance and replacement. ASP effectively removes 90% of BOD and COD (Sumani and Seguljic 39) as well as most of the TSS in the effluent waste. Despite heavy capital costs, this system's design attributes make it the most viable option for utilization in any given location.

The constructed wetland requires warmer climates for operation and land area to allow for treatment processing. This system can cost between $250,000 and $10 million for construction costs depending on land development needed for implementation. The greatest percentage of maintenance costs of the system is attributed to sludge management, which can cost $10,000 for tilling maintenance or up to $30,000 for complete solids removal. This system effectively removes 85-95% of BOD and 80% of TSS. Due to low construction costs, this is the most viable option in southern climates where land area is available for treatment.

The overland flow treatment system operates efficiently in warmer climates and needs the most land area for treatment due to the slower rate of application. The system capital cost is similar to that of the constructed wetland but with an additional $7,000 for the sprinkler system required. The maintenance costs are essentially equivalent to that of the constructed wetland. This system removes between 90 and 95% of the BOD.

RECOMMENDATION

For the purpose of this report, I recommend utilization of the activated sludge process. Within an existing system, upgrading to ASP can improve treatment process effectiveness as well as reducing excessive follow-up treatment such as pond systems. ASP can be implemented with an existing system. In the system used at the Evergreen Packaging mill in Pine Bluff, Arkansas, ASP can be implemented with the addition of a secondary clarifier, aeration basin, and piping. This system enables monitored control of effluent quality, which enables long term ease of adjustment for changing regulations and permits.

WORKS CITED

Choudhary, A.K., et al. "Constructed Wetlands: An Option for Pulp and Paper Mill Wastewater Treatment." *Electronic Journal of Environmental, Agricultural and Food Chemistry*, vol. 10, no. 10, 01 Jan. 2011, pp. 3024-3033. *Research Gate*, https://goo.gl/u2cfpD.

Crites, Ronald W. et al. *Land Treatment Systems for Municipal and Industrial Wastes*. McGraw Hill, 2000.

Crites, Ronald W. et al. *Natural Wastewater Treatment Systems*. Taylor & Francis Group, 2006, Boca Raton, FL.

Ellison, James. Phone interview. 18 January 2018.

Haddaway, Art. “Pulp & Paper: A Look at Wastewater Trends and Technologies.” *Industrial WaterWorld*, www.waterworld.com/articles/iww/print/volume-14/issue-1/features/pulp-paper-a-look-at-wastewater-treatment-trends-and-technologies.html. Accessed 6 Jan. 2018.

Knight, Robert L. *Use of Constructed Wetlands Effluent Treatment Systems in the Pulp and Paper Industry*. National Council for Air and Stream Improvement Technical Bulletin, No. 876, National Council for Air and Stream Improvement, 2004, Research Triangle Park, NC.

Martin, Alyssa. Phone interview. 18 January 2018.

Smook, Gary. *Handbook for Pulp & Paper Technologists*. 4th ed., TAPPI Press, 2016.

Sumani, Vipin and Seguljic, Thomas S. “Best Practices for Wastewater Treatment and Management.” *Paper360º*, November/December 2016, pp. 38-40.

United States, Environmental Protection Agency. *Constructed Treatment Wetlands*. Office of Water, August 2004.

United States, Environmental Protection Agency. *Construction Costs for Municipal Wastewater Treatment Plants: 1973-1978*. April 1980. Contract No. 68-01-4798.

APPENDIX A – PERSONAL INTERVIEW TRANSCRIPT

James Ellison, Environmental Engineer, Evergreen Packaging

Date: 1/18/18

Rachel Dickson (D): Do you mind if I record the interview for my notes?

James Ellison (E): No, that's fine.

D: A little bit of background; I am writing a paper for my technical writing class on wastewater treatment processes. It is a recommendation report so I am comparing three different types of systems: activated sludge process, constructed wetlands, and overland flow systems. I am comparing on certain criteria. What type of system does Evergreen use?

E: Evergreen uses surface aeration. We use aerated stabilization basins. We do clarification then take solids out through a clarifier then the water is pumped into aerated lagoons where we have surface aerators. We just treat it back there then it goes from the aerated ponds to the polishing pond, Johnson Lake, where it is stabilized then flows to the river. We clarify it, take the sludge out and process the sludge, then the water comes out of the clarifier at the top then goes to the secondary lift station and puts it in the aerator ponds. We use 75 hp aerators, and we have about 61 of them.

D: Do you know a rough number of how much water is used in a day at Pine Bluff?

E: We typically use between 26 and 30 million gallons a day. That is what is processed through the wastewater treatment system.

D: Any idea how much paper that translates into?

E: It's hard to say because most of our water is generated… Paper is going to be the least of the generators. Most of the water will be generated from your pulp mill process. Water is used for washes, cooking the chips, drive off some moisture there, then liquor out of chips is evaporated. Then the pulp is washed, then bleached. Lot of water on that side. Paper machines use an ancillary amount every day. Unless boil out of machine, the paper machines do not use much

D: Shut down days are biggest paper machine users.

E: Most of water comes from digesters and pulp stock wash. We take water in… we do have mill supply make up. We do dilute pulp to move it around in the big machines. Mill supply water is pulled in and sent through for process water. Used to wash pulp, thicken/thin pulp. We also use fire water and such that goes in but most is process water. We can pull it in but whatever we pull in will go back out.

D: Roughly what costs are associated with system operation? Do you pay for the water being used despite return?

E: We pull well water from the ground. There is a small tax charge for natural resources per well. The water is not really free, but we don't pay for it.

D: Any estimate of maintenance costs?

E: Hard to say, because I am not involved. Contact Jeff Hedden for more information. We have maintenance for every part of the mill, so we could conjecture the costs but I would have to find something to look at. Unknown right off hand.

D: How long has the current system been in use? Mill lifetime?

E: Kraft process is German or Swedish… Mill has been in operation since 1958 running current system.

E: Our wastewater treatment basically we clarify - remove solids, pump them out of the bottom. The clarifier has launders at the top, almost as if you put straws at the top of a bowl and fill it up with water. If the straws are angled correctly, the water will flow out of the straws. There is a ring of launders at the top of the clarifier. This causes a hydraulic pressure to help the solids to settle out. The mechanical drives rake and then the sludge is pumped out. We pump those and then dewater it in sludge press. Water returns to the clarifier and the solids are burned in the bark boiler. The water out of the top of the launders is ready for the next step of treatment. It goes into aeration stabilization basins. Surface aerators with a pump blasts the water from the surface up in a circular pattern like a propeller. Water introduced to the atmosphere picks up oxygen. The reason for this system is that bacteria are there to consume the organics in the water. Organic waste has biological oxygen demand. We run a 5 day BOD test to determine the loading. Measures the mg/l on day 1 and day 5; whatever is used up applied to the wastewater flow and that calculation give the load going to the river. Bugs are important. Bacteria is added though some naturally occurs. We add some to enhance the population. It is monitored by looking at the several types of bacteria. We look at free-swimming ciliates, stalk ciliates, rotifers, paramecium which look similar to ciliates but with no footprints. Those are larger than regular bacteria substrate that consume most of the organics. The larger organisms digest what is left. If these larger bugs are present it means the system is healthy because they have enough food to eat. If not present depending on time of year, the system may not be healthy. Most ponds the substrate is always there. We couldn't or depending on temperature, pH, retention time. We have a plug flow system, so once we treat it, it is gone. It flows through the ponds then is discharged. With activated sludge, there will be another clarifier. It goes to the activation tank then the sludge is collected in another tank, some of the sludge is wasted, some is recirculated. We are so big that we have that we have a plug flow that just goes straight through. They recirculate and add other reactors and filters, etc. They have to collect the bacteria. When they get to the secondary clarifier, they recirculate most of that and so much is wasted. If they have a shutdown or catastrophic failure, they lose their bacteria and must start over. They run mixed liquor, volatile suspended solids. This means they filter the solids, then burn them off, they have an ash-less filter paper. Whatever is left after solids removal. Percentage of this that is volatile suspended solids determines strength of bacteria. We don't have that luxury, not that complex. We run BOD, TSS, color. Our permits are predicated on those three pollutants: BOD, TSS, and pH. Depending on operation, there may be other parameters that you have to measure for.

D: How does climate affect the system?

E: Right now, if we have… Bacteria reproduce by fission, they split cells then those cells split. When it gets cold, the activity slows way down, like molasses flowing. The bacteria cannot produce as much when the activity level is down. They need kinetic energy and heat from higher temperatures. Without temperature, their reproduction is slowed down so they don't do as much in colder temperatures. Cold weather slows down the plug flow system. Where activated sludge recirculates allowing for better temperature controls. With Aeration stabilization basin, temperature will just wear you out. If the ponds are deep enough and the biomass near the bottom, the system will do alright but due to surface aeration, cold air is introduced into the water dropping the temperature. The temperature will not be as hot as it goes in because of fanning that water into the air. This cools temperatures and slows down BOD removal from waste.

E: Do you have access to any books or anything that can help you?

D: We have to get two subject matter experts. You are one of them and the other one send me the handbook for pulp and paper technologists.

E: We run the levels in the ponds and depending on the aeration you have, it is in proportion to what the removal rates should be. Most systems are designed to remove 85% of the loading coming into the system. I've found that in my polishing pond, we put 5 aerators in. Over time the lower the volume in the pond, the greater the oxygen transfer will be. More water means there is more water for you to treat which will lessen the oxygen transfer. If level is raised, the retention time must be raised. If volume, retention time is dropped, you get more oxygen transfer if the temperature is right. If the temperature is cold, you are basically shooting yourself in the foot by forcing higher volume/retention time.

D: Do you mind if I email you if other questions pop up?

E: I'll do what I can to try to answer them.

APPENDIX B – PERSONAL INTERVIEW TRANSCRIPT

Alyssa Martin, Environmental Engineer, International Paper

Date: 1/18/18

Alyssa Martin graduated in 2013 from Purdue University with a degree in Environmental and Ecological Engineering. She has worked for International Paper at their Mansfield, Louisiana, location for close to five years as an environmental engineer. Her responsibilities include maintaining environmental compliance, including operation of the wetland wastewater treatment plant and solid waste landfill.

Rachel Dickson (D): Do you mind if I record the interview for my notes?

Alyssa Martin (M): Go for it.

(D): On average, how much water is used in a day at Mansfield.

(M): We are lower than most mills; we use anywhere from 14 to 18 million gallons a day. Industry standard is about 25 million gallons a day. I can get an actual number if I need to.

(D): About how much paper is made at Mansfield in a day for comparison?

(M): Not sure. 200 tons per hour should convert like a couple thousand TPD.

(D): What costs are associated with running a wetland system?

(M): Wetlands systems are pretty low cost. If any pH control is necessary to maintain a neutral pH. It can survive up to 8 or a little bit higher especially if conditioned. Since it is a land system, we try to maintain a 7-7.5 pH from our testing. CO2 is added at our mill, others mills use acid so the addition of pH control chemical adds into cost. Long term maintenance is required since the plant mass grows and dies, a solid layer builds up which eventually becomes so dense that the plants cannot grow anymore. At that point, the system is taken out of service and dried out. One option is to let it dry and till the soil. The sludge biomass breaks down and allows you to aerate the soil. Returning to service heats it up by the cattail plants. If the solid layer gets so thick that it cannot rebound, the solids can be entirely removed which is very expensive. If you are willing to take things out of service more frequently about every other year, they dry out over a couple of months. The secondary sludge will dry out, aerate itself, cracks then things begin to regrow. The life can be extended this way although it will be necessary eventually to till it. The cheapest option, tilling costs about $10,000. Removing all material can cost $30,000. Equipment and such work costs.

(D) When removing it from service, what happens to the water?

(M): 6 wetland areas make it possible to take one out a year; rotating service.

(D): How long has the system at Mansfield been operating?

(M): Overland flow since startup in 1986. Wetlands since 2005.

(D): How does climate affect the system?

(M): Number 1 growth pressure we fight. Spring, summer, it loves. Doesn't really run well during drought, system likes rainwater to help clean caustic material and lower pH. When it is cold, micro activity slows down to almost nothing. As we do not want to move when it is cold, plants and bugs also do not want to grow. Currently there is no green due to the cold winter. Living in the south is the optimal location for the system. This was modeled after a similar system at the XXX plant in Tyler, TX which isn't as big but was the first company that put the system into use. The climate range is good because it typically doesn't get below freezing for a month.

(D): What capital costs go into building system?

(M): Excavation and dirt work are large. No idea how much. Drop in bucket compared to power boilers and such with mill construction. Return on investment great. Wetlands about $250,000 including grading, inlet and outlet weirs, etc.

(D): What environmental regulations, permits, apply to this system?

(M): We only have permits on final outfall. Outfall limits on pH, TSS, and BOD (lb/day rather than ppm because the Red River is not very clean). One item that makes this system different is land space. We have a ton of land space so our other mills run compact ASD or all of our other mills run ASP because it is more compact and tolerant of cold weather.