Case Study:

Implementing a Waste Reduction and Recycling Program at a Commercial Construction Site

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Acknowledgments

Successful waste reduction, reuse and recycling on the Alliant Energy Worldwide Headquarters construction site that is the topic of this case study was made possible through the cooperation of every person on the site and many off site – the contractor, subcontractors, hauler, local resource people, and many others. We would like to recognize those who helped make this waste reduction and recycling project a success:

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Project Objectives

The objectives of the Alliant Energy construction waste reduction and recycling program were to:

- Assess the cost effectiveness and ease of construction materials recycling at a commercial site in Dane County.
- Identify and quantify recyclable/reusable material streams from commercial office construction projects to improve hauler bidding accuracy.
- Identify local markets for construction materials reuse and recycling and quantify transportation and handling costs.
- Develop an education/training approach on planning and implementing construction waste reduction, reuse and recycling at the management and field levels and an education protocol for use on other projects by Alliant Energy, its customers, and architects, builders, engineers and haulers.
- Recycle 50 percent of the construction waste generated in the construction of Alliant Energy's Worldwide Headquarters.

Summary

During the construction of Alliant Energy's Worldwide Headquarters (Alliant Energy), more than 75 percent of all construction waste was reused or recycled and more than $15,000 was saved through avoided disposal costs. The 325,000 square-foot building was constructed in Madison, WI on a 25-acre site between May 2000 and April 2002. We surpassed our 50 percent recycling goal and achieved this high recycling rate through the strong cooperation of all members of the recycling team, including Alliant Energy (owner), Opus North Corporation (design/build firm), Green Valley Disposal (hauler) and WasteCap Wisconsin (recycling consultant). Other important elements included incorporation of recycling expectations in the specifications, a well-designed recycling program, constant monitoring, education, adjustments, diligence in locating recycling markets and careful tracking of results.

This report is meant as a tool for building owners, architects, contractors, haulers and others interested in establishing a successful construction waste reduction and recycling program. It is the intention of this document that the steps outlined here could be followed to result in successful recycling at construction sites throughout Wisconsin and elsewhere.

Project Background

In Wisconsin, there is more construction and demolition debris generated than residential municipal solid waste.[1] Often, large quantities of relatively clean, high-value materials are available in the construction waste stream. Currently, there is increasing interest both in Wisconsin and nationally in recovering these materials.

Alliant Energy, an energy services company providing electric, natural gas and steam services to nearly three million customers worldwide, was committed to incorporating sustainable building techniques in the construction of their new worldwide headquarters in Madison, Wisconsin (see Appendix A. Sustainable Building Components at Alliant Energy's Worldwide Headquarters). As part of their effort to reduce the environmental impact of this large construction project, Alliant Energy desired to reduce the amount of waste they sent to the landfill during construction. They recognized the need to create a diverse team to formulate a successful Construction Waste Reduction and Recycling Plan for the site. Due to the innovativeness of this project and the potential positive impact on future recycling projects, a Wisconsin Department of Natural Resources (DNR) Solid Waste Reduction and Recycling Demonstration Grant was awarded in February 2001 to implement the plan. University of Wisconsin-Extension staff members were instrumental in helping to design the original recycling program and to put together the grant application. In Wisconsin, there are several challenges this project addressed including:

[1] Wisconsin Waste Characterization & Management Study Update. Franklin Associates, Ltd. Prepared for State of Wisconsin Department of Natural Resources. July 2002. Tables 1-1 and 1-5.

- Availability of recycling markets
- Lack of information about quantities of construction materials generated on commercial projects
- Lack of information about the costs of recycling on a construction site
- Lack of experience and training for construction management and subcontractors on how to plan for and implement a comprehensive construction site waste reduction and recycling program

Opus North Corp. built the 325,000 square-foot office building with a steel structure and pre-cast concrete façade. The three-story building has two wings centered around an open rotunda. Construction phases were closely followed to ensure a compatible recycling program was in place throughout the duration of the project.

Project Plan and Implementation

Forming a team

Alliant Energy Corporation, the building owner, provided oversight to the recycling program; an environmental consultant and a construction project manager represented Alliant Energy on the recycling team. The initiation of this recycling project by the owners and their continuous involvement were crucial to the program's success.

Opus North Corp., the design/build firm for the project, was responsible for on-site implementation of the plan. The assistant project manager educated the subcontractors, monitored and enforced the plan, responded to on-site issues and tracked materials being reused, reduced or recycled.

WasteCap Wisconsin was hired as a subcontractor by Opus North Corp. to provide technical and educational assistance, and to monitor, measure, document and publicize results of the waste reduction and recycling program. As the recycling consultant, they developed a time-based management approach for placement and timing of the various recycling containers, identified methods and markets for reducing, reusing and recycling construction materials, conducted training and waste audits, measured results, and shared the program's success through various media and outreach efforts.

Green Valley Disposal was the waste and recycling hauler. A construction service and sales representative coordinated dumpster and recycling bin placement and pick up, responded to on-site issues regarding material disposal and documented the materials leaving the site to track costs and quantities. Green Valley Disposal was also instrumental in finding markets for materials, including drywall.

- ✓ ***To Do:***
  The commitment of the team and the subcontractors on site is key to a successful waste reduction and recycling program. Designate staff members to design the recycling program, write specifications, serve as the recycling coordinator (the point person who makes sure the recycling program is working well and who is responsible for responding to any challenges and making adjustments as needed), be responsible for ensuring that all contractors and subcontractors are educated about the program, educate crews, coordinate dumpster placement and pickup, monitor and enforce the recycling plan and keep records on quantities and costs.

Specifying recycling

All subcontractors on site were required to comply with Opus North Corp.'s specifications (see Appendix C. Sample Specification Language). These general conditions defined the recycling program, and the reduction and reuse measures the subcontractors were expected to take.

- ✓ ***To Do:***
  Include reduction, reuse and recycling in construction specifications. It is important to include enforcement as part of the specifications. If a subcontractor puts trash in a recycling bin, the enforcement provisions outline what is done next. Will you ask the subcontractor to remove the material? Will they pay for the container if it has to be disposed as trash? Being clear up front can help you deal with (and prevent) problems later.

  Another important change to job site operations that is included in the specifications is who is responsible for trash removal. On job sites that do not recycle, often each trade is responsible for their own disposal. On a site that recycles, recycling is generally centrally managed by the contractor. Subcontractors should be asked to remove any costs for disposal from their bids.

  Sample construction waste recycling specifications are available at www.wastecapwi.org.

Identifying recyclable materials

To determine what we would recycle, we looked at what materials the building would be constructed from, when the materials would be generated and whether or not we could find a recycling market for the material.

- ✓ ***To Do:***
  Identify target materials from the job site that can be recovered from the waste stream. Remember to separate items banned from Wisconsin landfills, such as aluminum, glass and plastic cans and bottles, office paper and corrugated cardboard. Additional target materials should:
  - Be generated in significant quantities (at least 1-2 cubic yards per week)
  - Have a good market value or provide avoided disposal costs
  - Be fairly easy to sort on site

  If you aren't sure what materials will be generated as waste, pre-bid meetings are a great place to ask each of the subcontractors what materials they will generate as "trash." You can then determine which of these materials may be able to be separated for recycling.

  Finding markets: Your local waste hauler can be a great source for helping find recycling markets. The Department of Natural Resources maintains the Wisconsin Recycling Markets Directory, found on the Web at www.dnr.state.wi.us/org/aw/wm/recycle/md/marketsdirectory.htm. In addition, you can contact WasteCap Wisconsin, your local UW-Extension agent, local Department of Natural Resources recycling specialists, your local recycling coordinator from your municipality, and refer to the phone book. Consider local alternatives as well, such as concrete ground up on site, sawdust donated to local farmers for animal bedding, and drywall donated to farmers as a soil amendment.

Developing a construction waste reduction and recycling plan

- ✓ ***To Do:***
- Set aside time to manage the program (approximately 1-2 hours per week for construction)
- Select recycler(s) and make arrangements for collection. Bid out the service based on the materials you anticipate recycling. Consider allowing haulers to bid on one or two materials instead of the whole job (for example, a paper recycler may be able to give you a good deal on cardboard recycling, but may not be able to handle collection of other materials).
- Determine where to place containers, how many, what type are needed, and when. Make sure to put a trash container near all recycling containers or the recycling container may become a trash container.
- Write up a waste reduction and recycling plan. Describe what target materials you will recycle, the method for collecting the materials, the recycling providers to be used, the final destination of the materials, and the target material generation schedule. Post this information in a visible location where all can reference.

Table 1 describes materials separated on the Alliant Energy construction site, the method for collecting the materials, the recycling provider to be used and the final destination of the materials. As materials were generated, we added or removed containers. For example, a dumpster for drywall was not set up until the drywall contractors started to generate scrap and it was removed as soon as they were done. Note: The building had a cardboard and trash compactor installed. Once these were usable, these were utilized to collect cardboard and trash.

Table 1: Materials Recycled

Material	Collection Process	Destination/Use
Bottles and cans made of plastic, aluminum, and glass	95-gallon carts (9) and small tub containers located throughout the building. Taken to a central area for collection	Green Valley Disposal (GVD) Recycling Center for sorting, baling, and shipping to markets
Cardboard and paper	6-yard covered containers (2) – one by job trailer. Note: covered containers helped keep the paper clean and uncontaminated	GVD Recycling Center for sorting, baling and shipping to market
Concrete	12-yard container	GVD hauled for recycling
Drywall	20-yard container	GVD hauled to local farmer for grinding and land application as a soil amendment
Metal	12-yard container	GVD hauled to local scrap metal recycler for sorting and shipping to market
Pallets	Stacked	Pallet One collected for rebuilding and resale as pallets or chipping and sale as mulch
Reusable Materials	Separate on site	Reused on site (e.g. wood scraps), returned to suppliers (e.g. wooden spools)
Styrofoam	Stored indoors	Opus North Corp. hauled to Brown Sales Company for use in bean bag chairs
Stretch wrap	Only stretch wrap from moving carts was recycled. Placed indoors on loading dock in Gaylord boxes.	Cascade Asset Management hauled to Protect the Planet for baling and shipping to plastic lumber market
Wood	30-yard container. Recycled wood w/ nails. Can't recycle treated wood.	WoodCycle hauled for chipping, dying and resale as landscape mulch
Trash	20-yard container. 6-yard container by job trailer. 55-gallon containers (6) in building	GVD Transfer Station to Mallard Ridge Landfill (Delavan)

- ✓ ***To Do:***
  Here are some additional items you may want to include in your construction waste management plan:
  - Identification of projected construction waste materials
  - Identification of projected quantity of each material
  - Name of the landfill where trash will be disposed and the projected cost of disposing all project waste in the landfill
  - Estimated cost/cost savings of recycling
  - Description of meetings to be held to address waste management
  - Description for waste auditing procedures and accompanying forms

Educating, training and monitoring

We were diligent about training everyone working on the site about the reuse and recycling program. Opus North Corp. held **weekly meetings** with all of the foremen and a separate weekly meeting with the project managers. At these meetings, the recycling program was consistently discussed as an agenda item - everyone was reminded of their role to make the program a success, and everyone was asked for their input. WasteCap Wisconsin staff attended the meetings of the foremen approximately once a month. At these meetings, WasteCap Wisconsin staff thanked everyone for participating, informed them of the status of the reuse and recycling program, asked for their input, and handled any problems. These meetings were an excellent opportunity for the people working on the site to bring up issues including unusual recyclables which may be able to be diverted, locations of containers, reuse challenges, etc. For example, the fact that most of the wood generated contained nails was brought up at one of these meetings. Thanks to the input of the subcontractors, we were able to find a recycling market for the wood and other materials of concern.

In addition, Opus North Corp. staff was very committed to the success of this project, and their staff **continually monitored the recycling program and educated** anyone that they found was not properly separating the recyclables. Because the trades generate very different types of trash, it was very easy for Opus North Corp. staff to determine which trade was improperly separating so that they could address this issue with a representative from that trade. After the training meetings with the foremen, staff from WasteCap, Opus North Corp., and Green Valley Disposal would conduct **site visits, do waste audits and talk to the people working on the building** to see if they had any problems or suggestions. This was an excellent way to discover any issues that needed to be addressed, like clarifying what could and could not be recycled or moving recycling containers to where people were working for easier access. We were very pleased during these visits to discover that all of the people working on the site knew about the program and what to do. For example, during one of our visits, we talked to a person working his first day at this job site and he was able to tell us all of the requirements of the recycling program.

We also held **special events** where we could talk to everyone who was working on the job at once. Shortly after we received the grant, we held a kick-off event for everyone working on the site. We provided lunch, explained the program, and let the construction crews know that their efforts made the recycling program a success. In April 2001, we held an Earth Day celebration to educate new crews about the program and inform everyone about the status of the program and the positive difference they made. In December, we held an event to express our appreciation to all of the subcontractors. We again provided lunch, explained the program, and let the construction crews know the results of their efforts. At the end of the program in May 2002, Alliant Energy held a recognition reception for all the contractors and subcontractors involved in the construction project and the recycling program. Speakers at each of these

events included representatives from Alliant Energy, Opus North Corp., and WasteCap Wisconsin. These events were an excellent way to give everyone on the site the necessary recycling information they need to know, for example, what materials to separate and the results their efforts are making. Subcontractors reported that they found these events helpful and appreciated that their efforts were recognized.

Containers – Location and Signs

Trash containers were placed near all recycling containers. The containers were in the most accessible spot for the employees and located at the most commonly used entrance to the structure. In addition to labels and signs on and near the containers, most containers were a different size, shape or color.

We found that magnetic signs connected to the containers were not very effective, as they would often leave with the recycling container. Sandwich board signs were placed in front of each container and were very effective, as was signage that was painted right onto the containers (and therefore permanent). Signs that hook onto a dumpster at eye level may also be useful when material is being placed into the dumpster.

Signs were very brief and specific, were placed where people would put materials into the dumpster, and specified exactly what was to be put into the dumpster (e.g. "Wood Only. No treated wood. Nails OK.")

- ✓ ***To Do:***
  - Set aside time to explain the program to all of the subcontractors at the site, and instill in them that it is their responsibility to ensure that their laborers participate in the program. Educate at the pre-bid meeting, every weekly foremen meeting, any lunches you have for the subcontractors, etc. The site superintendent should conduct daily on-site monitoring.
  - Distribute the waste reduction and recycling plan to all levels of management.
  - Post signs that explain which materials go in which containers for the program. It is essential to the success of the recycling program that each container is clearly marked. Containers may need to be marked on several sides and written in various languages. Consider using signs that remain on site when the dumpster is picked up. Your recycling service provider may be able to help provide signs.
  - Periodically check the containers to ensure that the proper materials are being placed inside. If problems exist, find the person or people responsible and instruct them or their supervisor on how to properly participate. Use enforcement outlined in the specifications if necessary.

Documenting

Documenting the reuse and recycling helped us determine if we met our diversion goal and allowed us to measure the economic impact of recycling on the site. WasteCap Wisconsin compiled the reuse and recycling results. Opus North Corp. collected the data on materials reused from the site and provided it to WasteCap Wisconsin. For example, the electrical contractors were able to work with their supplier to send back the large wooden spools from the wiring for reuse. Green Valley Disposal was required to weigh all loads from the site before they were taken to markets. They provided the weights and, where possible, volumes of material removed to WasteCap Wisconsin on a monthly basis (see Appendix D. Sample Tracking Sheet). Green Valley Disposal and Alliant Energy provided information on costs of trash and recycling hauling. These numbers were compiled by WasteCap Wisconsin and provided to project team members on a regular basis.

- ✓ ***To Do:***
  - Have recycling service providers give you copies of records showing how much material is being removed and at what cost. Ask recycling service providers to weigh all dumpsters. If you are not able to obtain weight for all materials, use recycling conversions to estimate (see Appendix D. Sample Tracking Sheet and Appendix G. Recycling Conversions).
  - Calculate economic and environmental impact of your recycling program (see Appendix F. Recycling Economics Worksheet and Appendix G. Recycling Conversions). The spreadsheet in Appendix D may provide you with a useful format for documenting recycling from your site.

Sharing Results

The Alliant Energy construction waste reduction and recycling project has received a great deal of news exposure and positive recognition, both locally and nationally. Alliant Energy and WasteCap Wisconsin have collaborated to reach a wide audience through various media outlets. Listed under the heading Media Presentations on the following page are some of the media results and public presentations made to date.

One example is a Talk & Tour event WasteCap Wisconsin hosted October 9, 2001. A Talk & Tour is a business waste reduction and recycling business open house. Its purpose is to provide a hands-on learning environment for businesses to assist each other with waste reduction. Instead of educating businesses through a seminar or conference, businesses have welcomed this new approach -- to see a business in action and learn from their peers. Over 70 people registered for this event, including architects, contractors, engineers and other building professionals, recycling professionals, and others interested in waste reduction and recycling. Each attendee was given a packet of information so that they could use it as a reference to consider similar efforts on their job sites.

- ✓ ***To Do:***

Promote success in the program to managers, subcontractors, clients and the public. For example, one contractor took his employees on a company-sponsored fishing trip with the funds from recycling steel. Consider holding a recognition lunch for your subcontractors.

Media/Presentations

- Presentation to an Alliant Energy customer, U.S Department of Military Affairs and their contracted architect, Potter Lawson, Inc. September 2002.
- Recognition at **Alliant Energy Headquarters Open House**. July 2002.
- Presentation at the **National Environmental Protection Agency Jobs Through Recycling Annual Meeting**. June 2002.
- Presentation at the **AIA Annual Convention.** May 2002.
- Presentation at the **Associated Recyclers of Wisconsin Conference.** March 2002.
- **Madison, Wis. Fox 6 News.** March 2002.
- Presentation at **ConExpo**, Las Vegas, NV. February 2002.
- Presentation for the **Wisconsin State Department of Administration Project Manager's Training**. January 2002.
- ***Resource Recycling***. "Leading the Way to New C&D Recycling Markets" January 2002.
- ***Hard Hat News***. "Wood Recycling and Drywall Grinding" December 7, 2001.
- Presentation at the **Recycling Association of Minnesota Conference.** November 2001.
- Presentation at **Iowa's Waste Matters Conference.** October 2001.
- **Talk & Tour at Alliant Energy's worldwide headquarters** hosted by Alliant Energy, Opus North Corp., Green Valley Disposal and WasteCap Wisconsin. October 9, 2001.
- Presentation at the **Madison Chapter of the International Facility Managers' Association.** September 2001.
- Presentation at the **Great Lakes Regional Pollution Prevention Roundtable**. "Construction Waste Recycling at Alliant Energy Headquarters" July 2001.
- **Letter from Governor Scott McCallum.** "The results stemming from such an innovative endeavor will undoubtedly result in a cleaner environment, which ultimately benefits all of the residents of the great state of Wisconsin." June 13, 2001.
- ***Headquarters Headlines.*** "Presenters talk trash at Talk & Tour" Alliant Energy newsletter. November 2001.
- ***Environmental Building News.*** "Earthworms and Type X Drywall" October 2001.
- ***Milwaukee Journal Sentinel.*** "WasteCap helps businesses with their dirty work" October 23, 2001. Front page of the Business section.
- ***WasteCap's Web Site***. Front page of WasteCap's Web site in October and November 2001.
- **Madison, Wis. Channel 15 News.** Covered Talk & Tour at Alliant Energy's construction site on 10 pm news.
- ***The Capital Times***, Madison, Wis. October, 2001. Article inviting readers to Talk & Tour.
- ***The Green Valley Hauler*** "Construction Recycling!!!" October 2001.
- ***C&D Recycler*** "Wisconsin Project Sets C&D Recycling Goals" July/August 2001.
- ***BioCycle.*** "Wisconsin Companies Turn Wood Residuals Into Revenues" July 2001.
- ***Recycling News.*** "Building a Future for Construction Debris – Innovative, Large-Scale Construction Waste Reduction and Recycling Program Makes an Impact" Summer 2001.
- ***The Green Valley Hauler.*** "Recycling on a Construction Site?" July 2001.
- ***Contractor's Update*** "Building A Future for Construction Debris – Innovative, Large-Scale Construction Waste Reduction and Recycling Program Makes an Impact" May/June 2001. Newsletter of the Associated General Contractors.
- ***Associated Recyclers of Wisconsin*** "Building a Future for Construction Debris" June 2001.
- ***BioCycle.*** "Measuring the Results of C&D Debris Recycling" May 2001.
- ***Headquarters Headlines.*** "New headquarters contractors applauded for recycling efforts" May 2001.
- ***WasteCap's Email Bulletin***. April, July, September, October and November articles about the efforts of the team and inviting recipients of the bulletin to the Talk & Tour.
- ***Waste News.*** "Project gauges C&D recycling efficiency" May 28, 2001.
- ***The Daily Reporter.*** *CITY STATE* "Alliant, WasteCap recycle lessons, debris. $57 million construction project to serve as role model for state" April 2001.
- ***In Business,*** Madison, Wis. "Wisconsin Companies Turn Wood Wastes Into Revenues" Summer 2001.

Results

Upon project completion, over 75 percent of the material by volume was reused or recycled. These results exceeded the goal of 50 percent recycling rate. Table 2 represents the breakdown of recycled materials.

Table 2: Summary of Recycling and Trash Disposal

	Tons	**Proportion of Waste Stream (by weight)**	**Yards**	**Proportion of Waste Stream (by volume)**
Recycling	**526.62**	**67.9%**	**6840**	**75.7%**
Trash	249.34	32.1%	2197	24.3%
Total	761.52	100%	9037	100%

Table 3 represents the weight and volume of each material recycled. This information can be used to estimate potential quantities of construction materials generated on other commercial projects of similar size.

Table 3: Recycled Materials Summary

Material	Unit	# of containers pulled	Tons	Yards	Percent of total volume
Commingled	95 gal (.5 yd)	18	0.25	9	0.10%
Commingled	6 yarders	9	1.33	54	0.60%
Cardboard	6 yarders	85	17.85	510	5.64%
Cardboard	30 yd compactor	50	54.32	3622	40.08%
Wood	30 yarders	58	292.88	1740	19.25%
Metal	12 yarders	29	42.09	348	3.85%
Drywall	20 yarders	26	96.90	515	5.70%
Clean Fill	12 yarders	6	21.00	42	0.46%
Other Charges					
Total Recyclables		**281**	**526.62**	**6840**	75.69%

Table 4 represents total disposal costs, costs per unit weight and volume for each material and recycling and trash totals. As noted below, on average, recycling was $2.65 less expensive per cubic yard and $2.56 less expensive per ton.

Table 4: Costs of Recycling and Disposal

Material	Yards	Tons	Total cost	Cost if disposed of as trash	Avoided Disposal Cost	Average cost per yard	Average cost per ton
Commingled	9	0.25	$360.00	$49.00	($311.00)	$40.00	$1,440.00
Commingled	54	1.33	$0.00	$288.22	$288.22	$0.00	$0.00
Cardboard	510	17.85	$7,025.79	$2,901.90	($4,123.89)	$13.78	$393.60
Cardboard	3622	54.32	$3,810.65	$18,145.88	$14,335.23	$1.05	$70.15
Wood	1740	292.88	$11,072.00	$17,787.92	$6,715.92	$6.36	$37.80
Metal	348	42.09	$4,128.88	$2,997.06	($1,131.82)	$11.86	$98.10
Drywall	515	96.90	$4,772.70	$4,908.56	$135.86	$9.27	$49.25
Clean Fill	42	21.00	$984.79	$903.00	($81.79)	$23.45	$46.89

Other Charges			$1,848.91				
Total Recyclables	**6840**	**526.62**	**$33,911.02**	**$47,981.54**	**$15,826.73**	**$4.97**	**$64.57**
Total Trash	**2197**	**249.31**	**$16,735.75**			**$7.62**	**$67.13**

Table 4 also represents costs avoided by recycling. To assess the overall economic effect of recycling on this project, we calculated the expected disposal costs assuming no recycling program. This calculation is based on the cost of the trash disposed of on this project: $4.50 per cubic yard plus $34 per ton tipping fee.

This project avoided over $15,000 of disposal costs by recycling. This clearly demonstrates that recycling was a cost-effective strategy for managing the project's construction waste in addition to the many environmental benefits.

Conclusion

Results:

- **Economic**: **Over $15,000 was saved** through avoided disposal costs.
- **Environmental: 527 tons of solid waste was diverted from Wisconsin landfills**. We exceeded our goal of diverting 50 percent by **diverting over 75 percent of the construction debris**. As just one example of the environmental impact, 72 tons of cardboard were recovered. Seventeen trees are saved for each ton of paper recovered, so a total of **1,224 trees were saved** through recycling cardboard alone.
- **Technical:** The contractor, subcontractors, owner, and the hauler agreed that **recycling was technically successful and not difficult to accomplish**. Important techniques included proper placement of recycling containers, clear signage, constant education (at every weekly meeting of the foremen, daily reinforcement by staff, education at several special events, etc.), check-ins with contractors and subcontractors to address questions and make adjustments, daily on-site monitoring, and recycling language in the specifications requiring compliance. In on-site interviews and follow-up discussion, contractors and subcontractors reported that separating recyclables took almost no time at all. Extra time is needed, however, to educate crews, to properly document the amount and cost of collection of recyclables and trash, to find markets for unusual recyclables (e.g. drywall) and to create and place clear signs.
- **Social:** Wisconsin's Governor recognized this project in a letter to WasteCap Wisconsin, noting: "Such a plan could certainly change the way construction waste is handled statewide. The results stemming from such an innovative endeavor will undoubtedly result in a cleaner environment, which ultimately benefits all of the residents of the great state of Wisconsin."

Considerations that may hinder the implementation of these projects statewide include:

Local Recycling Markets – In Dane County, we found recycling markets for all of the commodities we recycled. As noted in the economics section, some of the materials were less expensive than trash disposal and some were more expensive, resulting in a net savings by recycling. In other communities, recycling markets for some commodities may not be available or may be cost-prohibitive. In particular, the markets for wood and drywall (the two largest portions of the construction and demolition waste stream according to the 1995 Camp, Dresser and McKee report) need to be developed statewide.

Drywall Guidelines/Permit Requirements – Currently, the only market for drywall from a commercial site in Wisconsin is land application on farmers' fields. There are only three DNR permits that have been issued for land application of drywall in Wisconsin. The Alliant Energy project led to a study of the impact to the biological community of Type X drywall and an exemption from solid waste rules to land-apply Type X drywall for this one project. However, it is unknown whether other projects that want to divert Type X drywall from their waste stream for land application will be able to do so. In addition, another Wisconsin-

based project involving WasteCap Wisconsin and the DNR is trying to discover whether or not drywall can be ground and applied on a construction site. Also, WasteCap Wisconsin has recently received a grant from the U.S. Environmental Protection Agency (EPA) to test the use of drywall in commercial fertilizer. Markets for drywall in Wisconsin and around the United States are new and currently being tested. Hopefully these studies will lead to the development of clear guidelines/permit requirements which business leaders who want to divert their drywall will be able to follow.

Based on the economic, environmental, technical and social success of recycling at this construction site, overall interest in the industry, and the potential to replicate Alliant Energy's experience around Wisconsin, we see a clear direction around the state and the United States for substantial expansion of construction waste recycling. As Josh Babiasz of Opus North Corp. stated, "In 10 years, this [construction waste recycling] will just be normal practice on all construction sites." We at Alliant Energy and WasteCap Wisconsin are grateful to the Wisconsin DNR for providing a demonstration grant, which helped make these results possible.

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This case study is intended as guidance only. It is not intended as a substitute for any applicable state, federal, and/or local regulation.

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Appendix A. Sustainable Building Components at Alliant Energy's Worldwide Headquarters

Alliant Energy is committed to preserving natural resources and providing a healthy place for its employees to work. Because of this commitment, sustainable components were incorporated into the new headquarters. Sustainable building technologies help us use energy and materials more efficiently, which saves money, preserves resources and reduces waste. "Green" practices are not only positive for the environment, but also can benefit our health. To help the environment and ensure the health and safety of its employees, Alliant Energy implemented the following sustainable technologies into the design, construction and operation of its new headquarters:

Construction Materials Reused/Recycled

Alliant Energy received a Wisconsin Department of Natural Resources (DNR) Waste Reduction and Recycling Demonstration Grant to implement an innovative recycling program during the construction phase of the building. The goal was to achieve a 50 percent waste diversion rate. Alliant Energy surpassed all expectations and reused or recycled over 75 percent of the materials generated on site.

Reused material – Materials returned to the vendors and contractors for reuse:
355 Wood Pallets
160 Wooden Spools
3,923 lbs. Polystyrene Packing Material
250 lbs. Aluminum Insulated Cables
3,133 lbs. Copper Data Cable
17,500 ft. 1-1/4" PVC-40 Conduit
19,197 lbs. Copper Wire

Recycled material – To reduce landfill waste, local markets were identified for the materials:
293 tons Wood (hauled to WoodCycle for chipping into mulch)
97 tons Drywall (permit obtained for land-spreading)
72 tons Corrugated Cardboard
42 tons Metal (hauled to scrap metal recycler)
2 tons Bottles and Cans
1000 lbs. Stretch Wrap from moving carts (recycled into plastic lumber)
2 Toner Cartridges

Alliant Energy recycled over 500 tons of the construction waste.

"What Alliant Energy is doing is groundbreaking. The company has gone above and beyond the call of duty in its recycling of construction waste. Alliant Energy has taken risks and people should be thanking them for that."

John Reindl
Dane County Recycling Manager

Purchase of Recycled Material

Materials with recycled content were purchased from local suppliers:

- Asphalt (6,699 tons) – East parking lot
- Fly ash (244 tons) – used in concrete for footings, walls, columns, and parking garage
- 6" reused raised access floor (1500 sq. ft.)
- Fireproof spray (75% percent recycled material)
- Dome acoustical treatment (80 percent recycled material)

Cafeteria

Reusable dishes are utilized in the cafeteria to reduce daily waste. Environmentally-friendly containers are offered for to-go orders.

- Reusable dishes
- The EPA has done studies on the environmental impact of reusable vs. disposable dishes and finds that even when considering the use of soap, hot water, etc. for the reusable dishes, they still have less effect on the environment.
- Environmentally-friendly EarthShell containers for to-go orders
    - EarthShell products are made of starches, limestone, and wood fibers, which are renewable resources. They also use less energy and produce fewer pollutants in their production vs. polystyrene and paper products, and they are biodegradable.

Heating, Ventilating and Air Conditioning (HVAC) System

The building is cooled using an off-peak ice storage system that lowers energy demand and saves Alliant Energy thousands of dollars annually. Polyisocyanurate foam core sheathing (rigid insulation) was used to aid in HVAC efficiency. Also, Energy Star high-reflectance and low emissivity roofing was used to conserve energy and extend the roof life.

Glass and Window Treatments

Special windows were used to allow the light in while keeping the heat out. The open office system enables employees to see natural light.

- Clerestory/transom glass Viracon, VE3-55 with 23% visible light transmittance
- Mini blinds
- View glass Viracon, VE-40 with 8% visible light transmittance
- Perforated roller shades with <12% light transmittance

Indirect Lighting

Features and enhancements of the indirect lighting include:

- Perforated pendant light fixtures
- Perimeter dimming
- Light-colored interior window frames
- White ceiling and soffits
- Perforated dark-value shades

Air Quality

Employee health and safety are top priorities at Alliant Energy.

- Reduced amount of indoor air contaminants by using a special floor pedestal adhesive with low volatile organic compounds (VOC's) - Taylor #105, manufactured by Envirotec Healthguard adhesives
- CO^2 Monitoring
- Smoking is not allowed in the building
- FM-200 fire suppression system (FM-200 replaces ozone depleting Halon 1301)

Erosion/Sedimentation Control and Landscaping

- Silt fence around perimeter of site (24.9 acres)
- Entire site drains into a 124,560 cu. ft. sediment basin
- Basin water filters through a 30 foot x 7 foot rock wall
- Native prairie grasses planted on site

Alternative Transportation

Employees are offered alternative options for commuting to/from work.

- Bike racks for cyclists and shower/changing rooms are provided
- Bus service and free bus passes are available

Appendix B. Executive Summary

Project: Waste Reduction, Reuse and Recycling during construction of Alliant Energy's Worldwide Headquarters. 325,000 square-foot building on a 25-acre site. Primarily steel frame construction with precast brick panels and glass set into prefinished aluminum frames.

Construction Period: June 2000 - April 2002
Contact: Heidi Rahn, Alliant Energy, Environmental Consultant, (608) 458-3214
Jenna Kunde, WasteCap Wisconsin, Associate Director, (414) 961-1100

Project Objectives

- Assess the cost effectiveness and ease of construction materials recycling at a commercial site in Dane County
- Identify and quantify recyclable/reusable material streams from commercial office construction projects to improve hauler bidding accuracy
- Identify local markets for construction materials reuse and recycling and quantify transportation and handling costs
- Develop an education/training approach on planning and implementing construction waste reduction, reuse and recycling at the management and field levels and an education protocol for use on other projects by Alliant Energy, our customers, as well as architects, builders, engineers and haulers.
- Recycle 50 percent of the construction waste generated in the construction of Alliant Energy's new Worldwide Headquarters in Madison, Wis. which had its grand opening in July 2002.

Background/Challenges

In Wisconsin, there is more construction and demolition debris generated than residential municipal solid waste.[2] Often, large quantities of relatively clean, high-value materials are available in the construction waste stream. Currently, there is increasing interest both in Wisconsin and across the country in recovering some of these materials. In Wisconsin, there are also several other challenges this project addressed, including:

- Market availability
- Lack of information about quantities of construction materials generated on commercial projects
- Lack of information about the costs incurred by subcontractors and haulers for recycling
- Lack of experience and training for construction management and subcontractors on new procedures, including how to plan and implement construction site waste management.

Results/Knowledge Gained

During the construction of Alliant Energy's Worldwide Headquarters, over 75 percent of the construction waste was reused or recycled and over $15,000 was saved through avoided disposal costs. These results exceeded the goal of 50 percent recycling rate. This resulted in **526.6 tons,** or 6,840 yards of construction waste being recycled.

[2] Wisconsin Waste Characterization & Management Study Update. Franklin Associates, Ltd. Prepared for State of Wisconsin Department of Natural Resources. February 1998. Pages 1-7 and 1-14.

Table 1 represents the weight, volume and cost of each material recycled as well as the amount of material landfilled. As noted below, on average, recycling was $2.65 less expensive per cubic yard and $2.56 less expensive per ton than landfilling the material.

Table 1. Recycled Materials Summary

Material	Unit	Yards	Percent of total volume	Tons	Total cost*	Cost if disposed of as trash**	Avoided Disposal Cost	Average cost per yard *	Average cost per ton *
Commingled	95-gal	9	0.10%	0.25	$360.00	$49.00	($311.00)	$40.00	$1,440.00
Commingled	6 yd	54	0.60%	1.33	$0.00	$288.22	$288.22	$0.00	$0.00
Cardboard	6 yd	510	5.64%	17.85	$7,025.79	$2,901.90	($4,123.89)	$13.78	$393.60
Cardboard	30 yd cmpctr	3622	40.08%	54.32	$3,810.65	$18,145.88	$14,335.23	$1.05	$70.15
Wood	30 yd	1740	19.25%	292.88	$11,072.00	$17,787.92	$6,715.92	$6.36	$37.80
Metal	12 yd	348	3.85%	42.09	$4,128.88	$2,997.06	($1,131.82)	$11.86	$98.10
Drywall	20 yd	515	5.70%	96.90	$4,772.70	$4,908.56	$135.86	$9.27	$49.25
Clean Fill	12 yd	42	0.46%	21.00	$984.79	$903.00	($81.79)	$23.45	$46.89
Othr Chrges					$1,848.91				
Total Recy.		**6840**	**75.69%**	**526.62**	**$33,911.02**	**$47,981.54**	**$15,826.73**	**$4.97**	**$64.57**
Total Trash	20 yd, 30 yd, 30 yd cmpctr	**2197**	**24.31%**	**249.31**	**$16,735.75**			**$7.62**	**$67.13**

* Includes rate per yard/ton and hauling fee
**Calculated using $4.50 per yard hauling rate plus $34 per ton charged for trash

To assess the overall economic effect of recycling on this project, we calculated the expected disposal costs assuming no recycling program. This project avoided over $15,000 in costs by recycling. This clearly demonstrates that recycling was a cost effective strategy for managing the project's construction waste in addition to the many environmental benefits.

Reused Material – Materials returned to the vendors and contractors for reuse:
355 Wood Pallets
160 Wooden Spools
3,923 lbs. Polystyrene Packing Material
250 lbs. Aluminum Insulated Cables
3,133 lbs. Copper Data Cable
17,500 feet 1 ¼" PVC-40 Conduit
19,197 lbs. Copper Wire
2 Toner Cartridges

Project Plan and Implementation

To achieve these results, the following steps were taken (see full report for details):

- A waste reduction and recycling team was formed.
- Waste reduction and recycling was included in project specifications.
- Items to recycle were identified and a hauler chosen.
- The team developed a construction waste reduction and recycling plan.

- All contractors and subcontractors were continually educated and trained. The recycling program was monitored daily and discussed at all project meetings. Waste reduction was consistently encouraged. Adjustments were made and challenges addressed.
- Results of the waste reduction and recycling program were carefully documented.
- Results were shared with managers, subcontractors and the public.

Summary

Recycling at the construction site of Alliant Energy's Worldwide Headquarters has proven to be cost effective, feasible and environmentally beneficial. As recycling markets continue to expand and contractors gain more recycling experience, less oversight will be needed to identify opportunities, train contractors and monitor success. Alliant Energy is committed to reducing the amount of waste it sends to landfills and will continue to share its successful recycling methods with others.

Appendix C. Sample Specification Language

The following is part of the Alliant Energy Worldwide Headquarters Project Specifications prepared by Opus North Corp., Section 1.1 General Conditions, and covers the clean up and recycling responsibilities of the Subcontractor.

CLEANING UP

Subcontractor at all times shall keep the site free from accumulation of waste materials or rubbish caused by his operation in accordance with the construction site waste recycling plan. At the completion of the Work, he shall remove all his waste materials and rubbish from and about the project, as well as all his tools, construction equipment, machinery and surplus materials and shall clean all glass surfaces installed by him and leave the Work "broom clean" or its equivalent, except as otherwise specified. Subcontractor shall clean, repair, and restore materials, equipment and surfaces damaged by Subcontractor to the original specified conditions.

If Subcontractor fails to clean up, Contractor may do so and Contractor's costs thereof shall be charged to Subcontractor.

Construction Site Waste and Recycling Plan

All Contractors will abide by the Recycling Guidelines stated below. Our goal is to minimize the environmental impact of the construction project and reduce our waste by 50 percent. To reach this goal, the following items will be diverted from the landfill waste stream and recycled or reused. There will be a site scrap log available to the subcontractors to help account for any material the subcontractor may remove from the site. In doing this we will be able to keep track of all the material landfilled or recycled by the subcontractor, if they decide not to use our receptacles. This will be a joint effort by Alliant Energy, Green Valley Disposal, Opus North Corp., WasteCap Wisconsin, and Subcontractors.

Cardboard and Office Paper
Place in designated containers located on the job site. Cardboard that is over 50 percent covered with paint, mud or other contaminants should be disposed of as trash. To keep the containers free of contamination they will be locked and regulated by the onsite job supervisor. A detailed list of acceptable items will be posted in the trailers and in protective plastic near each container. The cardboard and office paper will be sorted, bundled and sold in bulk to be made into new paper products.

Mixed plastic, glass, aluminum and steel containers, bottles, jars and cans
Place in 95-gallon carts, one by each trailer. Recyclable containers need to at least be empty. Bottles and cans will be sorted off-site and recycled. A detailed list of acceptable items will be posted in the trailers and in protective plastic near each container.

Wood, Metal, Clean Fill
Scrap wood, metal and clean fill will be stockpiled in a central location on-site. Wood will be separated both for reuse and recycling. Any dimensional lumber in good condition will be stockpiled in a separate location for reuse when short-length pieces are needed. The small scrap wood not reused will be chipped, dyed and used as landscaping mulch.

All metal will be collected and hauled to a local metal recycler for processing.

The clean fill includes cinderblocks, cement, concrete (with minimal rebar) and any combination of clay or soil. The clean fill will be hauled to a local mining pit or used on site as fill. Trees, branches and other organic matter cannot be placed in this container or the trash container. These items will be handled separately as the need arises.

Drywall/Gypsum

Drywall in good condition will be stockpiled in a separate location for reuse. Any scrap drywall will be placed in rolloff containers for recycling. Scrap drywall will be hauled to a local farmer for grinding and use as a fertilizer. All nails and screws must be removed before placing in the recyclable container. Painted drywall must be disposed of separately.

Other On-site Uses of Recyclable Materials

- *Use scrap wood for blocking, bracing and back framing, or as spacers in header construction.*
- *Use small pieces of plywood for drywall hanging and carpet tack strips.*
- *Save sizable pieces of drywall for use around doors, windows, built-ins or on another job.*

Packaging

- *Confirm that the correct amount of material is delivered to the site to help reduce waste.*
- *Specify minimal packaging when ordering materials.*
- *Return reusable or recyclable packing materials to the supplier (e.g. wood pallets, frames, etc.).*
- *Use cardboard boxes as collection containers.*
- *Protect finished floors with large pieces of cardboard.*

Other

- *Containers will be serviced when the on-site supervisor calls in. Clear access must be made to the containers and any locked containers must be unlocked.*
- *If a container that is designated for a specific recyclable item is contaminated, the entire load will be dumped as trash. Contractors responsible will be charged. Please help us avoid this.*
- *We want to know of other ways to reduce waste. Notify the site superintendent with suggestions.*

Alliant Energy, Green Valley Disposal, Opus North Corp. and WasteCap Wisconsin ask you to follow these guidelines and help others to follow them. Together we can create a better work environment and help preserve our environment for a better tomorrow.

Information from: WasteCap Wisconsin, Inc. and Green Valley Disposal

Appendix D. Project Tracking Sheet

Invoice #	Invoice Date	Service Date	Size	Unit	Yds of Trash	Trash Tons	Comm. yd3	Cardboard yd3	Wood yd3	Metal Tons	Clean Fill yd3	Drywall Tons	Rate per Yard/Ton	Haul Rate	Total $ Trash	Total $ Recycling
		2/28/2002	6	yards			6									$ -
23X00715		3/4/2002	30	yd compactor				52.67								$ 82.22
20354	12/18/2001		30	yard					30					$ 176.00		$ 176.00
20374	12/27/2001		30	yard					30					$ 188.00		$ 188.00
23X00715		3/11/2002	30	yd compactor				90.67								$ 69.40
201424		12/3/2001	20	yard								3.77		$ 180.00		$ 180.00
23X00715		3/13/2002	30	yd compactor				63.34								$ 78.62
23X00715		3/13/2002	30	yd compactor		3.94									$ 218.20	
225147		3/19/2002	12	yard							12			$ 160.79		$ 160.79
23X00715		3/20/2002	30	yd compactor				66								$ 77.72
23X00715		3/22/2002	30	yd compactor				57.34								$ 80.65
23X00715		3/27/2002	30	yd compactor				59.34								$ 79.77
23X00715		3/28/2002	30	yd compactor		3.32									$ 199.60	
		3/31/2002	6	yards			6									$ -
24X00926		4/1/2002	30	yd compactor				95.34								$ 67.82
24X00926		4/3/2002	30	yd compactor				88.67								$ 70.07
233631		4/4/2002	12	yard						1.77						$ 135.00
233631		4/5/2002	20	yards								2.3		$ 180.00		$ 180.00
24X00926		4/8/2002	30	yd compactor				30.67								$ 89.65
18291-20122	3/5/01-10/23/01		30	yard					1140					$ 188.00		$ 7,144.00
20123	10/24/2001		30	yard					30					$ 200.00		$ 200.00
Totals					12	248.74	63	4131.91	1740	42.09	42	96.9			$16,735.75	$34,003.72
Average yards per ton					20	8.78	40	66.67	5.33	8.27	2.00	5.31				
Average tons per yard					0.05	0.1138	0.025	0.035	0.1875	0.1209	0.5000	0.1882				
Total tons					0.6	248.74	1.575	72.17	292.88	42.09	21	96.9				
Total yards					12	2185	63	4131.91	1740	348	42	515				
	tons recycled		526.615				yards recycled		6839.9							
	tons trash		249.34				yards trash		2197							
	Recycling %		**67.9%**				**Recycling %**		**75.7%**							

Appendix E. Drywall Case Study

Alliant Energy was committed to reducing, reusing and then recycling everything we could from the construction site. This commitment and a team effort resulted in the first permit in Wisconsin to allow land application of Type X drywall. Drywall recycling was important to the success of this project and to construction waste recycling efforts. At 20%, drywall is the second largest component of the commercial construction waste stream.[1]

Green Valley Disposal, our hauler, contacted a local farmer who agreed to accept the drywall, grind it and apply it to his fields as a soil amendment. Green Valley Disposal then applied for and received approval from the Wisconsin Department of Natural Resources for landspreading waste gypsum wallboard as a soil amendment. However, the exemption specifically excluded Type X wallboard from being land applied. On commercial construction sites (including this project), contractors typically use 5/8", or Type X, drywall because of its fire rating.

The team was faced with the possibility of giving up recycling drywall. Instead, we looked into why Type X was not allowed for land application. In researching this issue, we worked with the following agencies and groups, among others. We are grateful for their cooperation and assistance:

- Wisconsin Department of Natural Resources
- Environmental Protection Agency
- local recycling coordinators
- UW-Madison Soil Scientists
- National Association of Home Builders Research Center
- US Gypsum Company
- The Gypsum Association
- US Composting Council
- American Society of Agronomy
- State of Georgia's Department of Natural Resources
- Drywall grinding equipment manufacturers
- Construction Materials Recycling Association
- Environmental Building News
- US Department of Agriculture's Research Service

The reason: Type X drywall contains fiberglass. "Chemically, Type X drywall is identical to drywall used in residential construction except for a small amount of fiberglass (less than 1%). Type X drywall is one-hour fire rated. The thicker 5/8" drywall [versus ½" drywall used in residential construction] contains a small amount of fiberglass as the fibers help hold the drywall together during a fire" said Dean Updegrove, Product Manager for US Gypsum.

There has been excellent research completed on the effects of land application of residential construction drywall scrap. Drywall provides nutrients, including calcium and sulfur, to the soil. Dick Wolkowski, University of Wisconsin-Madison soil scientist, conducted research on land application of drywall and found that "crushed wallboard appears to be as effective as commercial gypsum fertilizer." However, we found no studies investigating the effect of land application of Type X drywall, which is commonly used in commercial construction.
We worked closely with Wisconsin's DNR to determine what environmental concerns may arise from land application of drywall that contains fiberglass. "The agronomic effects of using drywall

[1] *Quantity and Composition Study of Construction and Demolition Debris in Wisconsin.* Camp, Dresser & McKee. Recycling Market Development Board. Department of Commerce. February, 1998. Table 3-4.

on agricultural fields has been fairly well-documented. The area that had not been well-studied involved the impacts to the biological community on agricultural fields after drywall containing fiberglass had been incorporated into the soil," said Gene Kennedy of Wisconsin's DNR. He then recommended that a study be conducted using a representative species (earthworm) that could be monitored over time for any detrimental effects, such as mortality or weight loss, that may be attributed to the introduction of drywall containing fiberglass.

Dick Wolkowski, UW Soil Scientist, received approval from the Wisconsin DNR to proceed with a six-week Type X drywall experiment. The Earthworm Subchronic Toxicity Test, recognized by the USDA and the US Composting Council as a standard method for soil testing, was selected to study the effects to the biological community of land application of Type X drywall.

In this test, earthworms were exposed to varying amounts of Type X drywall in two soil types. The composting council recommended using an artificial soil mix of silica sand kaolinite clay and shredded peat moss. We decided to conduct the experiment also using local soil. Drywall from the Alliant Energy construction site was crushed and added to each type of soil in amounts ranging from a control which contained no drywall to the equivalent of eight tons of drywall per acre (often, one to two tons per acre of drywall are used as a soil amendment). During the six-week study, the earthworms were tested weekly for mortality rate, weight, activity level, visual evidence of any lesions, and number of worm cocoons. Routine soil tests were also taken.

Results indicated that even at the high application rates of the drywall, there was no significant effect of the drywall on the earthworms. There was no decrease in number of worms, activity level remained high, and worm weight evenly decreased in all of the worms. Based on these results, the Wisconsin DNR approved the land application of Type X drywall.

After DNR's approval, we were ready to separate and process the drywall. Opus North Corporation crews separated the drywall into 30-yard containers and took responsibility for keeping the material clean and contaminant-free. WasteCap assisted the contract crews through employee education and used easy-to-read sandwich-board signs next to the drywall dumpster. WasteCap also coordinated monitoring and documentation efforts. Green Valley Disposal then hauled the material to a nearby farm.

To process the drywall for land application, various grinders were tested. The horizontal grinders worked best as they generated the least dust. In addition, they include an optional spray bar which sprays water onto the drywall to further reduce dust. The farmer next applied the ground drywall to his field at one to two tons per acre.

Drywall diversion has great potential. Land application of drywall can be environmentally and economically-beneficial. As noted earlier, crushed wallboard appears to be as effective as commercial gypsum fertilizer. Instead of *paying* to purchase commercial gypsum fertilizer, farmers can *charge* a tipping fee to receive clean drywall from construction sites. It can also be financially beneficial, as it was in this project, for the building owner and contractor. In order to recognize this economic benefit, the tipping fee the farmer charges must be less than that of the landfill, and the distance to the farm must be equal to or less than the distance to a landfill.

However, new research begs new questions. Do the results of this study indicate that now Type X drywall can be land applied on a large scale? What is the right grinder? Have contractors been provided with the information they need to keep the drywall free of contaminants? The answers to these questions will help turn drywall into an environmental and economic asset.

To obtain the report of the study of sensitivity of earthworms to Type X Gypsum Drywall, see www.wastecapwi.org.

Appendix F. Recycling Economics Worksheet

Economic Analysis of Recycling at the Alliant Energy Construction Site

May 2000 - April 2002

Material	Unit	# of containers pulled	Yards	Percent of total volume	Tons	Total cost*	Cost if disposed of as trash**	Avoided Disposal Cost	Average cost per yard *	Average cost per ton *
Commingled	95 gal (.5 yd)	18	9	0.10%	0.25	$360.00	$49.00	($311.00)	$40.00	$1,440.00
Commingled	6 yarders	9	54	0.60%	1.33	$0.00	$288.22	$288.22	$0.00	$0.00
Cardboard	6 yarders	85	510	5.64%	17.85	$7,025.79	$2,901.90	($4,123.89)	$13.78	$393.60
Cardboard	30 yd compactor	50	3622	40.08%	54.32	$3,810.65	$18,145.88	$14,335.23	$1.05	$70.15
Wood	30 yarders	58	1740	19.25%	292.88	$11,072.00	$17,787.92	$6,715.92	$6.36	$37.80
Metal	12 yarders	29	348	3.85%	42.09	$4,128.88	$2,997.06	($1,131.82)	$11.86	$98.10
Drywall	20 yarders	26	515	5.70%	96.90	$4,772.70	$4,908.56	$135.86	$9.27	$49.25
Clean Fill	12 yarders	6	42	0.46%	21.00	$984.79	$903.00	($81.79)	$23.45	$46.89
Other Charges						$1,848.91				
Total Recyclables		**281**	**6840**	**75.69%**	**526.62**	**$34,003.72**	**$47,981.54**	**$15,826.73**	**$4.97**	**$64.57**
Trash	20 yarders	56	1085		139.4	$10,185.97			$9.39	$73.07
	12 yarder, 6 yarder, two - 2 yrders	4	22		2.15	$343.33			$15.61	$159.69
	30 yarders	10	265		65.37	$3,628.46			$13.69	$55.51
	30 yd compactor	11	825		42.39	$2,553.18			$3.09	$60.23
	Finance Charge					$24.81				
Total Trash	**Total**	**81**	**2197**	**24.31%**	**249.31**	**$16,735.75**			**$7.62**	**$67.13**

* Includes rate per yard/ton and hauling fee

**Calculated using the $4.50 per yard hauling rate plus $34 per ton charged for all of the 20 yarders

Appendix G. Recycling Conversions

Table 1 identifies weight to volume and volume to weight conversion figures. Use of these numbers may be helpful when estimating the amount of recyclables diverted when only weight or volume is available. The conversion numbers below are:

(1) actual weight to volume ratio found on one commercial construction site (Alliant Energy) or

(2) from "Recycling Economics Worksheet" by Flad & Associates

Table 1. Weight to Volume Conversion

	Pounds per cubic yard	Tons per cubic yard	Yards per ton
Mixed Waste (2)	350 lbs/cu yd	.175 tons/cu yd	5.7 cu yds/ton
Cardboard (1/2)	70 lbs/cu yd	.035 tons/cu yd	20 cu yds/ton
Cans & Bottles (1)	50 lbs/cu yd	.025 tons/cu yd	40 cu yds/ton
Concrete (2)	1000 lbs/cu yd	.50 tons/cu yd	2 cu yds/ton
Drywall (1)	375 lbs/cu yd	.2 tons/cu yd	5 cu yds/ton
Scrap Metal (1)	242 lbs/cu yd	.12 tons/cu yd	8.3 cu yds/ton
Scrap Wood (1)	375 lbs/cu yd	.19 tons/cu yd	5.3 cu yds/ton

Table 2 identifies the weight of different materials found in commercial construction sites. Use of these numbers may be useful when estimating number of dumpsters needed for various materials.

Table 2. Construction Waste Composition by Weight (Tons)

Material	**Statewide Ave**[1]	**Alliant**	**Other WI Commerical Construction Site**
Trash	18.00%	32.13%	30.73%
Cardboard	13.00%	9.30%	11.79%
Drywall	20.00%	12.49%	25.84%
Metal	13.00%	5.42%	10.84%
Wood	36.00%	37.75%	20.44%
Plastics	0.00%	0.00%	0.22%
Concrete/Bricks	0.00%	2.71%	0.00%
Commingled		0.20%	0.14%
Total	100.00%	100.00%	100.00%

The following are some environmental statistics that may help motivate employees:

One ton of paper/cardboard is equivalent to 17 trees.[2] *On the Alliant Energy construction site, we recycled over 72 tons of cardboard. Therefore, this project saved 1,224 trees.*

[1] "Quantity and Composition Study of Construction and Demolition Debris in Wisconsin" Camp, Dresser & McKee. February, 1998. Table 3-4 Non-Residential Construction Waste Composition.

[2] "Recycling Facts and Figures" Wisconsin Department of Natural Resources. PUBL CE-163 98 Rev

Drywall adds calcium and sulfur to soils and provides benefit as a soil amendment. *We diverted 97 tons of drywall from the Alliant Energy construction site. Instead of the drywall sitting in a landfill, at a rate of 2 tons per acre, 48.5 acres of land received a valuable soil amendment.*

When you manufacture an item from recycled steel vs. new steel, the following savings are achieved[3]:

water use:	**40%**
water pollution:	**75%**
air pollution:	**86%**
mining wastes:	**97%**
energy:	**47 – 74%**

Recycling 1 ton of iron saves 1 ton of coal. *42 tons of scrap metal were recycled from the Alliant Energy construction site. Therefore, metal recycling on this project saved 42 tons of coal.*

There are approximately 80 trees used in the building of a 2,120 square foot house. It takes approximately 6.6 trees to equal one ton of dimensional lumber. [4] *293 tons of wood was recovered from the Alliant Energy construction site. This is equivalent to saving 1,933 trees or enough wood to build 24 houses.*

Recycling 1 ton of glass saves the equivalent of 10 gallons of oil
Recycling 1 ton of plastic saves the equivalent of 1-2,000 gallons of gasoline
Recycling 1 ton of aluminum saves the equivalent of 2,350 gallons of gasoline. This is equivalent to the amount of electricity used by the typical Wisconsin home over a period of 10 years.[5]
1.58 tons of cans & bottles were recovered from the Alliant Energy construction site. If half of these were aluminum cans, then 1,880 gallons of gasoline were saved – equivalent to the amount of electricity used by the typical Wisconsin home over a period of 8 years.

Disclaimer: All savings are approximate and estimated based on the best information available. No claims are made to the precise natural resource savings achieved.

[3] "Recycling Facts and Figures" Wisconsin Department of Natural Resources. PUBL CE-163 98 Rev
[4] USDA Forest Service Forest Products Laboratory. Estimated number of trees, and number of acres of forest land required to build a single family house, 1988 and 1996.
[5] "Recycling Facts and Figures" Wisconsin Department of Natural Resources. PUBL CE-163 98 Rev

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