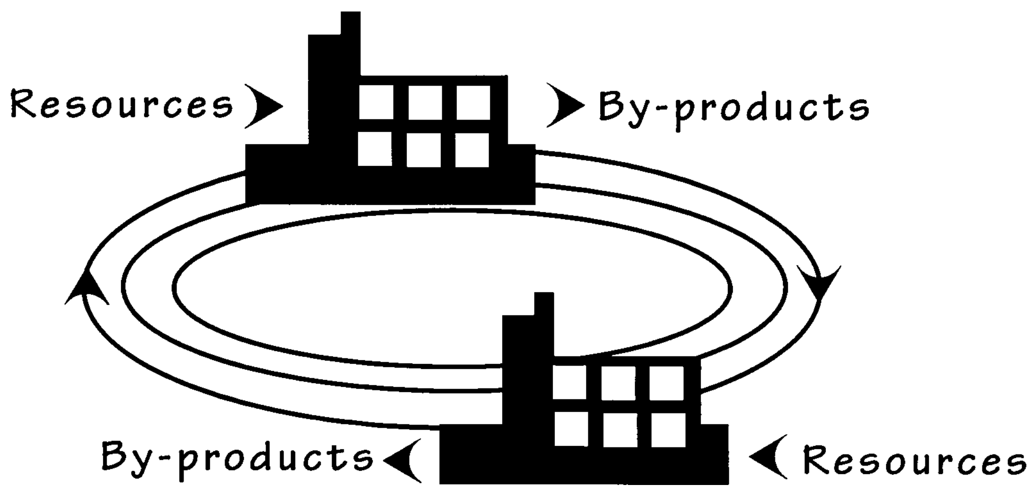
Industrial Ecosystem Development Project Report



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Acknowledgements

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- Ted Abernathy, Executive Director, Orange County Economic Development Commission (until 1998);
- Bob Bacon, Information Systems Manager, Triangle J Council of Governments;
- Phil Berke, Professor, Department of City and Regional Planning, University of North Carolina at Chapel Hill;
- Rick Childry, Executive Director, Greater Smithfield-Selma Chamber of Commerce;
- Cynthia Christian, Director, Existing Industry/Business Development, Greater Raleigh Chamber of Commerce (until 1998);
- Ted Conner, Vice President of Business Development, Greater Durham Chamber of Commerce;
- Oli Devaud, Director, Chatham County Economic Development Commission (until 1998);
- Bob Heuts, Executive Director, Lee County Economic Development Commission (as of 1998);
- Jeffrey Matthews, Director, Existing Industry/Business Development, Greater Raleigh Chamber of Commerce (as of 1998);
- Diane Minor, Environmental Engineer, North Carolina Division of Pollution Prevention and Environmental Protection (until 1999);
- Don Moss, Executive Director, Lee County Economic Development Commission (until 1998);
- Michael Overcash, Professor, Chemical Engineering, North Carolina State University;

- Greg Payne, Acting Director, Orange County Economic Development Commission (1998);

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- John Sigmon, Associate Dean, Nicholas School of the Environment, Duke University;

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- Joel Bolduc, a masters student in Environmental Management at the Nicholas School of the Environment at Duke University, worked on the project primarily during an eight-month period. He conducted in-plant interviews, but his most valuable contribution to the project was in setting up the database and training others to use it.

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- Carol Beam, a masters student in the Natural Resources Program at North Carolina State University, worked on the project during its last twelve months. She conducted many in-plant interviews, worked on identifying potential partnerships, and, with Lesley Fritz, was responsible for developing and summarizing most of the partnerships that were probable or already implemented by the time this project report was written.

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A Business Advisory Panel met during the first month of the project to review a draft of the survey booklet and subsequently field test the booklet's next draft. The following people were members of this group:

- Bill Boyer, Environmental and Industrial Hygiene Leader, Allied Signal, Inc.;
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Disclaimer

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Introduction

The Industrial Ecosystem Development Project was designed to help two groups of people. The first group is business people who are looking for ways to cut costs and reduce the use and disposal of natural resources by their businesses. The second group is people who are working to create more sustainable communities by identifying ways to turn wastes into useful products and reduce the generation of greenhouse gases in the air, pollution in the water, and trash in the landfill.

This project aimed to help both groups by developing a means to promote local economies that mimic ecosystems from nature. In the web of nature, there is no waste. One organism's byproduct is food for a neighboring organism. In local economies, this type of relationship exists, but in a greatly underdeveloped form. Promoting and developing these relationships can help meet the goals of both short-term cost cutting and long-term community sustainability.

The Industrial Ecosystem Development Project gathered data from 182 industries and institutions in a six-county region regarding the byproducts they had that might be usable by somebody else and the inputs they used that might be furnished from another facility's byproducts. This data, which was also connected to a Geographic Information System (GIS) map, was used to identify potential partnerships for the reuse of materials, water, and energy. The project played the role of matchmaker or facilitator in bringing together potential partners. During a one-year period, possible new partnerships were identified for 48% of the facilities participating in the project. Several partnerships were implemented immediately or were under negotiation when this report was sent to press; others are still under discussion or will involve further research in order to determine whether they will be cost effective. One of the partnerships currently under negotiation will save one party $100,000 per year and the other party $70,000 per year.

In addition to bringing value to project participants, the project produced information that will be valuable to other regions interested in developing their industrial ecosystems. For example, the inputs and byproducts listed by specific types of industries will be a useful guide regarding the same industries elsewhere. Similarly, stories of the matchmaking attempts that occurred will be useful guidance for others.

This report reviews the work done on this project over its two-year life and summarizes information that might be of interest to others. The report is divided into four sections. The first section summarizes the method used to obtain data, identify partnerships, and begin discussions between potential partners. The second section summarizes the data obtained. The third section describes the potential partnerships identified by the project. The fourth section addresses lessons learned and suggestions for others interested in undertaking industrial ecosystem development in their communities.

Section One: Methodology

The project area

This project took place in a six-county area that includes Raleigh, Durham, and Chapel Hill, North Carolina. The region has a population of approximately one million and covers 3,315 square miles. Its civilian labor force is over 550,000. Employment is very regional in nature: more than 100,000 people in the region cross a county line to work every day. Research Triangle Park, the 6,900-acre home of numerous research and development firms, straddles two counties. The region's largest industries are pharmaceutical, computer, communications, equipment, and related manufacturers. Medical, university, and state and federal government facilities are also a large portion of the regional economy.

There are over 30 local government jurisdictions in the six-county area. Most of these local governments are members of Triangle J Council of Governments, one of 18 voluntary, multi-jurisdictional planning and service agencies established by the State of North Carolina in the early 1970s.

Funding

This project was funded primarily through $162,888 in financial assistance from the U.S. Environmental Projection Agency. Financial assistance in the amount of $1,875 was also provided by the State of North Carolina's Division of Pollution Prevention and Environmental Assistance.   In-kind contributions totaling approximately $16,000 were also made by other project team members. These funds supported the project over its two-year lifespan from June 1997 through May 1999.

The project team

A project team was assembled to bring a variety of backgrounds to the work involved in the project. The project team was headed by staff at Triangle J Council of Governments, which provided overall project management, including day-to-day supervision. Triangle J staff also worked alongside other team members on every phase of the project and took responsibility for setting up the GIS maps, convening and working with local clusters of businesses, networking with related programs outside the region, and writing project reports.

The project team also included four faculty or staff members representing a variety of departments within three universities: the Chemical Engineering Department at North Carolina State University, the Nicholas School of the Environment at Duke University, and the Department of City and Regional Planning and the Center for Urban and Regional Studies at the University of North Carolina at Chapel Hill. These university partners provided overall technical guidance, helped recruit and train student interns, and, in the case of the Center for Urban and Regional Studies, provided additional administrative assistance. These project team members also provided key assistance in designing and field testing the survey instrument and choosing firms to target for participation in the project. The faculty member from the Chemical Engineering Department at North Carolina State University was also extremely helpful in categorizing survey responses and identifying potential partnerships.

Also serving on the project team were two staff people from the State of North Carolina's Division of Pollution Prevention and Environmental Assistance. These project team members provided overall project guidance and also provided valuable technical assistance in designing and field testing the survey form and identifying potential partnerships.

The project team was rounded out by one representative from the economic development commission or chamber of commerce from within each of the six counties where the project took place. These six representatives provided overall guidance, assistance with forming a Business Advisory Panel for the project, assistance with targeting and contacting industries to include in the project, and assistance with convening forums for presenting project results.

Student interns worked on the project throughout. Twelve interns worked for different periods ranging from six to thirteen months, including both part-time and full-time. Five were undergraduate chemical engineering students from North Carolina State University and seven were graduate students in various degree programs from Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill. The student interns provided the bulk of the daily work of visiting facilities, identifying and exploring potential partnerships, and summarizing data and partnership progress. One of the graduate students from Duke was responsible for setting up the database used for the project.

The project convened a ten-person Business Advisory Panel during the first month of the project to assist with designing a survey instrument. The Business Advisory Panel met once to review and comment on a rough first draft of a survey form, then field tested and provided feedback on a second draft. This group included representatives from local manufacturers of the following products:

- telecommunications equipment;
- semiconductors;
- pharmaceuticals;
- amino acids;
- industrial yarn for tires;
- textile yarn;
- nonwoven fabrics;
- plumbing fixtures; and
- mobile homes.

Brief overview of methodology

The first four months of the project involved designing and field testing a 16-page survey booklet for recording data from facilities, gathering public records on manufacturing firms in the area, identifying the first 90 target facilities, and hiring an initial group of student interns.

During the one-year period October 1997 through September 1998, the project team telephoned 343 facilities, invited them to participate in the project by completing the survey booklet, and mailed survey booklets to those interested in participating. During this same period, most of the 182 facilities that agreed to participate were visited, primarily by trained student interns, and survey booklets were picked up, reviewed with company representatives, and used to enter data in a database.

During the one-year period May 1998 through April 1999, facility sites were mapped and connected to the database; the database was used to identify potential partnerships; potential partners were contacted and meetings were convened for exploring partnerships; and summaries of potential partnerships were prepared. During the last six months of this period, presentations regarding the project findings were made to a dozen local groups interested in the project, such as chambers of commerce, the state energy department, and the state recycling association.

Throughout the project period, the project manager shared project methodology and findings with groups elsewhere in the country involved in related work. Examples of these groups include those involved in developing eco-industrial parks, developing policy regarding industrial ecology, and working in pollution prevention programs.

Designing the survey instrument

The survey instrument went through several drafts and was field tested by eleven businesses, nine of whom were represented on the Business Advisory Panel.

One of the issues involved in designing the survey document was how much detail to request from survey respondents. Asking for too much detail would probably discourage participation; asking for too little detail regarding materials might make it hard to tell whether materials were similar. The conclusion of the project team was that the purpose of the survey responses was to allow the project team to query the database for possible matches. Given that follow-up would be required in any event, it made sense to err on the side of requesting too little detail, since more detail could be obtained in follow-up contacts. It was decided that it was more important to get a large number of participants with at least some information than a small number of participants with quite detailed information.

Another concern in designing the survey document was how to address confidentiality. Survey responses would not be confidential, and it was feared that this would discourage participation. This concern was addressed in the following statement on page three of the survey document:

Please keep the following important points in mind as you fill out the survey:

✓ Only answer the questions you want to.

✓ Don’t worry about whether partnering would be economical. This is merely a first screening.

✓ The assumption is that confidentiality is not an issue with regard to the items in this questionnaire. If confidentiality is a concern, the Industrial Ecosystem Development Project would like to explore how to meet this concern.

The resulting survey document is a sixteen-page booklet with a lot of white space and an easy-to-read format. See Appendix A for a copy of the survey booklet. (Note that the survey booklet was printed on 11x17 paper and stapled in the middle. Some of the tables span two pages. Appendix A is printed on 8 ½ x 11 paper, so the pages should be read as if they were in the original format.) The cover of the booklet includes a one-sentence description of the purpose of the survey. Pages two and three are general instructions, background, and examples.

Page four of the booklet has four questions related to water use:

- boxes to check indicating how water is used (for example, irrigation) and whether non-potable water could be used;
- four boxes to check indicating the rough amount of water used per day;
- yes and no boxes to check indicating whether incoming water requires pretreatment;
- yes and no boxes to check indicating whether any wastewater has a temperature of more than 130 degrees, and, if so, for how many gallons per hour for how many hours per day.

Page five contains the instructions for reporting material inputs and byproducts on a “readily reusable materials” table, which stretches across pages six through 13. The table lists 46 different items, including process water, which the project team identified as readily reusable by various businesses. For example, various kinds of acids, solvents, and alkalis are listed in this table. The project team chose not to include in this table paper, cardboard, and beverage containers, which are routinely recycled at many facilities. The purpose of the project was not to connect facilities with recycling companies but to establish partnerships between facilities for the direct reuse of materials.

For each item used or discarded by the respondent, the following information is requested:

- a specific description;
- whether it is an input, an output, or both;

- the amount per year into the facility;
- whether as an input it has any recycled content;
- whether they could use it if it had any recycled content;
- whether it is reused internally;
- the amount per year recycled externally, treated on site, and sent for treatment or disposal;
- ideas for alternative sources or reuse.

The purpose of the list of 46 items is to impress respondents with the wide range of items that are reusable and to encourage them to think positively about reuse partnerships. Several pages of empty lines are also provided for respondents to add materials not already listed.

Some of the Business Advisory Panel members believed that respondents would be more likely to report amounts if they were given an option to use a range, so range codes are provided for the readily reusable materials table.

Page 14 of the booklet has three questions about fuel use:

- boxes to check regarding types of fuels used and alternatives being considered;
- a question about the total amount of electricity used;
- yes or no boxes to check regarding whether they use steam, and, if so, how many pounds per month and at what pressure and peak pounds per hour.

The inside back cover is for basic information about the respondent, and the back cover is blank for adding other comments.

Identifying facilities to include in the project

The project had a goal of gathering input and byproduct data from 100 to 200 facilities within the six-county project area. The project team began by choosing an initial group of 90 facilities to invite to participate in the project. The criteria for choosing these 90 facilities were likelihood of successful byproduct reuse partnership, likelihood of participation in the project, geographic diversity, and Standard Industrial Classification (SIC) code diversity. (SIC codes are the standard codes established by the federal government for classifying economic activities. For example, manufacturers of adhesives and sealants are classified as SIC 2891.)

The project team believed that companies required to file public reports regarding any environmental impact of their businesses would be likely to participate in the project, since these companies were probably interested in reducing this environmental impact. Therefore, the project looked at publicly available information on materials and processes from businesses in the six counties. Using central public sources, the project obtained records of the following environmental information supplied pursuant to federal mandates by local firms:

- Toxics Release Inventory (TRI) data;
- Biennial Reporting System (BRS) information on hazardous wastes;
- Tier Two reports to Local Emergency Planning Committees;
- National Pollution Discharge Elimination System (NPDES) permit information; and
- significant industrial water user (SIU) permit applications.

More detailed information on these sources of information appears in Appendix B.

The project created a spreadsheet to help identify which companies reported under which of the foregoing environmental programs. Tier Two reports were filed by many businesses in each county, including gas stations, so these reports did not prove helpful in choosing target industries. All of the companies reporting under any of the four other environmental programs were included in the pool from which the first 90 target industries were chosen.

Another task performed in preparation for choosing the initial target facilities was to develop a list of the most prevalent types of businesses in the region by SIC code. The project used the state Employment Security Commission database of employers for the six-county area. Retail, wholesale, and financial categories were deleted and the project sorted the remaining employers by SIC code. The project then printed out a list of all employers in SIC codes with the top 50 most numerous employers. This list was further divided by county.

The economic development officials on the project team were heavily involved in the next step, which was to review and edit the foregoing lists for each county. Based on their knowledge of employers in their counties, they eliminated from the lists companies that had recently gone out of business, companies with very small operations, and companies that were irrelevant for any other reason. They also flagged companies that should have a high priority due to likelihood of byproduct reuse potential or likelihood of participation. Finally, they added companies that in their assessment should have been on the lists but were not.

The final step was to produce a list of 90 target companies. This was done by using all the foregoing information, choosing a roughly equal number of companies from each of the six counties, and choosing companies that represented a wide range of SIC codes. Throughout the process of selection, project team members added suggestions, based on their various backgrounds, regarding companies likely to have reusable byproducts.

The project eventually targeted and contacted a total of 343 facilities regarding participation in the project. After the first 90 facilities, the project team added to the target list all the remaining facilities that had filed TRI, BRS, NPDES, or SIU reports; most major employers, especially those located in clusters of neighboring facilities; universities; hospitals; waste water treatment plants; facilities mentioned by other facilities as using byproducts; and companies representing SIC codes not already represented.

A subsequent analysis was done to determine a rough estimate of what percentage of manufacturing firms in the region were invited to participate in the project. This was done by counting the number of manufacturing firms listed in each county's most recent manufacturers directory, then counting how many of those listed were invited to participate in the project. The total number of companies listed was 1,095, of which 275, or 25%, were invited to participate in the project. The additional 68 facilities targeted by the project were not considered manufacturers and were therefore not listed in the directories. The specific percentage of manufacturing firms targeted from each county appears in Table 1.

Table 1
Percent of Manufacturers Invited to Participate in Project

County	Number of Listed Manufacturers	Number of Listed Manufacturers Contacted	Percent of Listed Manufacturers Contacted
Chatham	59	29	49%
Durham	187	53	28%
Johnston	120	34	28%
Lee	78	32	41%
Orange	39	5	13%
Wake	612	122	20%
TOTAL	1,095	275	25%

Contacting the target facilities

The initial contact with each target facility asking it to participate in the project was accomplished primarily by telephone. The project team believed that this task should not be handled by student interns but by permanent members of the community who might be considered professional peers of the people they were calling. The task of phoning was very time-consuming, however, so several different people made these calls over the months during which it took place. Those involved in phoning included some of the economic development professionals on the project team, staff from Triangle J Council of Governments and the Center for Urban and Regional Studies at UNC, and a solid waste consultant who subcontracted with the Center for Urban and Regional Studies.

For some of the target companies, the economic development project team members personally knew someone to contact. For other target companies, the project team contacted either the plant manager listed in the local manufacturing directory or the environmental safety and health manager listed in the public records the project collected. For large companies, the environmental safety and health manager usually understood and expressed enthusiasm for the project; therefore, the project tried to identify and contact these managers where possible.

Making these phone calls was a time-consuming process. The project estimates that it made, on the average, one relevant contact at a target facility for each hour and a half of phoning. In other words, a person allotting six hours a day for making phone calls during a five-day week would probably made contact with twenty relevant company representatives during the week.

Those who called target facilities did not adhere to a strict script regarding the invitation to participate. Appendix C is a sample “calling rap” that was used by one experienced caller.

A Target Facility Contact Report form was designed to record, for each target facility, the result of the phone contact. See Appendix D for a copy of this form. The caller used the form to record accurate contact information and whether the facility’s representative had agreed to participate. If the facility representative had declined to participate, the caller recorded the reason.

Of the 343 company representatives who were contacted by the project, the initial response of approximately 75% of these representatives was that they would be interested in participating or that they might be interested in participating but wanted to see the survey form and/or check with their supervisors. The 25% who declined to participate ultimately grew to 47% (161 of 343) by the end of the project period. The most common reason for deciding not to participate after initially expressing interest was lack of time or difficulty in scheduling a convenient interview time during the project period. The reasons given by all target facilities choosing not to participate in the project appear in Table 2.

Table 2
Reasons Given for Not Participating in the Project

Reason	**Number giving response**	**Percent giving response**
No relevant inputs, byproducts	72	45 %
Too busy	50	31 %
Closing or downsizing	17	11 %
Generally not interested	15	9 %
Other	7	4 %
	161	100 %

Once a facility representative agreed, even tentatively, to participate in the project, he or she was sent a cover letter, signed by the project manager, with several enclosures. One enclosure was the survey booklet. Another enclosure was a copy of *By-product Synergy: A Strategy for Sustainable Development - A Primer*, a 26-page booklet published by The Business Council for Sustainable Development - Gulf of Mexico. This is an excellent resource written from a business perspective, and the cover letter suggested that the project’s target companies look particularly at one page from this primer which summarizes some particularly helpful guidelines for identifying opportunities for byproduct reuse.

One of two cover letters was used, depending upon whether the facility representative had agreed to participate or had only stated that he or she would consider participating. There were only slight differences in the wording. A copy of the letter sent to those who agreed to participate appears in Appendix E.

At the beginning of the project, information from public records was used to identify possible reusables from target companies. For each target company, students from the chemical engineering department at North Carolina State University looked through the public records for that company and prepared a list of reported chemicals that fell within any of the 46 categories of readily reusables in the survey booklet. For example, the list would show that a company uses isopropyl alcohol, an item appearing in the project's readily reusables table category two, which is non-halogenated solvents. The list for each company was then sent along with the survey booklet to that company's representative once he or she had agreed to participate in the project. This was done at the suggestion of members of the Business Advisory Panel who had expressed the opinion that it would be helpful in streamlining the survey completion process for these companies. It was also believed that seeing this list would encourage companies to participate by showing companies they had reusables at their facilities. However, this practice was soon abandoned, because it was time consuming and it was not clear that it was worth the effort. One reason is that many companies had eliminated the use of chemicals listed in the public records.

Conducting in-plant interviews

A week or two after mailing a survey booklet to a company representative, a follow-up phone call was made to the company representative to schedule an in-plant interview and review and pick up the survey booklet. This phoning was another time-consuming task, taking about an hour and a half of repeated calling to make each appointment; however, the project team believed that this method of collecting the survey booklet would be more effective than having the survey booklets mailed back to the project. The process of scheduling the interview gave the company representative a deadline for completing the survey, the interview was helpful in clarifying survey responses, and the interviewer could ask additional questions that would have made the survey booklet too long.

The in-plant interviews were conducted primarily by the student interns. In order to prepare them for this task, three-hour training sessions were conducted by several project team members. One training session was conducted in October 1997 for the first group of interns, and another was conducted in May 1998 for a second group of interns. Each student received a training manual, which was a 3-ring binder containing the following information:

- several different documents regarding background on Triangle J Council of Governments and the project;
- a diagram of the Kalundborg, Denmark, industrial ecosystem as an example;
- a summary of the interview and reporting procedure;
- a sample cover letter sent to facilities agreeing to participate;
- suggested follow-up questions for interviews;

- an interview reporting form;
- an outline of the presentation by project team member and trainer Dr. Michael Overcash on interviewing;
- an outline of the presentation by project team member and trainer David Williams on facility walk-throughs;
- a list of general interviewing tips from Beverly Wiggins, Associate Director of the Institute for Research in Social Science at UNC;
- a list of abbreviations used in the survey booklet (for example, LDPE);
- a list of chemicals commonly reported in TRI and other public data, along with the corresponding category in the readily reusables table in the survey booklet;
- a list of pollution prevention and related program brochures to be carried to interviews and left with interviewees who express an interest;
- a map of the region.

In addition to covering the above material, the training included some role playing on interviewing facility representatives.

It proved most efficient to have one person in charge of setting up appointments for all the interviewers.

The interviewers were prepared with a file for each facility prior to the interview with that facility. The file contained the facility contact report, a copy of the cover letter sent to the facility, copies of any public records on the company, a copy of the summary of the readily reusable chemicals from these reports (where applicable), and a copy of the company's entry in the local or state manufacturing directory. The file also contained a map showing the rough location of the facility. This map was produced by a commercially-available map-making CD-ROM.

The main goal of the in-plant interview was to review and retrieve a completed survey booklet. During this process, the interviewers obtained clarification of survey responses and encouraged facility representatives to add more reusable items to their survey responses. Where possible, interviewers toured the facility, which invariably led to identifying additional items to add to the survey booklet. In addition, interviewers attempted to elicit responses to several questions the project team believed would be helpful in assessing potential partnerships. The answers to these questions were later recorded by the interviewer on an Interview Reporting Form, which appears in Appendix F. Examples of these questions are the following:

- What barriers do you see to your use of recycled content?
- Do you have the capacity to do much more on-site treatment than you already do?
- Are you aware of any energy sharing done at other nearby facilities?

Following most of the interviews, the interviewer assessed the facility's level of experience with reuse and characterized it as one of the following:

- no experience;
- no experience, but interest;
- a few examples have been implemented;
- some large examples have been implemented; or
- extensive reuse takes place already and few additional options remain.

The 164 facilities for which this characterization was made are described in Table 3.

Table 3
Characterization of Reuse Experience
Of 164 Participating Facilities

Experience with reuse	Number of facilities	Percentage of facilities
A few examples had been implemented	64	39%
Some large examples had been implemented	34	21%
No experience, but interest	27	16%
Extensive reuse; few options remain	24	15%
No experience	15	9%
Total	164	100%

The interviewer subsequently returned the file, which then also included the completed survey booklet, and the completed interview reporting form, to Triangle J Council of Governments for data entry.

Entering the data

For about half of the facilities, a quality check was done by the chemical engineering project team members prior to data entry. These team members reviewed the chemicals in the survey responses and made sure they were properly and consistently assigned to one of the 46 readily reusable categories. This review was eventually eliminated due to time constraints.

For database sorting purposes, materials were coded 1 through 46 corresponding to the 46 categories in the survey booklet. Materials listed by survey respondents that did not fit into one of these 46 categories were initially coded “99” for “other.” Later on, some of the category 99 materials were assigned new numbers, since these materials appeared repeatedly in survey responses.

The interviewers typed the interview reporting form responses into documents on the Triangle J Council of Governments computer network in order to make it easy for the data entry person to copy the responses into the database. It took an average of about 30 minutes to enter the data from each survey booklet and interview reporting form into the database.

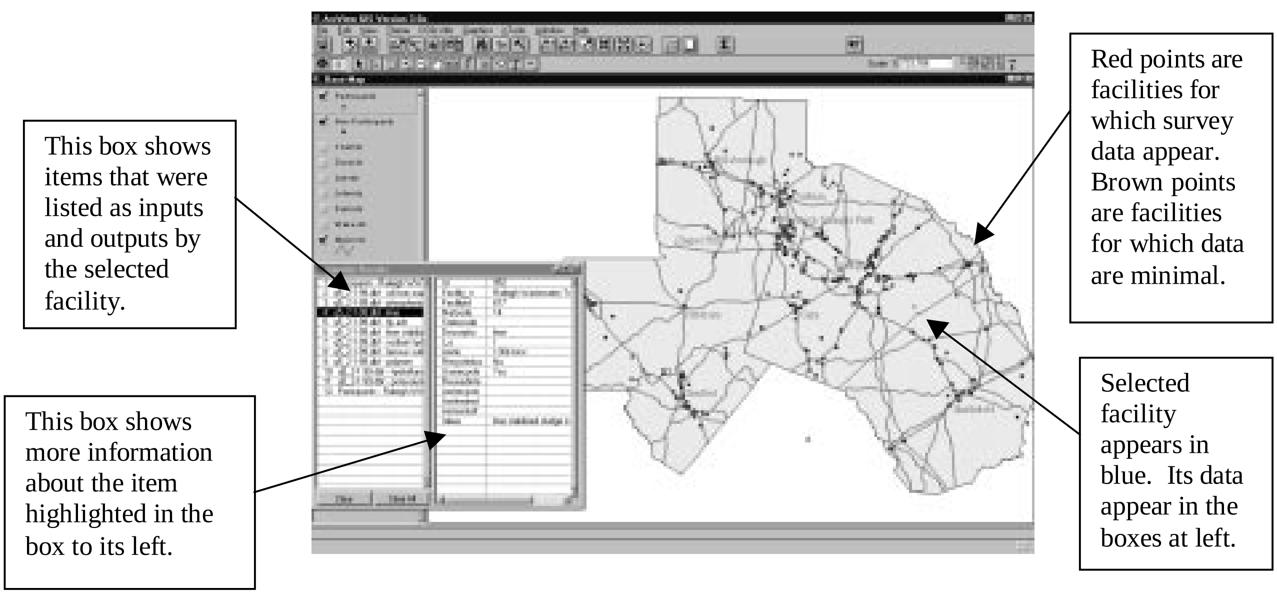
Preparing the GIS maps

Street maps showing the approximate site of each facility were prepared using a commercially-available map-making CD-ROM. The interviewers carried these maps with them to the in-plant interview and marked on the maps the actual location of the facility. These maps were then used by Triangle J Council of Governments' GIS department to place each facility on a GIS map. These GIS map sites were linked to the database.

Many layers of other data can be put onto the GIS maps, but the project generally produced and used maps drawn only with county boundaries, major towns and cities, major roads, and the facility sites. The sites of facilities that had completed the survey booklet were shown in one color, and sites of other facilities were shown in another color. The latter sites were those for which the project had confirmed locations, addresses, and SIC codes. The project could have added many such sites to the map using commercially available software, but it chose not to do so at this point in the project.

Figure 1 shows how an overall view of the six-county area looked on the software used for the GIS maps. (The original of this view is in color.) In Figure 1, the site of the Raleigh Wastewater Treatment Plant has been selected, so it appears as a blue point. The other points are either red or brown, depending upon whether the site has completed the survey booklet. The byproducts and inputs data for this facility appear in the left-hand side of the box at the bottom left of the map. The right-hand side of this box shows detail regarding the highlighted input from the left-hand side of the box.

Figure 1
GIS Map of Six-County Area Showing Facilities



Several other ways of displaying the facility sites on GIS maps were also explored. Maps were produced with US Geological Survey topographic maps as background and with aerial photos as background. GIS-based parcel maps were explored as another means of showing facility sites, but these maps were not available for all six counties. These three alternatives might prove more useful in the future, but they primarily added visual interest rather than substantive value to the information presented. Moreover, using maps with this level of detail significantly inflates the size of the document file and file download time for the user.

Identifying potential partnerships

The process of using the database to identify potential partnerships began after the project had obtained data from approximately 60 facilities. The database was queried for facilities using or discarding the same material. The sorted information was then reviewed for promising matches. Detailed specifications regarding particular materials are necessary in order to determine whether partnerships are possible, yet this requisite level of detail was usually not provided in survey responses. Follow-up phone calls to survey respondents were therefore necessary in order to obtain more detail.

Duplicate notes on follow-up calls regarding potential partnerships were kept in the files of the facilities involved and also in files regarding the relevant material. As each partnership exploration continued, it therefore became necessary to rely also on the files, not just the database, for the most current information on the potential partnership. Notes could have been kept current as text in the database, but the awkwardness of viewing and printing out strings of text that usually ran outside the cells in tables led those working on this stage of the project to prefer handling files once the database had been used to do checks for potential partnerships.

Database queries were done throughout the last year of the project in order to identify new potential partnerships. The database was not generally accessible to project participants; it was used at Triangle J Council of Governments by project team members. On occasion a laptop was used to bring the database to a project participant in order to review possible partnerships.

Another means of identifying partnerships was by convening groups of representatives from clusters of neighboring facilities. Two such groups were initiated by the project. One was a group of representatives from six nearby facilities that included three pharmaceutical plants; the other group, in a different county, included representatives from six facilities of which three were related to the production of wood products. A third group of facilities, in Research Triangle Park, which straddles two other counties, had met regularly prior to the project. This group used project data to discuss new potential partnerships.

The project manager led discussions of potential partnerships at two or three meetings of each of the three foregoing groups during the last year of the project. For each of the three groups, a diagram of the industrial partnerships in Kalundborg, Denmark, was used as a visual aid in explaining the concept of an industrial ecosystem. A copy of this diagram is in Appendix G. The project also prepared a diagram of partnerships between local industries (some located just outside the project region) that predated the project. This diagram appears in Appendix H. This diagram was used in several of the project discussions and presentations.

The database and other means of identifying partnerships revealed many possible items that could merit exploration for potential partnerships. With limited time, however, the project chose to focus on 49 partnerships that appeared to have the most potential. These were the following:

- absorbents
- acetone
- blasting media
- carbon
- chromic acid
- coal ash
- concrete paste
- conveyor belts
- copper
- desiccant
- drums
- electricity
- ethanol
- fabric
- fiberglass
- floppy disks
- food waste
- foundry sand
- furniture fluff
- glass vials
- hydrochloric acid
- hydrogen peroxide
- ink
- kaolin clay
- methanol
- nitric acid
- packing materials
- paint
- phosphoric acid
- plastic
- plastic bags
- plastic IC tubes
- plastic sheeting
- rubber blankets
- sawdust
- soap
- sodium hydroxide
- solvents
- steam
- steel
- sulfuric acid
- tobacco dust
- water – heated
- water – unheated
- wire
- wood
- wood ash
- wood chips
- wood fluff

Numerous meetings were convened and phone discussions were held in the process of exploring these potential partnerships. Some of the above items necessitated doing additional research to determine whether partnerships made sense. In many cases, the short period covered by this project did not allow a conclusive analysis of the project potential and therefore further analysis will be necessary.

Section Two: Data Summary

The 182 survey respondents represented 108 different four-digit SIC codes. Four-digit SIC codes fall within broader categories of two-digit SIC codes. (For example, SIC 2813, industrial gases, falls within SIC 28, chemicals and allied products.) The distribution of the 182 survey respondents among two-digit SIC codes appears in Table 4.

Table 4
SIC Codes Represented by Participants

2-digit SIC Code	Industrial Classification	Number of Companies Participating in Project
O1	Agricultural production --crops	1
O2	Agricultural production – livestock & animal specialties	2
14	Mining and quarrying of non-metallic minerals, except fuels	1
20	Food & kindred products	6
21	Tobacco products	1
22	Textile mill products	2
23	Apparel	5
24	Lumber & wood products, except furniture	9
25	Furniture & fixtures	5
27	Printing, publishing, & allied industries	6
28	Chemicals & allied products	20
30	Rubber & miscellaneous plastics products	8
32	Stone, clay, glass, & concrete products	7
33	Primary metal industries	7
34	Fabricated metal products, except machinery & transportation equipment	20
35	Industrial & commercial machinery & computer equipment	12
36	Electronic & other electrical equipment & components, except computers	20
37	Transportation equipment	4
38	Measuring, analyzing, controlling equip.; photographics; med/optical; clocks	5
39	Miscellaneous manufacturing industries	4
49	Electric, gas, & sanitary services	16
50	Wholesale trade -- durable goods	2
73	Business services	2
80	Health services	4
82	Educational services	4
87	Engineering, accounting, research management, & related services	7
95	Administration of environmental quality & housing programs	2
TOTAL		182

The average survey respondent listed eight items as reusable inputs and/or byproducts in the survey section on materials. Fourteen facilities listed twenty or more materials. A typical list of reusable items is the following list from an adhesives and sealants manufacturer:

- iron-magnesium catalyst (input);
- sodium hydroxide (input);
- hydrochloric acid (input);
- methanol (input and output);
- wood pallets (output);
- phosphoric acid (input);
- activated carbon (input).

(Note that the above list omits the amounts and detail provided in the survey response.)

The database can be sorted and queried in numerous ways. One useful presentation of the data regarding materials is shown in Table 5. Table 5 is one small section of a larger table that appears in Appendix I. Table 5 and Appendix I present specific materials listed as inputs and byproducts by survey respondents from industries classified by four-digit SIC code. For each material listed, the table shows whether it was an input (I), a byproduct (O), or both (IO). In the next column, the table records whether the facility reported that it was flexible enough to use an input item in a recycled form. The column on the far right shows the project's unique facility identification number, which also enables the reader to determine how many facilities reported from within each SIC code. For example, under SIC code 2048, facility 594 reported that it uses sawdust and bakery waste, such as dough, as inputs; facility 111 reported that it had four items as inputs, three of which are also byproducts.

Table 5
Example of
Reusable Inputs and Byproducts Reported by 182 Participants, Organized by SIC Code

SIC Code and Description of Item	I or O?	I Flexible?	Facility ID#
SIC 0182 Food crops grown under cover			
1 double layer greenhouse film	O		489
SIC 0252 Chicken eggs			
1 acetic acid	I	Yes	721
2 activated carbon	I	Yes	721
3 carbohydrates	I	Yes	721
4 fatty acids	I	Yes	721
5 hydrogen peroxide	I	Yes	721
6 non-halogenated solvents	I	Yes	721
7 other acids	I	Yes	721
8 water if enough BOD/COD	I	Yes	721
SIC 0279 Laboratory animals			
1 Chevron #2 Lithium	IO		708
2 paper bags (bedding)	IO	Yes	708
3 paper bags w/ wax-like inner lining (holds 50 lbs.of food)	IO	Yes	708
4 pine shavings & wood chips	IO	Yes	708
SIC 1429 Crushed & broken stone			
1 all-purpose & specific application	I		678
2 conveyor belts- 8 ft. long, 1.5 in. thick	IO		678
3 crankcase, hydraulic, EP oils; transmission fluids	IO		678
4 hoist, suspension, & drag cables	IO		678
5 process water	I		678
SIC 2048 Prepared feeds & feed ingredients for animals			
1 bakery waste (cookie & cake dough, potato chips, etc.)	I		594
2 microlox special 50 & 70 oils	IO		111
3 perox acid sanitizer	IO		111
4 plasma	I		111
5 reverse osmosis water	IO	Yes	111
6 sawdust	I		594
SIC 2051 Bread & other bakery products, except cookies & crackers			
1 Domino ink (67-56-1 3%) (67-17-5) (141-78-6 3%)	IO		493
2 doughnuts	O		650
3 ethyl alcohol (haz. waste mixed w/ soybean oil)	IO		493
4 grease-normal machine maintenance	IO		650
5 hydraulic oil	IO		493
6 metal drums - 55 gal. size, used for conditioners for dough, lined	O		493
7 mineral oil	IO		650
8 oil-normal machine maintenance	IO		650
9 plastic buckets to hold fillings 5 & 10 gal. size	IO		650
10 rubber gloves used in pkging.	IO		650
11 soybean oil (used in fryers)	IO		493
12 sugar glaze	IO		650
13 water used in mixing dough	IO		650

Another way of sorting the data appears in Table 6. Table 6 is one small section of a larger table that appears in Appendix J. Appendix J presents the types of industries (by four-digit SIC code) that reported using or discarding each type of reusable material listed on the survey form. Table 6 shows several of the industry types using or discarding halogenated solvents.

Table 6
Example of
Types of Facilities That Reported Using or Discarding Specific Reusables

	1 Halogenated Solvents		
SIC	**2052**	**Cookies & crackers**	
		freon	IO
		chlorform	IO
SIC	**2392**	**House furnishings, except curtains & drapes**	
		iron phosphate	IO
		mineral spirits	IO
SIC	**2521**	**Wood office furniture**	
		lacquer thinner	IO
SIC	**2711**	**Newspapers: publishing and printing**	
		halogenated solvent	I
SIC	**2752**	**Commercial printing - lithographic**	
		halogenated solvent, hydrocarbon based	IO
SIC	**2813**	**Industrial gases**	
		tetrachloroethylene	I
SIC	**2824**	**Synthetic organic fibers, except cellulosic**	
		chloroform/cresol	IO
		1,1,2,2 tetrachloroethane/phenol	IO
		tetrachloroethane	IO
		trichloroethylene, aerosol cans	IO
SIC	**2833**	**Medical chemicals & botanical products**	
		cfc-11	IO
SIC	**2834**	**Pharmaceutical preparations**	
		methylene chloride	I
		chloroform	I
		cfc-11(99%) w/ (1%)isopropyl alcohol	IO
SIC	**2835**	**In vitro & in vivo diagnostic substances**	
		mixed bag of 20-30 solvents	O
SIC	**2841**	**Soap & detergents**	
		methylene chloride	IO
SIC	**2851**	**Paints, varnishes, lacquers, enamels, & allied products**	
		halogenated solvent, aromatic 100	IO
SIC	**3272**	**Concrete products**	
		halogenated solvent (Safety Kleen)	I
SIC	**3398**	**Metal heat treating**	
		trichloroethylene	IO

Tables 5 and 6 and Appendices I and J present information reported in the reusable materials section of the survey booklet. Data from other sections of the survey can also be queried to find potential partnerships. For example, several businesses reported levels of steam use that merit further inquiry regarding possible partnerships involving excess steam.

Section Three: Partnership Reports

The project explored potential partnerships involving 49 different materials. Of these 49 materials, partnerships were implemented or are probable in the short-term for 12 materials:

- acetone
- carbon
- desiccant
- hydrochloric acid
- methanol
- packing materials
- plastic bags
- sawdust
- sodium hydroxide
- wood ash
- wood chips
- wood fluff

Partnerships appear possible in the long-term for an additional 24 of the 49 materials:

- absorbents
- blasting media
- coal ash
- conveyor belts
- copper
- drums
- electricity
- ethanol
- fiberglass
- floppy disks
- food waste
- foundry sand
- furniture fluff
- glass vials
- ink
- paint
- plastic
- rubber blankets
- steam
- steel
- sulfuric acid
- water – unheated
- wire
- wood

Partnerships seemed unlikely for the remaining 13 of the 49 materials:

- chromic acid
- concrete paste
- fabric
- hydrogen peroxide
- kaolin clay
- nitric acid
- phosphoric acid
- plastic IC tubes
- plastic sheeting
- soap
- solvents
- tobacco dust
- water – heated

Of the 182 facilities participating in the project, probable or possible partnerships were found for 88, or 48%. The 88 facilities, described by SIC code, are listed in Table 7 with the materials involved in these partnerships.

Preceding Table 7 is a narrative description and evaluation of each of the 49 potential partnerships. The probable partnerships are listed first, followed by the possible partnerships and then the unlikely partnerships. For nine of the 12 probable partnerships, it was possible to calculate projected cost savings and carbon emission reduction due to the partnership. (One of these nine is a one-time exchange rather than ongoing relationship.) A pre-partnership scenario is compared with a post-partnership scenario. Cost estimates were based on figures provided by the facilities involved. Estimates of carbon emission reduction amounts were made based on the estimated reduction in transportation mileage and the estimated reduction in energy use due to reduced demand for newly manufactured materials. The formulas for these carbon emission estimates are described in Appendix K.

It is important to note that the foregoing partnerships were only those the project had time to explore during the limited project period. These 49 potential partnerships are by no means the only ones possible between the project participants. Furthermore, partnerships regarding some of the 13 items in the “unlikely” group might be possible between other companies not yet involved in the project.

By encouraging partnerships between facilities, this project did not seek to discourage source reduction or the use of established recycling markets. The project sought to encourage local partnerships that provided an alternative to the following:

- disposal in a landfill;
- disposal in wastewater;
- disposal by a hazardous materials handler; or
- recycling or reuse involving more distant transportation.

Closing the reuse loop as tightly as possible will reduce truck miles traveled, which can have a significant impact on greenhouse gas emissions. Based on figures provided in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual*, an average heavy-duty gasoline truck will produce a quarter ton of carbon-based emissions every 135 miles traveled.

Probable Partnership: Acetone

Material description
Acetone is a colorless, volatile, flammable, toxic liquid compound frequently used in industry as a solvent and in organic chemical synthesis. While most commonly referred to as acetone, it is also referred to as dimethylketone and 2-propanone.

Producers of this byproduct
Many companies use acetone as a solvent to wash equipment and have a nearly pure acetone waste byproduct. However, the standards for the solvents used by some companies, such as the pharmaceutical and cosmetics industries, are very strict, requiring the distillation of acetone before reuse. Many of these facilities do not have stills, so they blend all their solvent wastes together to be sold for fuel. When enough acetone is used, however, it can be cost effective to segregate acetone from the other solvents. One such facility, a gem manufacturer (SIC 3674), currently has between 1,000 and 10,000 gallons of nearly pure acetone output per year, which it began separating early in 1998. This company is a synthetic diamond manufacturer that needs extremely pure acetone for its processes but would like to sell its acetone byproduct to someone who does not have such high quality requirements.

Users of this byproduct
One plastics company in the area (SIC 3089) reported using acetone to make adhesives, and it can tolerate discoloration and water content in the acetone. This company uses about 17,000 gallons annually, making a partnership with other companies for this byproduct economically worthwhile.

Evaluation of partnership potential
Currently these two companies are still trying to arrange a meeting time to discuss a partnership. The plastic company will host the meeting in order to show how the acetone will be used in its processes. The potential of this partnership occurring is quite high due to the enthusiasm of the plastics manufacturer and the willingness of the diamond manufacturer to sell acetone. These companies plan to work out the pricing and transportation issues of the partnership between themselves at the meeting to be scheduled soon.

Analysis of acetone partnership

<u>Pre-partnership scenario</u>
Seller
A gem manufacturer annually produces 5,000 gallons of an almost pure acetone byproduct with a little deionized water mixed with it. It sends this waste to a hazardous waste company that makes a fuel blend with this and other chemicals. The gem manufacturer pays $120 per 55-gallon drum for acetone disposal, for a total of $10,920 per year.

Buyer
A plastics company currently buys about 6,500 gallons of pure acetone from a company located in Fayetteville, NC. The cost of the material and transportation is $23,000 per year.

<u>Post-partnership scenario</u>
Seller
The gem manufacturer would give all of its acetone product to the plastics company. The gem manufacturer would no longer pay for treatment and disposal of acetone, saving $10,920. It could also earn additional revenue by selling the material.
Buyer
The plastics company would pay a hauler about $5,000 annually to pick up the acetone from the gem manufacturer, for a net savings of $18,000 per year.
Transportation
A third party carrier would travel from Durham, NC, to the gem manufacturer, then to the plastics company, then back to Durham (91 miles roundtrip). This would eliminate two routes: the 300-mile roundtrip acetone disposal trip and the 80-mile roundtrip acetone delivery trip to the plastics company. Since each route was traveled approximately every three weeks, elimination of the two old routes results in a net savings of 4,895 vehicle miles traveled after accounting for the new partnership route's travel miles.

Annual Cost Savings To Seller	$10,920
Annual Cost Savings To Buyer	$18,000
Total Annual Cost Savings	$28,920
Annual Mileage Saved By Seller	5,100
Annual Mileage Saved By Buyer	-205
Total Annual Mileage Saved	4,895
Annual Tons Carbon Reduction From Travel	9 tons
Annual Amount of Material Reused	5,005 gallons
Value of Manufacturing Replaced Annually by Reuse	$18,000
Annual Tons Carbon Reduction From Manufacturing	5.4 tons
Total Annual Tons Carbon Reduction	14.4 tons

Probable Partnership: Carbon

Material description
Carbon and activated carbon are materials used to cleanse and purify processes by filtering out particles in fluid and air. Typically activated carbon is the media in filters, and it has a specific capacity for its purifying ability. This filtering ability is usually measured in units of time, such as it can continuously filter for 36 days before reaching capacity.

Producers of this byproduct
Many companies use filters that contain activated carbon. Depending on their processes, they may use many or few filters, and the size and type of filters also varies. Large filters often do not need to be replaced in entirety, but only the filtering media, activated carbon. Typically, the activated carbon has no filtering capacity left after being removed from the filter, and must be discarded. Occasionally a process demands ultra cleanliness, in which case it may be dangerous to keep the carbon filter media in use until it has reached maximum capacity. Some companies discard it after it has reached a certain percentage of capacity. One local amino acid producer (SIC 2833) discards activated carbon long before it reaches maximum capacity.

Users of this byproduct
Most companies are afraid to incorporate previously used activated carbon into their processes because there is no guarantee or reliable date for when maximum capacity will be reached. However, carbon is organic and is a good coloring agent for mulch. Two facilities have the capability and possibility to produce a mulch product in the near future. One facility is a wastewater treatment plant (WWTP) (SIC 4952), and the other is a yard waste facility. Both facilities are located near the amino acid producer.

Evaluation of partnership potential
A trial run of mulch production has already begun with the amino acid producer, the WWTP, and a facility with wood chips as a byproduct. The trial run incorporates wood chips, lime stabilized treatment sludge, and carbon colorant, and the product will be chemically analyzed for feasibility for home and garden use. This process is expected to need only a portion of the amount of activated carbon available, so if the yard waste facility decides to start producing mulch, it could also use this byproduct. The yard waste facility is interested in pursuing this possibility, but has not actively begun any trials.

Analysis of carbon partnership

<u>Pre-partnership scenario</u>
Seller
An amino acid manufacturer annually produces 150 tons of used activated carbon waste. Currently, the waste goes to the landfill, picked up three times a week with other waste at a cost of approximately $13,200 per year in tipping fees and transportation.
Buyer
The local wastewater treatment plant could use carbon as an additive to its sludge/wood chip mix for coloring. Making mulch from its sludge is a new process, so it has not been using carbon

until now. The wastewater treatment plant is presently performing a trial run with the sludge, wood chips, and carbon, and it thinks it would be possible to use all the waste carbon from the amino acid manufacturer.

Post-partnership scenario

Seller

The amino acid producer would give its carbon to the wastewater treatment plant. The amino acid producer would avoid associated tipping fees but would still pay a carrier to transport the material. By eliminating carbon waste from its trash, its waste stream will be smaller and fewer landfill pickups will be necessary. The net number of trips would be about the same, though, since fewer trips on the landfill route would be made up by additional trips to the wastewater treatment plant. The cost savings to the amino acid producer would be $3,750 in tipping fees.

Buyer

The wastewater treatment plant would receive the carbon at no charge and would in turn donate the mulch produced by the sludge/wood chip mix

Transportation

The same waste hauler used currently by the amino acid producer to haul material to the landfill would haul it to the wastewater treatment plant, which is three miles closer. This would save six miles roundtrip, or 312 miles annually if the new route is taken once a week.

Annual Cost Savings To Seller	$3,750
Annual Cost Savings To Buyer	$0
Total Annual Cost Savings	$3,750
Annual Mileage Saved By Seller	312
Annual Mileage Saved By Buyer	0
Total Annual Mileage Saved	312
Annual Tons Carbon Reduction From Travel	0.57 tons
Annual Amount of Material Reused	150 tons
Value of Manufacturing Replaced Annually by Reuse	$0
Annual Tons Carbon Reduction From Manufacturing	0
Total Annual Tons Carbon Reduction	0.57 tons

Probable Partnership: Desiccant

Material description
A desiccant is a material that is used to absorb water vapor from the air and create a dry atmosphere in a container. It is commonly used in packaging of food, pharmaceutical products, and chemical reagents. The material may be packaged in a variety of package sizes.

Producers of this byproduct
Desiccant pouches are often included along with shipped items to prevent rust or other water vapor harm during transit. An amino acid producer (SIC 2833) has waste silica gel desiccant pouches at its facility. Amino acids are produced in bulk supplies of single amino acids. Often a customer requests a mixture of several amino acids together, so the company must mix the materials together. Strict FDA guidelines prevent the reuse of the desiccant pouches from the original amino acid packages. The company produces as many as 500 of these 5” x 6” pouches per day.

Users of this byproduct
These desiccant pouches could be reused by a variety of different people. Any company that needs to protect an item or area from water vapor can use desiccants in its process. Possible targets for reuse include industries in the area that already use desiccant pouches for shipping their products, as long as they were not subject to FDA regulations; marinas that need to eliminate mold and mildew inside boat compartments; hotels for reuse as ashtray filler; and flower drying operations.

Evaluation of partnership potential
A boat marina is interested in using the waste desiccant pouches, but it could only use a small amount of the material. The small amount makes this partnership not feasible.
Several large hotels were approached regarding reuse of the desiccant in large ashtrays, but no one was interested in this option. The small pouches of desiccant would have to be cut open and the desiccant poured out for use, which is too labor intensive.
A company that does large-scale flower drying stated it could use desiccant to facilitate flower drying, but it currently relies on air drying.
A tool manufacturer (SIC 3423) agreed to take 1,200 of the amino acid producer’s waste pouches annually for shipping metals from place to place. Companies in the area with similar needs are likely to be found to use the remaining amount.

Analysis of desiccant partnership

Pre-partnership scenario
Seller
An amino acid producer has 52,000 waste desiccant pouches per year available for reuse. Disposal costs are estimated at $193.05 per year.

Buyer
A local tool manufacturer has a branch in Greenville, Mississippi, that purchases 1,200 desiccant pouches per year for moisture protection in its steel shipments at a cost of $1,500.00 annually.

Post-partnership scenario
Seller
The amino acid producer will save an estimated $5.89 annually by providing 1,200 desiccant pouches to the tool manufacturer. This leaves 50,800 desiccant pouches still being landfilled at a cost of $187.16.
Buyer
The tool manufacturer reuses 1,200 pouches for packaging its products. A local division of this company picks up the material from the amino acid plant and brings it to its own plant. From there the desiccant travels to another tool manufacturing plant in Greenville, Mississippi by way of a truck that travels between the facilities for deliveries, resulting in no additional mileage for transport.
Transportation
The partnership will save the amino acid producer one trip to the landfill annually for travel savings of 22 miles. The waste desiccant is hauled a distance of 18 miles from Raleigh to the tool manufacturer in Apex four times annually, resulting in 144 additional miles. A total of 912 travel miles to Greenville, MS for delivery of new desiccant are avoided annually. This partnership results in travel savings of 790 miles annually.

Hypothetical total use scenario
Seller
If all the desiccant is reused, the amino acid producer would save $193.05 in disposal fees.
Buyer
The hypothetical buyers would save $ 650,000 by reusing these desiccant pouches rather than purchasing new desiccant pouches. Total mileage saved is not estimated, but 195.65 pounds of carbon could be saved from the replacement of new material by reused.

	Partnership	Hypothetical
Annual Cost Savings to Seller	$5.89	$193.05
Annual Cost Savings to Buyer	$1,500.00	$650,000.00
Total Annual Cost Savings	$1,505.89	$650,193.05
Annual Mileage Saved for Seller	22	
Annual Mileage Saved for Buyer	768	
Total Annual Mileage Saved	790	
Annual Tons Carbon Reduction from Travel	1.44 tons	
Annual Amount of Material Reused	0.18 tons	7.722 tons
Value of Manufacturing Replaced Annually by Reuse	$1,500.00	$650,000.00
Annual Carbon Reduction from Manufacturing	.45 tons	195.65 tons
Total Annual Tons Carbon Reduction	1.89 tons	195.65 tons

Probable Partnership: Hydrochloric Acid

Material description

Hydrochloric acid is a strong, highly corrosive acid. It is colorless or slightly yellow in color. It is commonly used to clean metal objects in an industrial production process and for pH adjustment within a wastewater treatment system.

Producers of this byproduct

Five companies reported having a hydrochloric acid byproduct. Hydrochloric acid is a common input into industrial processes. After the acid has been used for a while it becomes less powerful and not as effective for a facility to use. For example, a pharmaceutical manufacturer (SIC 2841), an amino acid producer (SIC 2833), and a gem manufacturer (SIC 3674) produce significant amounts of hydrochloric acid byproduct at their production facilities.

Users of this byproduct

Several companies indicated a willingness to use recycled content hydrochloric acid in their processes. Many companies use an acid as part of their wastewater treatment program in order to alter the pH of wastewater before it is released. Other companies may use hydrochloric acid as a part of their production process. For example, a tool manufacturer (SIC 3423) and a chemical specialty company (SIC 2841) use hydrochloric acid on a regular basis.

Evaluation of partnership potential

An amino acid producer and a tool manufacturer met to discuss the possibility of an acid exchange. The amino acid producer has a large amount of acid available that might meet the needs of the tool manufacturer. Unfortunately, the high levels of amino acids in the available acid waste may affect the chemical reactions within the tool manufacturing process. The tool manufacturer must remove all metal from its wastewater stream, and the amino acids may present a problem with the metal removal.

A gem manufacturer was evaluated as a possible acid provider, but it mixes all the acids at the facility together along with hydrogen peroxide, making the acids of a very low value. If it were able to keep the materials separated in the production process , this manufacturer would be an ideal partner for someone interested in reusing hydrochloric acid. A more viable partnership was found between the pharmaceutical manufacturer and the specialty chemical producer.

Analysis of hydrochloric acid partnership

<u>Pre-partnership scenario</u>

Seller

The pharmaceutical manufacturer has 12,323 gallons of hydrochloric acid waste each year. The material is used in its wastewater treatment process.

Buyer
The specialty chemical manufacturer buys 24 55-gallon drums of hydrochloric acid each year from a distributor.

<u>Post-partnership scenario</u>
Seller
The pharmaceutical manufacturer will reduce the amount of material purchased to neutralize this acid in its wastewater treatment process.
Buyer
The specialty chemical manufacturer will save $1,056 annually by reusing hydrochloric acid rather than purchasing new acid.
Transportation
Delivery of new hydrochloric acid to the chemical manufacturer involves 168 travel miles annually. This partnership would involve 1,104 travel miles annually to pick up this material from the pharmaceutical manufacturer, resulting in a net overall addition of 936 miles.

Annual Cost Savings to Seller	uncertain
Annual Cost Savings to Buyer	$ 1,056.00
Total Annual Cost Savings	$ 1,056.00
Annual Mileage Saved for Seller	0
Annual Mileage Saved for Buyer	-936
Total Annual Mileage Saved	-936
Annual Tons Carbon Reduction from Travel	-1.7
Annual Amount of Material Reused	24 drums
Value of Manufacturing Replaced Annually by Reuse	$ 1,056.00
Annual Carbon Reduction from Manufacturing	.32 tons
Total Annual Tons Carbon Reduction	-1.38

Probable Partnership: Methanol

Material description
Methanol is a colorless, highly polar liquid also known as methyl alcohol or wood alcohol. It is toxic by ingestion and extremely flammable. Methanol has many important industrial uses, including use in the manufacture of formaldehyde and acetic acid, use in the manufacture of synthetic proteins by continuous fermentation, use as fuel for utility plants, use as a source of hydrogen for fuel cells, and use in the production of antifreeze, shellac, and dye.

Producers of this byproduct
An amino acid manufacturer (SIC 2833) plans to enter a contract next year increasing production of a certain amino acid. This change in production will necessitate large amounts of methanol for the process of fermentation in this production. The company will produce a byproduct that is a 50% methanol solution that, in terms of 100% solution, will amount to almost 60 tons of methanol per year. There is a potential problem with this solution, however; it will be contaminated with the amino acid serine in 100,000 ppm (10g per deciliter or 10%). Unknown at this point is the effect the amino acid contaminant will have on the solution, since it may contribute a large amount of nitrogen. A high nitrogen content may constitute a barrier to reuse by many facilities, since nitrogen cannot be released in wastewater in large amounts. This company is doing testing on this potential byproduct for nitrogen content and biological oxygen demand. Another producer of methanol is a manufacturer of urea-formaldehyde resins (SIC 2891). This company uses methanol to methylate resin, and the methanol solution is stripped off in an 80% methanol, 20% water solution. The methanol is used in a batch process that results in approximately 2,500 gallons of methanol byproduct every 10-12 days. This amounts to 75,000 gallons of pure methanol per year. This company is confident that there are no other contaminants, no nitrogen in particular, but it is also planning to run further tests on this methanol byproduct for biological oxygen demand and total nitrogen.

Users of this byproduct
Wastewater treatment plants (WWTP's) (SIC 4952) can use methanol to remove nitrogen at several stages of the treatment process, especially at the filters. Some plants already use methanol, but many more may need to incorporate it into their treatment processes to meet increasingly strict standards. There are varying degrees of ease in which methanol can be incorporated into the process, depending on the age and capacity of the plant. One area WWTP already uses 100% methanol in its process, which amounts to 60,000 gallons every six months. This methanol has a specific gravity of 0.79 and results in a 2 mg/L decrease in nitrogen at the filters. The amount of methanol used depends upon the amount of water treated at the plant.

Evaluation of partnership potential
In a meeting held between the two byproduct producers and several WWTP's, two potential barriers to partnerships became apparent. One barrier is the possible nitrogen content of the amino acid manufacturer's byproduct, since the methanol is used to remove nitrogen at the wastewater treatment plant. The other potential barrier is that the amount of methanol needed by the WWTP exceeds the amount produced by these two facilities combined. The WWTP would need to continue using some of its methanol from its existing source. Methanol is stored at the

WWTP in a 12,000-gallon storage tank. It is necessary for the WWTP to know the concentration of the methanol in order to use the correct amount, which necessitates having the entire tank at the same concentration. The WWTP could not mix methanol of different concentrations in the same tank. A separate tank would therefore be required for each source of used methanol. A fiberglass tank costs around $35,000. At the time this report went to press, both producers of the byproduct were performing a complete chemical analysis on their products. In addition, the resin manufacturer was discussing the possibility of assisting with the purchase of a tank at the WWTP for its methanol.

Analysis of methanol partnership

Pre-partnership scenario

Seller

A resin manufacturer annually produces 300,000 gallons of an 80% methanol, 20% water solution as a byproduct, equivalent to 240,000 gallons of pure methanol. Currently, the company treats this solution for sewer disposal at a cost of $35,000 per year.

Buyer

A WWTP currently buys 290,000 gallons of pure methanol to treat wastewater at a cost of $0.59 per gallon, or $171,000 per year.

Post-partnership scenario

Seller

The resin manufacturer could sell all of its methanol byproduct to the wastewater treatment plant for half the price of pure methanol. This manufacturer would no longer pay for treatment and disposal of methanol, saving $35,000 and would earn an additional $70,800 by selling the material. After figuring an annual cost of approximately $5,000 for transportation, the net difference for the resin producers would be increased annual revenue in the amount of $100,800.

Buyer

The WWTP would pay half the price of pure methanol for the solution from the resin producer, saving $70,800 per year. It would still need to supplement the reused methanol with 50,000 gallons of pure methanol. The WWTP would also need to buy an additional tank to store the impure methanol at a cost of $35,000. Accordingly, cost savings would only be $35,800 the first year.

Transportation

A third party carrier would travel from Durham, NC, to the resin plant, to the wastewater treatment plant, and back to Durham. This would result in an additional 140 miles traveled per year over the roundtrip transportation of methanol from its source to the wastewater treatment plant.

Annual Cost Savings To Seller	$100,800
Annual Cost Savings To Buyer	$70,800 (except only $35,800 1st year)
Total Annual Cost Savings	$171,600
Annual Mileage Saved For Seller	0
Annual Mileage Saved For Buyer	-140
Total Annual Mileage Saved	-140
Annual Tons Carbon Reduction From Travel	-0.25 tons
Annual Amount of Material Reused	240,000 gal
Value of Manufacturing Replaced Annually by Reuse	$70,800
Annual Tons Carbon Reduction from Manufacturing	21.25 tons
Total Annual Tons Carbon Reduction	21 tons

Probable Partnership: Packing Materials

Material description
Packing materials include urethane foam, plastic bubble wrap, and packing peanuts.

Producers of this byproduct
Packing materials are produced by a wide variety of companies. Almost all companies receive shipments to their facilities. For example, a computer assembly facility (SIC 3577) receives components packed in cardboard and surrounded by foam, bubble wrap, and peanuts. This material makes up a large percentage of the facility's landfilled waste.

Users of this byproduct
Packing materials can be used by a wide variety of companies. Any company that ships fragile items out on a regular basis uses some type of packing material to protect the shipment during transit. A china distribution facility (SIC 5023), a parts machining facility (SIC 3599), and an upholstered furniture company (SIC 2599) reported using bubble wrap as an input and would be willing to use recycled content. Shipping companies (SIC 4513) are also potential users.

Evaluation of partnership potential
Unfortunately, the computer assembly company is not willing to separate the material at its facility. Moreover, some of the potential users are located too far away from the source of the packing materials to justify a partnership for the exchange of a small amount of bubble wrap. Two shipping company chains were interested in obtaining some of the packing materials to use in their stores. A representative from one firm visited the computer assembly facility and a preliminary exchange was made, which is represented in the analysis below. Since that exchange, the shipping company has expressed concern about the process the computer assembly facility suggested for picking up the packing materials. The computer facility is not willing to store the material for any amount of time, but the shipping company cannot afford the cost of picking up the material every few days. Further discussion has determined that the partnership may work only if a third party were available to pick up the material from the computer assembly facility and store it for short amounts of time for the shipping stores. If a third party could assume this role, all the packing material could be diverted and divided between several shipping stores in the area. Other possibilities may also develop with continued intervention of a facilitator.

Analysis of packing material partnership

<u>Pre-partnership scenario</u>
Seller
A computer assembly facility has 90,000 pounds of waste foam packing material available for reuse annually. All foam is currently disposed of in a landfill.

Buyer
A shipping company uses packaging material to pack items for its customers. It purchases1 ,825 bags annually. The material costs about $5.00 per bag. This results in a cost to the company of $9,125.00 each year.

<u>Post-partnership scenario</u>
Seller
The computer assembly company estimates it would save $1,459.20 in disposal fees each year by providing packing materials to the shipping company.
Buyer
By obtaining one half of the packing material it needs from the computer facility, the shipping company would save $4,562.00 annually.
Transportation
The computer assembly facility eliminates 822 miles annually by reducing the number of trips made to the landfill. The shipping company reduces the travel miles from purchasing new materials shipped from Charlotte, NC, from 8,632 miles annually to 4,316 miles annually. The shipping company adds 264 travel miles annually by collecting the material from the computer facility.

Annual Cost Savings to Seller	$1,459.20
Annual Cost Saving s to Buyer	$4,562.00
Total Annual Cost Savings	$6,021.20
Annual Mileage Saved for Seller	822
Annual Mileage Saved for Buyer	4052
Total Annual Mileage Saved	4874
Annual Tons Carbon Reduction From Travel	8.88
Annual Amount of Material Reused	4.56 tons
Value of Manufacturing Replaced Annually by Reuse	$4,562.00
Annual Carbon Reduction From Manufacturing	1.37 tons
Total Annual Tons Carbon Reduction	10.34 tons

Probable Partnership: Plastic Bags

Material description
Plastic bags are made from a variety of different plastic types and come in many different sizes and shapes. Some companies receive bags as packaging material for inputs. These bags protect components from degradation during shipping. Many of these bags are only slightly used.

Producers of this byproduct
Several companies reported waste plastic bags as a significant byproduct. Many electronics companies reported that components for their equipment were shipped to their facilities in plastic bags. Most of these bags are small and are specially designed to eliminate static electricity. Other facilities such as hospitals receive materials in sterile plastic bag packaging. One company, an amino acid producer (SIC 2833), has clear, HDPE plastic bags used to line its fiberboard drums as a byproduct. These bags seemed particularly reusable because of their high quality and availability. The bags hold 40 gallons and are made of high quality tear resistant plastic. The company produces its amino acids in bulk supplies of single amino acids. Often a customer wants a mixture of several amino acids together, so the company must mix them together. The liners and drums that are emptied when the amino acids are mixed cannot be reused by the company because of strict FDA regulations. As many as 500 of these bags may be produced in one day.

Users of this byproduct
No company reported an input of plastic bags in its survey responses. Some of the smaller bags could be reused for shipping, but no companies responding to the survey were able to use the available materials at this time. Larger bags could be used by litter control programs or as trash bags to line trashcans at a variety of facilities. Since no users of large plastic bags such as those produced by the amino acid producer were identified through the survey, alternative possible users were identified and explored. Garbage and litter collection seemed to be likely candidates for reuse of these bags.

Evaluation of partnership potential
The statewide highway litter collection program uses plastic bags for litter collection, but it could not use the waste bags because of the litter program's color-coded separation system for recyclables and other litter. A county stream clean-up program also uses bags for litter collection, but it could not use a large amount of the bags on a regular basis, and it had no space available to store the bags. A national litter control organization provides bags for litter collection statewide, but storage of the bags would also be difficult for this organization. The county school system has agreed to use the plastic bags as an alternative to its plastic garbage bags. The school can pick up bags on a regular basis and store them in its warehouse until the schools need them

Analysis of plastic bag partnership

Pre-partnership scenario

Seller

An amino acid producer has 90,000 waste plastic liners available for reuse annually. Before the partnership, all liners were disposed of in the landfill at a cost of $619.53 annually.

Buyer

A county school system uses plastic bags to line trash containers in all schools. It purchases 200,000 liners for this purpose annually. The liners cost $15.12 for a case of 250. This results in a cost to the school system of $12,096.00 each year.

Post-partnership scenario

Seller

The amino acid producer estimates that it will save $619.53 in disposal fees each year by providing 90,000 plastic bags to the schools rather than disposing of them in the landfill.

Buyer

The waste bags only provide a portion of the garbage bags needed by the schools, but the school system saves $5,443.20 of its original garbage bag purchasing costs by reusing these bags.

Transportation

The amino acid producer saves 66 travel miles each year by eliminating trips to the landfill. The school system originally received its plastic bags from Annapolis, MD, a round trip distance of 593 miles, 12 times per year. By using the waste bags, 5 deliveries per year could be avoided. The school system adds 103 travel miles annually to pick up the bags from the amino acid facility, for an overall travel savings of 2,862 miles annually.

Annual Cost Savings to Seller	$619.53
Annual Cost Savings to Buyer	$5,443.20
Total Annual Cost Savings	$6,062.73
Annual Mileage Saved for Seller	66
Annual Mileage Saved for Buyer	2862
Total Annual Mileage Saved	2928
Annual Tons Carbon Reduction from Travel	5.33 tons
Annual Amount of Material Reused	14.63
Value of Manufacturing Replaced Annually by Reuse	$5,443.20
Annual Carbon Reduction from Manufacturing	1.64 tons
Total Annual Tons Carbon Reduction	6.97 tons

Probable Partnership: Sawdust

Material description
Sawdust is the byproduct resulting from cutting and sanding wood. The particles resulting from this process can range from dust sized particles to shavings or chunks, depending on the process. Sawdust has limited industrial applications and is commonly landfilled with other wood waste; however, if not contaminated by paint, wood treatment chemicals, or laminates, sawdust can be used as a packaging material or as an absorbent for oils or lubricants.

Producers of this byproduct
Nearly all industries that cut or saw wood have sawdust as a byproduct. Some examples of these industries are furniture companies, cabinetmakers, lumber mills, and wood flooring manufacturers. One cabinetmaker (SIC 2434) produces fine sawdust particles, which are collected in a vacuum system. This system then retains the sawdust in a 40-gallon bag, which is emptied two to three times each month. Currently, this material is added to its wood waste and is taken to the landfill. Two different sawdust waste streams are produced at this site. One sawdust stream is from the main saw and sander, which cuts pure wood and has pure wood sawdust; the other stream, which is smaller, is produced from cutting laminated wood and has laminate contaminated sawdust. These two streams are currently collected together in the same vacuum bag, but could be easily separated.

Users of this byproduct
Sawdust produced in mass quantities has several applications, including use as a livestock feed additive, as an additive to pulp used to make paper, and as a fuel to fire brick kilns. However, it is not economically feasible to ship small quantities of sawdust for these purposes. One company, which is located directly across the street from the cabinetmaker, can use sawdust to pack hazardous chemicals that are shipped to be incinerated. This company (SIC 9511) is a hazardous waste collector which takes waste from companies and stores it until there is a large enough quantity to transport to a recycling facility. Occasionally it receives waste that cannot be cleaned or recycled, and this waste is sent to an incinerator. It uses vermiculite as a packing material for these substances, but it could use sawdust, since it is combustible, does not necessitate unpacking the container upon arrival at the incinerator, and leaves no residue behind as plastics would.

Evaluation of partnership potential
In a meeting of these two companies, no barriers to a partnership emerged, so partnership logistics were worked out. The chemical company has a stockpile of 55-gallon drums, which it collects to be reconditioned. The company agreed to take two of these drums from this stockpile to the cabinetmaker. The cabinetmaker will collect the pure wood sawdust with the vacuum system and empty the collection bag to the drums instead of his trash container. Once a drum becomes full, the cabinetmaker will call the chemical company to pick it up. They are going to have a rotational system so that the cabinet shop will always have an extra drum to use after one gets full and before the chemical company can pick it up and drop off another. In a subsequent conversation, the topic of sawdust as an absorbent was discussed. Both of these businesses use absorbents to soak up spills at their facilities. Sawdust alone cannot be used as an absorbent

because it floats to the top of the spilled media, however, both companies thought sawdust could be used as an absorbent if a containment media could be prepared. They indicated an interest in using sawdust as an absorbent if it could be put into a cotton sleeve or sock and was cheaper than current absorbent socks, which contain vermiculite as the absorbent medium.

Analysis of sawdust partnership

Pre-partnership scenario

Seller

A cabinet shop produces approximately 48 55-gallon drums of sawdust as a byproduct of its processes each year. This byproduct is dumped into its general waste dumpster, and its diversion will not decrease the number of dumpster pickups.

Buyer

A hazardous materials handler located across the street from the cabinet shop currently uses vermiculite to pack materials that are shipped to an incinerator. It uses approximately 420 bags of vermiculite each year, which it picks up itself and for which it pays $5 per bag. It could use sawdust as an alternative to vermiculite for this packing purpose.

Post-partnership scenario

Seller

The cabinet shop donates all of its sawdust to the hazardous materials handler.

Buyer

The hazardous materials handler sends two 55-gallon drums to the cabinet shop by handtruck. The cabinet shop calls the hazardous materials handler when they fill up to exchange them for empty ones. Although the hazardous materials handler is not sure whether there will be enough sawdust to meet its needs, ideally it would not need to purchase any vermiculite. This would save approximately $500 in transportation fees and $2,100 in material cost each year.

Transportation

The hazardous materials handler could eliminate a 40-mile round trip every two weeks, amounting to 960 miles saved per year. The partnership scenario involves no vehicular transportation.

Annual Cost Savings To Seller	$0
Annual Cost Savings To Buyer	$2,600
Total Annual Cost Savings	$2,600
Annual Mileage Saved For Seller	0
Annual Mileage Saved For Buyer	960
Total Annual Mileage Saved	960
Annual Tons Carbon Reduction From Travel	1.75 tons
Annual Amount of Material Diverted	48, 55-gal drums
Value of Manufacturing Replaced Annually By Reuse	$2100
Annual Tons Carbon Reduction From Manufacturing	0.6 tons
Total Annual Tons Carbon Reduction	2.35 tons

Probable Partnership: Sodium Hydroxide

Material description
Sodium hydroxide is an alkali commonly used to alter the pH of wastewater before it is released from a company's wastewater treatment facility.

Producers of this byproduct
No survey respondents reported producing a sodium hydroxide byproduct. This is because sodium hydroxide is used to adjust the pH of wastewater and is used up in the process and released along with the wastewater. One company, a wood products producer (SIC 2943), had an excess amount of this material left over from a process change.

Users of this byproduct
Many companies indicated a willingness to use recycled sodium hydroxide as an input at their facilities to alter the pH of their wastewater. The sodium hydroxide would have to be fairly high quality to stay within the wastewater permits of the facilities. Metal impurities would be an especially big problem.

Evaluation of partnership potential
The wood products manufacturer and an adhesive resin producer (SIC 2891) met and were able to arrange an exchange of the leftover amount of sodium hydroxide that the wood products manufacturer had available

Analysis of sodium hydroxide partnership

Pre-partnership scenario
Seller
The wood products manufacturer has three 55-gallon drums of sodium hydroxide that it cannot use because the company has switched to potassium hydroxide. Since this material is one year old, the company's only option would be to dispose of it as non-hazardous waste at a cost of $500 per barrel.
Buyer
The adhesive resins producer buys sodium hydroxide for use in its wastewater treatment process. The material is obtained from a supplier in Wilmington, NC.

Post-partnership scenario
Seller
The wood products manufacturer will save an estimated amount of $1,500 by providing the three drums to the adhesive resin producer rather than sending it for non-hazardous waste disposal.
Buyer
The adhesive resin manufacturer will save $82.50 by using this sodium hydroxide rather than purchasing new sodium hydroxide.

Transportation

This material will be transported .25 miles across the street from one facility to the other, rather than the 30 miles it would be moved for hazardous waste disposal. The adhesive resin manufacturer will save 315.75 miles of delivery travel by using this material rather than obtaining it from Wilmington, NC.

Note: This partnership is a one-time exchange, not an on-going relationship.

Annual Cost Savings to Seller	$1,500
Annual Cost Savings to Buyer	$82.50
Total Annual Cost Savings	$1,582.50
Annual Mileage Saved for Seller	29.75
Annual Mileage Saved for Buyer	315.75
Total Annual Mileage Saved	345.5
Annual Tons Carbon Reduction from Travel	.63 tons
Amount of Material Reused	165 gallons
Value of Manufacturing Replaced Annually by Reuse	$82.50
Annual Carbon Reduction from Manufacturing	.02 tons
Total Annual Tons Carbon Reduction	.65 tons

Probable Partnership: Wood Ash

Material description
Wood ash in this context is the ash that remains when wood is burned as a boiler fuel. It has a high pH.

Producers of this byproduct
Two neighboring companies reported significant amounts of a wood ash byproduct. One is a plywood manufacturer (SIC 2435) that produces 10 to 12 tons per week from burning gum and poplar trees. The other is a particleboard manufacturer (SIC 2493) that produces 15 to 20 tons per week from burning pine bark. Elsewhere in the county, a furniture manufacturer (SIC 2521) produces about 3 cubic yards of wood ash each year from burning hardwoods.

Users of this byproduct
The county where the above producers of wood ash as a byproduct are located is a predominantly rural county. Many farmers could use wood ash to add pH to their fields.

Evaluation of partnership potential
A meeting was convened that included representatives from the plywood and particleboard manufacturers, a representative from a nearby composting company (SIC 2875), and the local cooperative extension agent. The cooperative extension agent had a list of farmers who wanted wood ash, and he knows people with spreader trucks. The plywood manufacturer was willing to load its wood ash into dump trucks and haul it somewhere if necessary. A representative from the composting company had a best management practice sheet for wood ash that could be used as a template for land application permits. The issue of who would be responsible for yearly and lifetime limits for land application permits was discussed but not resolved. The parties have planned to follow up on this. It looks like a very promising partnership. The furniture manufacturer could be added to the system once it is set up.

Probable Partnership: Wood Chips

Material description
Wood chips in this context are wood shavings used for animal bedding.

Producers of this byproduct
A local company (SIC 0279) breeds and raises rodents and small animals for scientific experiments. Its business uses a large amount of wood shavings for animal bedding, which, mixed with feces from the animals, is also their largest waste product. The company orders 2,080,000 pounds of bedding per year, and it has this amount plus the weight of the feces leaving the facility each year going to the landfill. This material could easily be composted with other materials to make a mulch product.

Users of this byproduct
There are two facilities interested in using the wood chip material to make mulch. One is a local government yard waste facility, but its permit does not currently allow it to take this type of material. The other facility interested in this material is the local wastewater treatment plant (WWTP) (SIC 4952). It is interested in mixing the bedding material with wastewater treatment plant sludge to make a mulch.

Evaluation of partnership potential
The animal breeder and the WWTP are performing a trial run of the wood chips/sludge mix with added carbon from another facility for coloring. It is likely that a permanent partnership will be established between these three facilities.

Analysis of wood chips partnership

Pre-partnership scenario
Seller
A laboratory animal breeding facility produces approximately 420 tons of wood chip waste in a year. This waste is a mixture of wood shavings and animal feces. In tipping fees and transportation service charges, the lab spends nearly $58,800 a year for disposal of this material in a landfill.
Buyer
A local wastewater treatment plant currently has a very large amount of lime stabilized sludge byproduct. This material, if mixed with wood chips, could make a mulch.

Post-partnership scenario
Seller
The animal lab would give the wastewater treatment plant a portion of its wood chips and avoid associated disposal costs. The wastewater treatment plant estimates it could take one load a week, or about 1/6 of the total material the animal lab produces. The cost savings in tipping fees for the animal lab would be $1,760 annually.

Buyer
The wastewater treatment plant would receive the wood chips at no cost.
Transportation
The same waste hauler the animal lab uses to haul material to the landfill would haul it to the wastewater treatment plant. This would save eight miles roundtrip, or 416 miles annually.

Annual Cost Savings To Seller	$1760
Annual Cost Savings To Buyer	$0
Total Annual Cost Savings	$1760
Annual Mileage Saved For Seller	416
Annual Mileage Saved For Buyer	0
Total Annual Mileage Saved	416
Annual Tons Carbon Reduction From Travel	0.76 tons
Annual Amount of Material Diverted	70 tons
Value of Manufacturing Replaced Annually by Reuse	$0
Annual Tons Carbon Reduction from Manufacturing	0
Total Annual Tons Carbon Reduction	0.76 tons

Probable Partnership: Wood Fluff

Material description
Wood fluff is the fibrous trim material from particleboard manufacturing. It is very, very fluffy, so water is added to it in order to keep it from blowing away during transport. It contains formaldehyde.

Producers of this byproduct
A local particleboard manufacturer (SIC 2493) produces 20 to 25 tractor trailer loads of wood fluff per week. It is currently transported to another county for use as a landfill cap, but the landfill will be capped by the end of 1999.

Users of this byproduct
A local composting facility (SIC 2875) can use wood fluff containing formaldehyde. At the 130 degree temperature achieved during composting, the formaldehyde breaks down into urea (nitrogen) and water, both of which are desirable in compost.

Evaluation of partnership potential
At a meeting of the two potential partners, the composting facility stated that it could accept half of the wood fluff byproduct from the particleboard manufacturer. This partnership would probably not occur until the end of 1999.

Possible Partnership: Absorbents

Material description
Absorbents are materials that soak up liquid. They may be made of organic, inorganic, or synthetic materials such as peat moss, straw, clay, or nylon.

Producers of this byproduct
Sawdust and shredded fabric were two possible sources of absorbent material reported as byproducts by project participants. Several companies produced these byproducts.

Users of this byproduct
163 participants were sent a separate survey regarding the use of absorbents at their facilities. 42 companies out of the 163 responded, which is a response rate of 26%. 27 of the 42 stated they would consider using an alternative absorbent source.   Two additional companies stated they might use an alternative absorbent, depending on the quality. Only three companies said they would not be interested in using alternative absorbents at all. The remaining ten companies returning the survey did not use absorbents at their facilities.

Evaluation of partnership potential
The best possibility for incorporating recycled material into absorbents would be in absorbent socks. Sixteen companies stated they would use alternative socks on a regular basis, estimating a total of about 366 socks per month , or 4,392 per year.

The socks could be made from a variety of materials identified by the project.   Possibilities include fabric scraps, sawdust, or scrap non-woven material. Socks could be manufactured by companies that produce the scrap materials or by a new business introduced to fill this need.

A four-foot sock sells for about $2.50 per sock. The price increases or decreases depending on the quantity purchased. For an alternative sock to be successful if would need to be created for less than that price.

The largest supplier of absorbent socks is New Pig, located in Tipton, PA. A delivery of socks from Tipton to the Triangle area is an 879-mile round trip to deliver the material, resulting in 1.6 pounds of carbon emissions.

Further investigation of the feasibility of using local byproduct material in absorbent socks is necessary, but it appears to be a possible partnership.

Companies Willing to Use Recycled Absorbents	
Company	**Socks/month**
Cookie and Cracker Bakery (SIC 2052)	5
Electronic Capacitor Producer (SIC 3675)	25
Biological Products Manufacturer (SIC 2836)	20
Hydraulic Log Loader Manufacturer (SIC 3553)	0
Laboratory Animal Production Facility (SIC 0279)	unknown
Wastewater Treatment Facility (SIC 4952)	16
Wastewater Treatment Facility (SIC 4952)	0
Measuring Device Manufacturer (SIC 3829)	5
Hospital (SIC 8062)	0
Electronics Company (SIC 8734)	25
Electrical Controls Manufacturer (SIC 3491)	0
Electrical Controls Manufacturer (SIC 3491)	10
Nonwoven Materials Manufacturer (SIC 2824)	15
Automotive Component Producer (SIC 3714)	60
Sign Manufacturer (SIC 3993)	0
Offset Heat Printer (SIC 2752)	100
Tobacco Stemming Company (SIC 2141)	0
Measuring Tape Manufacturer (SIC 3423)	50
Measuring Device Manufacturer (SIC 3829)	0
Newspaper Publishing Company (SIC 2711)	5
Toxicology Research Facility (SIC 8733)	0
Copper Powder Producer (SIC 3399)_	0
Wastewater Treatment Facility (SIC 4952)	5
Laminate Flooring Manufacturer (SIC 2493)	0
Nonwoven Fabric Manufacturer (SIC 2297)	25
Machine Parts Company (SIC 3599)	0
Metal Forge (SIC 3462)	0
Flour and Corn Products (SIC 2051)	emergency use
Medical Tubing Manufacturer (SIC 3083)	0
Total Use	316

Possible Partnership: Blasting Media

Material description
Blasting media are used by industrial gas producers to clean the interior and exterior surfaces of gas cylinders. Three types of blasting media are used by one local company: glass particles, sand, and tiny plastic beads.

Producers of this byproduct
Two local companies reported byproducts that appeared to be possible sources of blasting media. One was a hazardous waste handler (SIC 9511) that had crushed soda lime glass from fluorescent light bulbs. The other was an institutional cooking equipment manufacturer (SIC 3589) that had a glass bead byproduct.

Users of this byproduct
One local industrial gas producer (SIC 8731) was interested in an alternative source of blasting media.

Evaluation of partnership potential
Discussions with the three above parties revealed that the soda lime glass was not acceptable to the industrial gas producer. Moreover, the institutional cooking equipment company decided that disposing of its byproduct on site was easy and environmentally safe and therefore it wasn't interested in doing something else with it. Time constraints prohibited further exploration of possibilities, but blasting material appears to be a material that is worth looking into in more detail.

Possible Partnership: Coal Ash

Material description
Coal ash is produced from coal-fired steam or electricity generating plants. There are two basic types of coal ash: fly ash and bottom ash. Fly ash is a fine, powdery material often collected by electrostatic precipitators or giant vacuums called bag houses. Bottom ash is heavier and granular and accumulates at the bottom of the boiler. Both types have numerous uses. For example, fly ash can be used in cement and concrete production, and it can also be used in road bases or soil amendments; bottom ash can be used in roofing shingles, road bases, and concrete blocks.

Producers of this byproduct
Several facilities in the region burn coal and have coal ash as a byproduct. Discussions were held with three facilities regarding their coal ash. One was a 300-megawatt coal-fired electricity generating facility (SIC 4911), and the other two were universities (SIC 8221). The electric utility produces 25,000 to 30,000 tons of fly ash per year and 3,000 to 4,000 tons of bottom ash. Both types of ash are now in wet form and are put together into a settling pond, where the ash sinks to the bottom. The ash is not being reused, but the facility is considering modifying its equipment to separate the fly ash from the bottom ash and capture them for reuse. One of the universities produces 6,000 tons of mixed fly and bottom ash per year, and the other university produces 30,000 tons of combined fly and bottom ash per year. Both universities currently truck their ash to users outside of the region.

Users of this byproduct
A local brick manufacturer (SIC 3251) is interested in using bottom ash from its neighbor, the electric utility. The electric utility is also exploring the possibility of investing in one or more new local companies that would locally manufacture a product from its fly ash.

Two other facilities reported using coal ash. One is a concrete product manufacturer (SIC 3272), which uses bottom ash from a power plant outside the region. The other is a wastewater treatment plant (SIC 4952), which uses fly ash from a power plant outside the region.

Evaluation of partnership potential
The outcome of the electric utility's exploration of investing in a manufacturing enterprise is critical to the local coal ash reuse landscape. If a new enterprise is established, it could probably use coal ash from several local sources in addition to the electric utility. The electric utility is taking the lead in negotiating regarding this possibility, so the other potential partners are awaiting the outcome of this situation. Representatives from the two universities have stated that they are open to sending their ash to a more local operation if it were to become environmentally and economically advantageous to do so. Given these developments and the existing use of coal ash, additional future coal ash partnerships seem promising.

Possible Partnership: Conveyor Belts

Material description

Conveyor belts are rubber bands that vary in width, thickness, and reinforcement material. Most are made of styrenebutadiene rubber, with a mesh reinforcement of either steel or nylon layered between the rubber

Producers of this byproduct

Manufacturers of aggregate, quarry, concrete, cement, and brick frequently use conveyor belts to transport their stone materials and products. When the belts snap or get too worn to use safely, they are replaced with new ones, and the old ones are discarded. Typically ½ to one inch thick and over 40 feet long, each belt is heavy and contributes a large amount of mass sent to the landfill from these companies. However, the companies using conveyor belts typically have a large amount of space to store used conveyor belts, creating a good potential partnership scenario.

Users of this byproduct

While this item is made of rubber, it is hard to recycle in traditional ways due to the inseparable layers of reinforcement material. There are no tire or rubber processors in North or South Carolina who can process or recycle this material. In some instances, the original manufacturer will take back used conveyor belts for resale if they are still in reasonably good shape. However, the challenge is to find users who will take conveyor belts, or pieces of them, to use as is. One possibility is to use them as a floor liner where a non-slip floor surface is desirable. Restaurants and garages typically use such a non-slip floor material. However, several local facilities indicated that while this material was similar to products in current use, the products they use are inexpensive and are of a superior quality better suited to their needs. There is some indication that farms or stables could use the material in their barns, but further research is needed regarding the feasibility of this type of partnership.

Evaluation of partnership potential

The potential of a partnership with conveyor belts is limited; however, there may be some farms or stables that could use this material.

Possible Partnership: Copper

Material description
Scrap copper may come in a variety of forms, including chunks or wire. The wire may be a variety of lengths and gauges.

Producers of this byproduct
Scrap copper wire results from wiring operations that have an excess of the materials they use to wire circuits together. Most copper scrap is sold for recycling.

Users of this byproduct
Some scrap copper, especially copper wire, may be reused as is. Otherwise it may be melted for reuse in another capacity.

Evaluation of partnership potential
An electrical panel manufacturer (SIC 3625) produces approximately 362 tons of scrap copper per year. Currently it sells this material to a scrap metal dealer. The project investigated a possible partnership with a producer of copper powders (SIC 3399) that is actively seeking to enlarge its supply of clean number 1 level scrap copper. This copper can have some oxidization but no insulation; it must also be free of solder joints, which contain tin and lead.

Several problems were identified that made this particular partnership unfeasible.

- First, the copper powder producer may not be willing to offer a competitive price.
- Second, the quantity may not be sufficient to justify an ongoing relationship.
- Finally, it is possible that the current use for the scrap copper wire is environmentally superior to the one offered by the copper powder producer. Much of the scrap wire is currently reused in its original form.

After lengthy discussion, no agreement could be reached. The electric panel manufacturer indicated that it is not willing to change its recycling process at this time.

There are, however, at least two other local companies that produce scrap copper: a plumbing products company (SIC 3432), and an electrical coil and transformer manufacturer (SIC 3677). Time constraints prevented an exploration of partnerships with these two companies.

Possible Partnership: Drums

Material description
Fifty-five-gallon metal drums are used for transporting a variety of materials.

Producers of this byproduct
Six companies reported metal drums as a byproduct. The number of drums discarded annually by these six companies totaled 31,399.

Company	Amount Available Annually
Street Sweeper Manufacturer (SIC 3499)	300
Measuring Tape Manufacturer (SIC 3423)	500
Metal Fabrication Company (SIC 3444)	55
Medical Diagnostic Company (SIC 2835)	144
Chemical Distributor (SIC 2842)	30,000
Flour and Corn Products (SIC 2051)	400
Total Amount Available	31,339

Users of this byproduct
Drums are in demand by many users, often as trash barrels.

Evaluation of partnership potential
The value of a new metal drum is about $60.00. With a means of matching local demand for used drums with the supply, much more local reuse could occur.

Possible Partnership: Electricity

Material description
Electricity refers to the generation of electrical power.

Evaluation of potential partnership
Two neighboring pharmaceutical companies (SIC 2834) expressed an interest in exploring generating electricity at their industrial park. Because their plants are located at some distance from the generating source, these pharmaceutical plants currently experience power interruptions from any interruption along the lengthy line in between. A local source of power would probably be more stable. This is a topic that is being explored slowly and with great caution, however, so there is no further progress to report on this.

Possible Partnership: Ethanol

Material description
Ethanol, also called ethyl alcohol, is the alcohol found in alcoholic beverages. Its chemical symbol is C2H5OH. Ethanol is also used in the preparation of detergents, flavorings, and fragrances; as a solvent; and as a gasoline additive to create oxygenated fuels required by the Clean Air Act. It can be produced by fermenting fruits, grains, or vegetables; or it can be produced by heating ethylene and water under pressure in the presence of a phosphoric acid catalyst. The U.S. Bureau of Alcohol, Tobacco, and Firearms regulates and taxes ethanol usable for beverages, so ethanol used for other purposes is denatured (made unfit for human consumption) by adding 4.7% unleaded gasoline or a similar substance.

Producers of this byproduct
Several pharmaceutical companies had ethanol as a byproduct in various amounts and concentrations. One pharmaceutical company (SIC 2836) did not mention this byproduct on the survey form or during the plant visit, but during later discussions with representatives from several nearby industries, it mentioned that it had 30,000 gallons of ethanol byproduct per week. This was a 30% ethanol concentration, with 3-5% methanol, 1-5% denatured protein, 1-5% sodium acetate and sodium carbonate salts, and the remainder water. The company was sending this byproduct to Texas.

Users of this byproduct
The Energy Division of the State of North Carolina's Department of Commerce has established a program for promoting ethanol as an automobile fuel. As part of this program, it has set up an ethanol fuel pump in Raleigh for the more than 400 state-owned vehicles that can use ethanol as a fuel. This program is interested in converting byproduct ethanol into the type of ethanol that can be used as fuel. The fuel used by the state's vehicles is E-85, which is 85% ethanol and 15% gasoline.

Evaluation of partnership potential
Discussion with representatives from the state Energy Division and the broker who supplies the current E-85 fuel used by the state confirmed they were interested in more information about the pharmaceutical plant's ethanol. By the time the pharmaceutical plant was contacted again, however, it reported that it may no longer have much ethanol byproduct. The byproduct was generated due to problems with the company's solvent recovery system tanks, which had been shut down for about a year. The company expects a new system to be operational soon that provides for more storage on site and therefore eliminates most of the need to send ethanol off site. With the new system, the company would have approximately 15,000 gallons of ethanol byproduct per year instead of 30,000 gallons per week. The new system needs FDA approval, however. In the unlikely event that this approval is not forthcoming, there might still be a possibility for a partnership. The possibility of using the 15,000 gallons per year can also be explored further.

Possible Partnership: Fiberglass

Material description
Fiberglass is glass in the form of fine threads. Like other glass products, it is made from sand. Fiberglass can be woven into cloth or used for air filters and insulation. Fiberglass reinforced plastics are used for boat hulls, automobile and aircraft parts, and many other items.

Producers of this byproduct
Several companies reported sending scrap fiberglass to the local landfill. These included an electrical control panel manufacturer (SIC 3625), a satellite dish manufacturer (SIC 3663), a swimming pool systems manufacturer (SIC 3589), and a plastic molder (SIC 3089).

Users of this byproduct
If the byproduct could be ground up and remixed, it could perhaps be used by the byproduct producers themselves or by other fiberglass users in the region.

Evaluation of partnership potential
Discussions were held with the four producers of fiberglass byproduct concerning the use of a fiberglass recycling technology. The byproduct from the satellite dish manufacturer contains stainless steel, which presented a challenge for reuse. The initial response of the other three companies was that they did not think the volumes they produced warranted use of the recycling technology. Time constraints prevented exploring this further, but it might prove fruitful to do a more thorough analysis of the economics and specifications of the recycling technology and determine whether it might be economical for a group of companies to use together.

Possible Partnership: Floppy Disks

Material description
Floppy disks are disks used in computers. They are made of plastic and metal.

Producers and users of this byproduct
There are many businesses and institutions in the project area that use and discard floppy disks.

Evaluation of partnership potential
A floppy disk recycler in California claims four million computer disks are thrown away every day by personal computer users in America. This disk recycler dismantles diskettes and recycles the individual pieces. If the diskettes were previously unused and are still wrapped in plastic, then they are checked to insure adequate memory capability and resold as recycled disks. The pieces of the disassembled diskettes are all reprocessed in-house. Scrap metal is sold and plastic is melted. This company charges $0.10/lb to accept floppy disks, which is $200 per ton. This would not be economical in the project area, where landfill fees are around $35 per ton. On the other hand, further investigation of the economics of this business is warranted before dismissing this possibility.

Possible Partnership: Food Waste

Material description
Food waste is the kitchen-area food waste from employee cafeterias.

Producers of this byproduct
During a meeting of representatives from several nearby industries, three of them noted that they had cafeteria food waste that could possibly be composted together in a central location. Discussions were subsequently held with cafeteria managers and an analysis was done of the amount of this type of food waste from these three companies. The cafeteria at one pharmaceutical plant (SIC 2836) serves 800 people per day, six days a week, and it was estimated that 116 tons of kitchen food waste could be easily composted each year. The cafeteria at another pharmaceutical plant (SIC 2834) serves 130 people per day, five days a week, and it was estimated that 21 tons of kitchen food waste could be easily composted each year. The cafeteria at the third plant, a heavy equipment manufacturer (SIC 3524), serves 550 people per day, five days a week, and it was estimated that 29 tons of kitchen food waste could be easily composted each year.

Partnership potential
At a joint meeting, the three neighboring companies discussed the possibility of composting individually, together at one of the companies, or together at a nearby site. Although there was some interest in pursuing one of these options, it was not a high priority for any one of the three companies. One of the companies planned to follow up by contacting the local cooperative extension service representative and setting up a consultation for assistance with this idea.

Analysis of food waste composting partnership

Pre-partnership scenario
Two pharmaceutical companies and a heavy equipment manufacturer currently landfill all their cafeteria food waste. The landfill is located approximately 13 miles from their plants.

Post-partnership scenario
The three companies could compost a total of 166 tons of kitchen food waste per year at the site of one of the companies. Although this may not eliminate any waste pick-ups from two of the companies, it is likely that one of the companies would be able to eliminate one waste pick-up per week. This would eliminate one 26-mile round trip to the landfill each week. A cost analysis has not yet been done comparing this scenario to landfilling as usual.

Annual Cost Savings To Seller	unknown
Annual Cost Savings To Buyer	n/a
Total Cost Savings	unknown
Annual Mileage Saved By Seller	1,352 miles
Annual Mileage Saved By Buyer	n/a
Total Annual Mileage Saved	1,352 miles
Annual Tons Carbon Reduction From Travel	2.46 tons
Annual Amount of Material Reused	166 tons
Value of Manufacturing Replaced Annually by Reuse	none
Annual Tons Carbon Reduction From Manufacturing	none
Total Annual Tons Carbon Reduction	2.46 tons

Possible Partnership: Foundry Sand

Material description
Foundry sand consists primarily of clean, uniformly sized, high quality silica sand or lake sand that is bonded to form molds for ferrous (iron or steel) and nonferrous (copper, aluminum, or brass) metal castings. These sands are clean prior to use, but after casting they may contain metal. The most common casting process used in the foundry industry is the sand-cast system. Virtually all sand-cast molds for ferrous castings are of the green sand type. Green sand consists of high quality silica sand, about 10 percent bentonite clay (as a binder), two to five percent water, and about five percent sea coal.

Producers of this byproduct
A local foundry (SIC 3322) generates approximately 700,000 to 900,000 pounds per year of post process sand. The waste sand contains metals and other scrap materials from the plant such as slag (a hard chunky compound of materials such as silicon, phosphorous, manganese, and limestone) and furnace liner (a ceramic). It produces only ferrous metals, hence the spent sand does not contain contaminants such as cadmium, lead, copper, nickel, or zinc, which are present in sand after non-ferrous production.

Users of this byproduct
There are many widely known applications for foundry sand. It can be used as a fine aggregate substitute in construction applications and as kiln feed in the manufacture of Portland cement. It is also possible to use spent sand as an input in brick manufacturing. Most foundry sand is landfilled, sometimes as a supplemental or beneficial daily cover material. As a fine aggregate it works as a substitute in asphalt paving mixes and can substitute in flowable (or controlled density) fill applications. A local brick manufacturer (SIC 3251) would consider using the sand if it were free of metals. A local street and highway construction agency (SIC 1611) is considering a proposal to use the sand as pipe bedding.

Evaluation of partnership potential
Discussions with potential partners resulted in the conclusion that neither of the identified potential users could use the foundry sand unless the metal and other scrap content in the sand were filtered out. The foundry currently does not have the means or finances to perform this task. Potential users are unwilling to absorb the cost and potential liability of sorting the metals out of the sand. Subsequent to these discussions, the foundry talked with a composting facility that said it might be interested in the sand. There was no time for further follow-up on this, however.

Possible Partnership: Furniture Fluff

Material description
Furniture fluff is a generic term for the stuffing used to fill upholstered furniture. This is no exact material, but is generally any item that is soft and could be used to stuff furniture or other items, like coffins. Most quality manufacturers use polyester fluff, which compresses under pressure but bounces back, retaining the shape of the cushion.

Producers of this byproduct
There are many potential producers of fluff, ranging from laundries with large amounts of lint to fabric makers with yarn lint and yarn scraps that ensue from the weaving process. One upholstered fabric manufacturing company (SIC 2221) produces 0.8 tons of yarn scraps and yarn lint per month. These are swept from the floor and put into dumpsters for the landfill. This amounts to 21 cubic yards of loose material per month, or 15 cubic yards if compacted. Another facility (SIC 2297) produces dozens of cubic yards a week of very clean, white fluff as a byproduct of non-woven fabric manufacturing.

Users of this byproduct
Potential users of this product range from upholstered furniture manufacturers, to stuffed animal makers, to casket manufacturers. One furniture company in particular (SIC 2599) was interested in using an alternative stuffing in its sofas to reduce production costs. It currently uses three compressed bales of polyester fiber per week. The fiber, after going through a machine to chop the bales into small tufts, is clean, white, odorless and "springy." It bounces back to its original shape after compression.

Evaluation of partnership potential
Unfortunately, after taking a sample of the fluff from the upholstered fabric company to the furniture manufacturer, it was found that the quality of the fluff was not high enough for its needs. The fluff had an oily odor to it and would need to be washed. It also failed to spring back after compression. One suggestion the plant manager had for a use of this fluff was with stuffed animal manufacturers. Another possibility for reuse is with casket manufacturers.
The other fabric fluff byproduct was of high quality, but it came to the project team's attention at the close of the project period and it was not possible to complete an investigation of the potential for reuse of this material.

Possible Partnership: Glass Vials

Material description
The glass vials that are the subject of this partnership are small glass vials of ultra pure water produced by pharmaceutical firms and used by hospitals. Many of these tiny vials are discarded as a result of strict FDA regulations.

Producers of this byproduct
Several pharmaceutical firms reported discarding these glass vials. One facility (SIC 2834) discards 70,000 pounds per year of empty glass vials. A neighboring company (SIC 2836) annually discards about 100,000 bottles, vials, and glass. A third company in the same industrial park (SIC 2834) has glass labware, but the waste amount is currently unquantified.

Users of this byproduct
Various markets for crushed glass exist in the region, depending upon the exact type of glass.

Evaluation of partnership potential
Discussion with a glass recycler revealed several possible hindrances to a glass recycling partnership between the pharmaceutical companies. Glass comes in several different types, depending on the specific recipe used to make the glass. Types 1 and 3 glass (soda-lime glass) can be fairly easily mixed together as long as they are the same color. However, type 2 (borosilicate glass) is more problematic. Type 2 can't be mixed with either types 1 or 3, but also other type 2's in most cases, due to differing material content. For recycling, the amount of boron between different types of number 2 glass must match so that it can be melted down at the same temperature (borosilicate melts at different temperatures). If the glass from these companies is jointly crushed, the types of glass must be separated and the amounts of boron in the different type 2 glass products must be close enough to the same percentage so that a glass recycler can uniformly melt the material. To determine this, either the manufacturer would need to guarantee the percentage of boron or a mass spec analysis would need to be done on each of the materials, which costs $300-$400.

It was subsequently determined that one pharmaceutical company's vials are type one boro-silicate glass with an expansion coefficient of 51. Another facility has both type one and type two glass from three different suppliers. Although the three companies had hoped to explore joint crushing of glass for recycling, they determined that this would not be economical.

The reason there is still life in the glass vial partnership is that a more thorough survey of the region's medical and pharmaceutical firms may reveal that some of these facilities have compatible glass that could be economically crushed in a joint venture.

Possible Partnership: Ink

Material description
Ink in this context is ink used in printing.

Producers of this byproduct
Five companies reported producing waste fluid ink that could potentially be reused.

Company	Waste per Year	Units
Switch Manufacturer (SIC 3643)	20	gal
Foam Rubber Insulation Manufacturer (SIC 3069)	100	gal
Newspaper Printer (SIC 2711)	100	gal
Tortilla Manufacturer (SIC 2051)	100	gal
Electro-mechanical Assembly Contractor (SIC 3575)	30	gal
Total	350	gal

Users of this byproduct
There are many potential users of ink.

Evaluation of partnership potential
The estimated value of the annual ink byproduct from the foregoing five companies is $24,500, assuming it is clean enough to reuse easily. Time constraints did not allow further research regarding this potential partnership.

Ink Available Annually	350 gal
Estimated Value of One Gallon	$70.00
Potential Total Value	$24,500
Carbon Reduction from Manufacturing	7.37 tons

Possible Partnership: Paint

Material description
Paint in this context is wet paint.

Producers of this byproduct
The following companies reported having a wet paint byproduct:

Company	Description	Waste per Year (gals)
Hydraulic Log Loader Manufacturer (SIC 3553)	Dupont IMRON	3,822
Utility Industry Valve Producer (SIC 3491)	Enamel	25
Fire Control Unit Producer (SIC 3625)	Polyurethane paint	2,426
Automotive Component Producer (SIC 3714)	Alkyds & epoxies	15,000
Pharmaceutical Manufacturer (SIC 2834)	Mixed touch-up paint	50
Swimming Pool System Manufacturer (SIC 3589)	Water based paint	100
Sheet Metal Work Facility (SIC 3444)	Assorted baking enamels	6,000
Contract Research Organization (SIC 8731)	Latex and oil based	650
Oven Manufacturer (SIC 3589)	Luminar paint (wet)	50
Total		28,123

Users of this byproduct
There is a local demand for leftover paint in the region, as illustrated by the fact that the household hazardous waste collection sites in the region collect and make available leftover paint from households, for which there is strong demand.

Evaluation of partnership potential
The estimated value of the annual paint byproduct is $421,845. This paint could be gathered in a central location and distributed to other companies using a paint exchange.

Paint Available Annually (gal)	28,123
Estimated Value of One Gallon	$15.00
Potential Total Value	$421,845
Carbon Reduction from Manufacturing	127 tons

Possible Partnership: Plastics

Material description
Plastics in this context are plastics that are recyclable through a broker in a nearby county.

Producers of this byproduct
Numerous companies produce plastics as a byproduct. Several of them are located near each other within or just outside Research Triangle Park. Six of these companies reported landfilling various plastics that could be recycled, since they were not produced in large enough amounts to make transportation to a plastics broker economical. These companies included an electronics research facility (SIC 8734) that has scrap HDPE buckets, jars, and lids; an engine assembly plant (SIC 3724) that has scrap bubble wrap, stretch wrap, shrink wrap, and polyurethane foam; a toxicology research laboratory (SIC 8733) that sends tyvek suits to the landfill; a resins and adhesives research facility (SIC 2851) that has scrap styrene; an electronic equipment manufacturer (SIC 3829) that landfills plexiglass; and a fiber optic cable manufacturer (SIC 3357) that has scrap PVC.

Users of this byproduct
Although there are no local users of these plastics in the form in which they are produced as byproducts, there is a nearby plastics broker that would be interested in these plastics. It is not economical for the broker to pick up small amounts, however.

Evaluation of partnership potential
A summary of the plastic waste produced by several nearby plants has inspired representatives from some of these plants to begin to discuss a system for joint storage of these plastics for a one-stop pick-up service by the broker. Discussions have just begun, but it appears that this idea has a great deal of promise.

Possible Partnership: Rubber Blankets

Material description
Rubber blankets in this context are printing blankets, which are cloth sheets with a rubber backing. They are used in the printing industry to transfer ink to the printing surface. The blankets are reused until they become damaged and no longer produce a clear image.

Producers of this byproduct
Six companies in the study reported a byproduct of printing blankets. They are printers of various types.

Company	Amount Available Annually
Offset Heat Printer (SIC 2752)	800
Commercial Printer (SIC 2752)	73
Commercial Printer (SIC 2752)	500
Newspaper Publishing (SIC 2711)	696
Printing Services (SIC 2759)	8
Printing Services (SIC 2721)	38
Total	2,115

Users of this byproduct
No current users of rubber printing blankets were identified; creative alternatives were explored, however.

Evaluation of partnership potential
Several possibilities for reuse were explored.

- Auto repair shops use fender covers to protect car finishes while the mechanic leans against the car to do work. One facility examined a blanket as a replacement for these fender covers, but indicated that it might damage the finish of the car, which would be an unacceptable risk.
- Monument companies use rubber stencils to etch letters into stones. In the past, these stencils were cut by hand, but now they are made professionally. Company representatives stated they would not be able to use the printing blankets.
- Stone sculptors use mats to protect the walls of their shops where they sandblast. One stone sculptor in the area took a sample printing blanket for a trial, but the success of this trial has yet to be determined.

Members of the project team are convinced there is a good reuse for these rubber printing blankets. They are easily cleaned and are a beautiful blue color, smooth, and about 40 inches square.

Possible Partnership: Steam

Material description
Steam is generally produced by boilers, and many industries use steam in their production processes.

Producers of this byproduct
In response to a survey question regarding whether the facility used steam, 42 facilities stated that they used steam. A few reported amounts and pressures at levels that merit further investigation regarding reuse potential, but time constraints limited this investigation to two producers of a steam byproduct. One was a resin producer (SIC 2891), which, at a meeting of several neighboring industries, reported that its facility had excess steam that might be usable by neighbors. The other was a university (SIC 8221) with a cogeneration facility that produces steam for heating and cooling its campus and produces electricity as a byproduct. The university also depends on an electrical utility company for electricity, since the university's generator has a 28 megawatt capacity and the university has a 60 megawatt peak demand in the winter. During the summer, the outside price of electricity is very high, so the university produces steam in order to produce the electricity as a byproduct and save money on utility bills. This process produces excess steam during the summer.

Users of this byproduct
Two of the resin company's neighbors, a plywood manufacturer (SIC 2435) and a particleboard manufacturer (SIC 2493), expressed an interest in the resin company's excess steam, primarily as a back-up source of winter heating. These plants are within about 1,500 feet of the resin plant. The university's cogeneration facility is also located approximately 1,500 feet from a commercial area with numerous businesses.
Another steam partnership was discussed by a cluster of neighboring pharmaceutical plants (SIC 2834 and 2836). All three of them are users of steam.

Evaluation of partnership potential
The resin producer invited a consultant from the state's Industrial Extension Service to tour its plant with several of its managers and discuss the use of excess steam. During the visit it was determined that upgrades to the existing process could significantly reduce the amount of excess steam, thus eliminating the likelihood that this steam could be used by neighbors.

Discussions were also held with the university's cogeneration plant managers regarding use of excess steam by neighboring businesses. The university representatives expressed the opinion that this would not be economical. They estimated that steam would be available for only 35 to 40 days during the summer, and the cost of the underground pipes for the steam would be $1,000 per foot. This would be a $1.5 million investment for the pipes alone.

Although these two partnership possibilities did not prove fruitful, there are still several other producers of steam byproduct that could be contacted regarding potential partnerships.

The three pharmaceutical plants that use steam discussed the possibility of setting up a line from the public landfill 10 miles away and sending methane to the industrial park where the pharmaceutical plants are located. A central boiler would burn methane and produce steam for all three plants. Although this would not be cost effective right now, it might very well be economical in five years. The three companies are gathering more information on steam use and continuing to discuss this with the county public works director.

Possible Partnership: Steel

Material description
Mild steel is characterized by its low carbon content (two-tenths). Scrap mild steel is a common waste material, most often coming in the form of small unusable shapes, shavings, and chips.

Producers of this byproduct
Among the local companies that produce mild steel as a byproduct are an industrial valves company (SIC 3491), an auto parts forging company (SIC 3462), and a metal fabricator (SIC 3444). Most companies with scrap steel have contracts with scrap metal dealers. These dealers buy at a low price, sort the metals, and resell the sorted materials at a slightly higher price. There is a well-established market for the exchange and recycling of this and other metals.

Users of this byproduct
A local foundry (SIC 3322) produces gray and ductile iron and uses scrap mild steel in the smelting process. It purchases most of its mild steel from scrap metal dealers. The steel must be free of contaminants such as chrome and magnesium.

Evaluation of partnership potential
The valve manufacturer expressed an interest in selling its scrap mild steel directly to the foundry instead of to the scrap dealer. This company considers its contributions to the stock build-up at the dealer's site to be a potential liability if there were any environmental problems at the site. The valve manufacturer would therefore prefer to sell directly to a foundry. The two parties have not yet had a meeting to discuss this potential partnership. One critical factor will be a delivery schedule. The time between arrival of the mild steel at the foundry and smelting the mild steel must be extremely quick in order to avoid contamination of the ground with oils. Another critical factor is quality, since the foundry requires that the mild steel be free of contaminants.

Possible Partnership: Sulfuric Acid

Material description

Sulfuric acid is a corrosive, dense, oily liquid that may be colorless to dark brown, depending on purity. It is commonly used in many industrial production processes.

Producers of this byproduct

An amino acid producer (SIC 2833) produces about 171,000 pounds of sulfuric acid as a byproduct each year. The material may be contaminated with amino acids from its process, which may be a barrier to reuse.

Users of this byproduct

Several companies reported they could use recycled sulfuric acid in treating wastewater. For example, a tool manufacturer (SIC 3999), uses 14,860 pounds of sulfuric acid each year for pH adjustment in the wastewater treatment system at its production facility.

Evaluation of partnership potential

The amino acid manufacturer and the tool manufacturer met to discuss the possibility of an acid exchange. One possible barrier to the reuse of this waste sulfuric acid was revealed during their meeting. The amino acids present in the byproduct from the amino acid factory may inhibit the chemical reactions used by the tool manufacturer to remove metal from its wastewater. The tool manufacturer representative agreed to do some jar experiments to determine whether the amino acids would be a problem. He also said that the sulfuric acid might be usable for cleaning metal clips. The amino acid manufacturer representative expressed a willingness to look into whether there are places in the production process where the sulfuric acid is not contaminated and the byproduct could be isolated and captured for reuse. The results of these inquiries were not available when this report went to press, but both parties are very interested in a partnership and it is possible that something will be worked out.

Possible Partnership: Water - Unheated

Material description
Water in this context is non-potable wastewater from wastewater treatment plants.

Producers of this byproduct
At least two local wastewater treatment plants (SIC 4952) are very interested in promoting reuse of non-potable water. This would reduce the need for investing in new treatment plants and reduce the amount of nitrogen and phosphorus discharged into the Neuse River Basin.

Users of this byproduct
Significant amounts of non-potable water can be used by industries for irrigation, for cooling, and, with additional treatment, for boilers. Discussions were held with several nearby industries located in one industrial park regarding use of non-potable water. These companies included three pharmaceutical companies (SIC 2834 and 2836) and a heavy equipment manufacturer (SIC 3524).

Evaluation of partnership potential
The local wastewater treatment facility determined that it would be cost effective to run a non-potable water line to the industrial park if the use would be 250,000 gallons per day or more. An initial survey of these four companies and six of their neighbors revealed that they used more than 500,000 gallons of water per day. Further investigation is being done on how much of this could be non-potable.

The other wastewater treatment facility is not near any large industrial water users, but it may be economical to use non-potable water for irrigating the lawns maintained in a nearby business park. A list of 14 businesses located in the area was developed, but time constraints did not allow pursuing this any further.

Possible Partnership: Wire

Material description
The wire in this context is insulated or non-insulated copper electrical wire that is still on spools. The diameter of the wire varies and the type and presence of insulation can also vary.

Producers of this byproduct
Many companies who build electrical machinery or lay wire overestimate their material needs and have leftover wire. Often, the wire used in one operation will not meet specifications for others, and the companies are left with perfectly good wire they cannot use and for which they have no storage space. Typically the wire will be left on the spools and can easily be used by other companies if they need wire of that specification. One company (SIC 3677) has different types of copper wire left over on occasion. The company has been sending it to the landfill if it is not used after a certain amount of time.

Users of this byproduct
The leftover material is typically generated only sporadically, which makes a regular partnership with wire users awkward. Scrap metal dealers might be interested in the material, but they are unable to process the material unless they strip the insulation off. This can be labor intensive and not cost effective. One local company that specializes in recovering communications equipment (SIC 3681) was interested in taking or buying this material, however.

Evaluation of partnership potential
Based on initial communications with the foregoing firms, a partnership seemed promising; however, partnership talks were put on hold because one of the firms is relocating to another facility in the area in August or September of 1999. All new transactions have been halted until this move occurs. A partnership remains possible between these two companies. Furthermore, a warehouse and byproducts taxi service could make other partnerships for the use of this material possible.

Possible Partnership: Wood

Material description
Wood in this context is mostly the small pieces of wood left over from a production process. Also included are bark and wooden spools.

Producers and users of this byproduct
Several companies reported wood waste as a byproduct, and one composting company reported using wood chips in its compost.

Facility SIC Code	Description	I-O	Amt In Per Yr	Amt Sent Off Site Per Yr
2511	sawdust/wood chips	O		480 cu. yd.
2752	wood, chipboard cores	IO	2000 lbs.	2000 lbs.
2451	wood wastes w/ metal staples	O		
2451	wood wastes w/o metal staples	O		
2434	wood scraps/ 55 gal./2 weeks	O		26 drums
2435	woodwaste (bark w/ some rock & dirt)	O		104 tons
3681	wood (cable & wire rolls)	IO		
2875	sawdust and wood chips	I	5,000 cu.yd.	

Evaluation of partnership potential
Untreated wood without metal can be used as boiler fuel or can be ground up and incorporated into mulch. A coordinated effort to capture small amounts for this purpose could be effective. Coordinated use of a wood grinder with magnets to separate metal could also prove fruitful. Time constraints prevented the project from pursuing this further.

Unlikely partnership: Chromic Acid

Material description
Chromic acid is used for chrome plating in manufacturing processes.

Producers of this byproduct
Four companies reported a significant amount of chromic acid as a byproduct.

Company	Amount Available Annually (gal)
Amino Acid Producer (SIC 2833)	22,000
Electronic Equipment Manufacturer (SIC 3679)	5,000
Tool Manufacturer (SIC 3423)	838
Generator Production Facility (SIC 3677)	500
Total Amount Available Annually	28,338

Users of this byproduct
One company, a tool manufacturer (SIC 3423), indicated a willingness to use recycled content chromic acid in its process.

Evaluation of partnership potential
The amino acid producer and the tool manufacturer met to discuss a possible transfer of acids from the amino acid producer to the tool manufacturer. This partnership was not feasible because of the amino acids present in the waste material and the strength of the acid after it had been used once. Telephone conversations occurred with all acid producers and users to evaluate the likelihood of acid waste partnerships, but none was feasible at this time.

Unlikely Partnership: Concrete Paste

Material description
The concrete industry generates a great deal of waste material that is often sent to the landfill for disposal. Concrete is a mixture of cement, sand, and aggregate. Not all the concrete mixed and sent to the job-site is always used. This unused portion is brought back to the concrete plant and must be removed from the trucks before it hardens. Most often, it is sent through a process to remove the sand and aggregate material, leaving only cement and water behind. The sand and aggregate is reused and the concrete is deposited in a wash pit where the solid material sinks to the bottom. A similar process occurs when the trucks are rinsed out at the end of each day. Over time, the wash pits fill up with cement particles and must be cleared out. The resulting material is a paste ($CaCO_2$) with a pH of approximately 12.

Producers of this byproduct
All concrete plants produce this material as a byproduct from washing their trucks. One concrete plant (SIC 3273) participated in this project.

Users of this byproduct
Because of the high pH of this material, it could be used to neutralize acid wastewater. The leftover concrete could also be made into other concrete forms such as barriers and blocks.

Evaluation of partnership potential
Wastewater treatment operators were skeptical about using this material for pH adjustment for fear it would solidify within the system and cause a blockage. The idea of using it to replace lime in lime stabilization was also explored, but this would need research in order to establish its feasibility. The high calcium level in this material would make it a useful soil amendment, but no composting operations in the area are interested at this time. The best option seems to be for concrete plants to reuse this material to make blocks or barricades which could be sold as a sideline business. Metal forms are available for molding the concrete, and information about this possibility is being supplied to the concrete plant participating in the project.

Unlikely Partnership: Fabric

Material description
Fabric in this context is mostly the small pieces of fabric scrap left over after fabric is cut into pieces. This process sometimes leads to lint or yarn byproducts as well.

Producers of this byproduct

Facility SIC	Description	Amt Sent Off Site/Yr	Ideas
2599	fabric (short ends of fabric)	all	could be used for quilt-making
3949	cloth scraps (cotton & polyester mixed)	52 cu. yds	
2391	fabric scraps		company in NJ buys all their scraps.
2329	fabric scraps (mixed types, colors, sizes)	216 tons	
2521	multiple fabrics (includes leather, vinyl, etc.)		
2392	fabrics (mixed linen, vinyl, etc.)	46000 yds.	
2297	rag scraps	confidential	does not want anyone to use its rag scraps as rags; would compete with marketed product

Evaluation of partnership potential
Discussions were held with a number of people knowledgeable about textile scrap reuse, but no partnership seemed realistic at this time. The above facilities do not produce enough of any one type of fabric, even between them, to make reuse economical. One future possibility for use of these scraps, however, is to use them as absorbent material by stuffing them into fabric sleeves or socks.

Unlikely partnership: Hydrogen Peroxide

Material description
Hydrogen peroxide is an oxidizing agent often used for wastewater treatment.

Producers of this byproduct
A semiconductor manufacturer (SIC 3674) produces a hydrogen peroxide byproduct. The hydrogen peroxide available from this facility is mixed with acids and other wastes, making it unusable for other companies. When hydrogen peroxide is used as a component in wastewater treatment processes, it is consumed during the process.

Users of this byproduct
The following were potential users of recycled content hydrogen peroxide:

Companies Willing to Use Recycled Content Sodium Hydroxide	Amount Used Annually (gal)
Wastewater Treatment Facility (SIC 4952)	55
Tool Manufacturer (SIC 3423)	50
Pharmaceutical Manufacturer (SIC 2834)	?
Medical Tubing Manufacturer (SIC 3083)	300
Total	405

If a relatively clean source of hydrogen peroxide could be identified, 405 gallons could be re-used by project participants annually. This partnership would result in an annual cost savings of $6,764 and an emission reduction of 2 pounds of carbon per year due to replacing new with used hydrogen peroxide.

Annual Use	405 gallons
Estimated Cost per Gallon	$16.70
Potential Cost Savings	$6,764
Carbon Reduction from Manufacturing	2 tons

Unlikely Partnership: Kaolin Clay

Material description
Kaolin clay is a fine-grain white clay. It is obtained from open pit mines with high concentrations of highly weathered Precambrian rocks. Kaolin clay is principally used in the production of Portland cement. However, it has many additional uses. It is the primary coating ingredient in glossy paper, and it is also used in the composition of porcelain and facial cleansing creams. When glossy paper is burned, the ash retains a high kaolin clay content and can be used as an input in brick manufacturing.

Producers of this byproduct
Producers of glossy paper byproduct could be sources of kaolin clay. One local printing company (SIC 2752) produces a large volume of shredded glossy paper annually. Approximately 40 percent of the 75,000 pounds of shredded paper leaving the facility each year are glossy. The company currently sends waste paper to a paper towel company in another state. It has the capability to separate glossy from plain paper, but it has elected not to do so and to ship the paper mixed.

Users of this byproduct
A local brick manufacturer (SIC 3251) has experimented with kaolin clay as an input. In general, the ash can work well as a filler ingredient in the manufacturing of bricks.

Evaluation of partnership potential
The brick manufacturer discontinued its use of kaolin clay due to the staple content in the ash. It does not have metal sorting technology on site, and it cannot tolerate any metal content in its inputs. It was also noted that it is easier to extract metallic materials from the glossy paper when the dry paper is converted into the wet pulp form. The brick manufacturer also stated that it would accept the kaolin clay only in ash form. Moreover, this brick manufacturer stated that it already has a sufficiently large supply of inputs and does not really need this ash.

Unlikely Partnership: Nitric Acid

Material description
Nitric acid is used within manufacturing processes and to alter the pH of wastewater.

Producers of this byproduct
Five companies reported a significant amount of nitric acid byproduct.

Company	Amount Available Annually (gal)
Animo Acid Producer (SIC 2833)	22,000
Gem Manufacturer (SIC 3674)	5,000
Electronic R&D (SIC 8734)	500
Electronic Equipment Manufacturer (SIC 3679)	5,000
Tool Manufacturer (SIC 3423)	53,400
Total Amount Available Annually	85,900

Users of this byproduct
Several companies indicated a willingness to use recycled content nitric acid, but none of the available amounts were acceptable for reuse because of contaminants present and the strength of the acid after it has been used.

Evaluation of partnership potential
An amino acid producer and a tool manufacturer met to discuss a possible transfer of acids from the amino acid producer to the tool manufacturer. This partnership was not feasible because of the amino acids present in the waste material and the strength of the acid after it had been used once. Telephone conversations occurred with all acid producers and users to evaluate the likelihood of acid waste partnerships, but none was feasible at this time.

Unlikely Partnership: Phosphoric Acid

Material description

Phosphoric acid is a colorless, odorless liquid or a sparkling, transparent, crystalline solid, depending on the temperature and concentration. It is used in pharmaceutical production processes and pH adjustment within wastewater treatment systems, among other things.

Producers of this byproduct

Four companies reported a phosphoric acid byproduct. An amino acid producer (SIC 2883) produced 33,000 gallons per year; a fire control unit producer (SIC 3625) produced 4,000 gallons per year; a metal fabrication company (SIC 3444) produced 400 gallons per year; and a gem manufacturer (SIC 3674) produced an unspecified amount.

Users of this byproduct

Many companies use phosphoric acid to regulate the pH of their wastewater. Several companies reported a willingness to use recycled content phosphoric acid, but they also stated that it must have a high quality in order to meet wastewater permit requirements. For example, a satellite dish manufacturer (SIC 3663) uses phosphoric acid for wastewater treatment. It currently uses less than 100 pounds of phosphoric acid each year. It is willing to use recycled content as long as it does not cause a conflict with its wastewater treatment permits.

Evaluation of partnership potential

None of the available phosphoric acid was acceptable for reuse by the companies willing to use recycled phosphoric acid.

Unlikely Partnership: Plastic IC Tubes

Material description
IC tubes are plastic tubes, square rather than circular in cross-section, designed to hold small electronic components. They are approximately ½ inch in diameter and 12 inches long. The product is left hollow or empty after the stacked up electrical components are taken out of the tube.

Producers of this byproduct
Many companies use IC tubes in the manufacture of telephones, cellular phones, and other related machinery. Several facilities reported producing a large but unspecified amount of IC tubes as a byproduct.

Users of this byproduct
A plastics recycling company located in a county bordering the project area has accepted IC tubes for recycling in the past, but it has stopped dealing in this type of plastic waste. IC tubes have a rubber plug on one end, have paper or plastic labels, and can be made of different kinds of plastic that are indistinguishable by eye. These characteristics make IC tubes costly to handle relative to the value of the plastic. A partnership with a sheltered workshop in the region was explored as a cost-effective means of removing plugs and labels.

Evaluation of partnership potential
The services of the sheltered workshop were not cost-effective enough to make the plastics recycling company interested in accepting the IC tubes.

Unlikely Partnership: Plastic Sheeting

Material description
Plastic sheeting in this context is the plastic material used in the covering or roof of greenhouses. The film can range in exact specifications, but over 80% of the greenhouses in North Carolina use a specific type. This film is a double layer of EVA-based plastic that is a total of 4mm thick, with an air pocket between the two layers. It is specifically designed to distribute light evenly and block UV light transmission, and it is made to last three years.

Producers of this byproduct
There are many potential producers of greenhouse film, including all greenhouses not using permanent structures with glass. One greenhouse (SIC 0182) produces 2 tons, or 2 acres, of continuous scrap greenhouse film every year, which is currently disposed of in a landfill. This facility chooses not to use the same film over multiple growing seasons due to damage incurred from the sun.

Users of this byproduct
Potential users of this product range from house painters to plastic recyclers; however, knowledge of the product's exact specifications would be necessary. There may be pesticides and other additives in the material that make it hard to recycle.

Evaluation of partnership potential
Construction workers and painters can obtain cheaper dropcloths that are in sizes easier to handle and which do not require cutting. Plastic recyclers expressed concern about contamination from the use of pesticides. Within the time period of this project, it was not possible to obtain detailed information to allay these concerns or to identify other partnership opportunities.

Unlikely Partnership: Soap

Material description
Soap in this context is the bar soap furnished by hotels and discarded after a few uses.

Producers of this byproduct
The larger hotels often have more guest rooms and provide larger bars of soap, which makes them better targets for a reuse program involving soap.

Users of this byproduct
A manufacturer of specialty cleaning chemicals (SIC 2819) reported that it would be possible to use hotel and motel soap to make some kinds of cleaning agents.

Evaluation of partnership potential
A small company in California collects soap from hotels for reuse, but it is a break-even business that was done to promote the company's plumbing business. This company works with 100 of the larger hotels in its area. The company employs one man and supplies him with a car to pick up the soap from each of these establishments once a month. Each hotel is supplied with a container for collection, and generally 50-150 pounds of soap is picked up each month from each establishment. Some of the soap is still partially wrapped, and it is the responsibility of the driver/collector to unwrap the bars before taking them to the processor. The soap processing lab pays $0.15/pound for the soap bars and reformulates them into industrial detergents and cleaning compounds. Ten-dollar gifts are occasionally given to the maids when they have done a good job gathering soap, but no other payment for the soap is made. In the project area, one local hotel's housekeeping supervisor responded to this idea by pointing out that the housekeeping staff is already very busy and added, "What's in this for us?" Establishing a partnership for soap is not impossible, but the amount of work involved to set it up and the amount of driving around to pick up soap may not be worth the amount of resources saved and the one job created.

Unlikely Partnership: Solvents

Material description
The category of solvents includes the halogentated and non-halogenated solvents used for various purposes in research or manufacturing, such as dirt and grease removal or use as a main component in solution formation. Some examples of the materials in this category are ethanol, xylene, and isopropyl alcohol.

Producers of this byproduct
Many types of facilities produce waste solvents.

Users of this byproduct
Potential users of waste solvents are facilities that either do not need ultrapure solvents or are able to use distilled product. Distillation can be an economical means of purifying solvents where there is enough quantity of one type

Evaluation of partnership potential
Likely partnerships for the solvents methanol and acetone have been created through this project. The likelihood of partnerships regarding other solvents seems low, however. Several solvents used by numerous facilities were examined thoroughly in the effort to create partnerships. These materials included isopropyl alcohol, ethanol, xylene, and methyl ethyl ketone. Partnership opportunities for these substances were hindered by lack of sufficient quantities of output and/or solutions of several solvent types, rather than merely one type.

Unlikely Partnership: Tobacco Dirt

Material description
Tobacco dirt is the byproduct from the tobacco stemming process. It is primarily tobacco leaf stems and leaf pieces. It is lightweight organic matter.

Producers of this byproduct
Tobacco stemming operations (SIC 2141) produce this material from the stemming process.

Users of this byproduct
This material can be used as a soil amendment. An egg production facility (SIC 0252) also expressed an interest in obtaining this material to use as a bulking agent in its poultry waste composting program.

Evaluation of partnership potential
The tobacco stemming company already pays a local farmer $15 per ton to haul away its tobacco dirt. The farmer land applies the material to his fields. A cost analysis was completed for the potential partnership with the egg production facility, but, in the meantime, the tobacco stemming company signed a three-year contract with another facility to land apply the material.

Unlikely Partnership: Water - Heated

Material description
Water in this context is heated wastewater from a coal-fired electrical power plant.

Producers of this byproduct
A coal-fired electrical power plant (SIC 4911) produces heated wastewater as a byproduct.

Users of this byproduct
Greenhouses (SIC 0182) and fish farms (SIC 0273) are two industries that could use heated wastewater.

Evaluation of partnership potential
Discussions were held with the power plant regarding potential reuse of its heated wastewater. Power plant personnel were familiar with a power plant in South Carolina that had used wastewater for heating greenhouses, and follow-up research was done on this South Carolina project. This research determined that problems developed when the wastewater temperature fell below its usual 85 degrees. The wastewater from the power plant in the project region is 90 degrees for four to six months a year but sometimes drops to as low as 70 degrees. This could be a problem, but the main problem was lack of space nearby for greenhouses. Fish farming was also investigated as an option. Discussions were held with the thermal aquaculture experts at North Carolina State University. The water in the fish tanks needs to be in the 75 to 85 degree range, but it was determined that groundwater, not surface water, is necessary for these tanks. It is very unlikely that the power plant's wastewater could be used for either greenhouses or fish farming. On the other hand, if a neighboring landowner were interested in this and had enough space, it might be worth further discussion concerning technology for capturing heat from the power plant's wastewater.

Table 7
Facilities for Which Possible Partnerships Were Found, Listed by Number of Possible Partnerships

(* = probable partnership)

Pharmaceutical Manufacturer (SIC 2836)
- Absorbents
- Ethanol
- Food waste
- Glass vials
- Steam
- Water - unheated

Insulin Manufacturer (SIC 2834)
- Electricity
- Food waste
- Glass vials
- Steam
- Water - unheated

Amino Acid Producer (SIC 2833)
- Carbon*
- Desiccant*
- Plastic bags*
- Sulfuric acid

Pharmaceutical Manufacturer (SIC 2834)
- Electricity
- Glass vials
- Steam
- Water - unheated

Wood Product Manufacturer (SIC 2493)
- Sodium hydroxide*
- Steam
- Wood ash*
- Wood fluff*

Plywood Manufacturer (SIC 2435)
- Steam
- Wood
- Wood ash*
- Wood fluff*

Measuring Tape Manufacturer (SIC 3423)
- Absorbents
- Desiccant*
- Drums
- Sulfuric acid

R & D Facility for Electronics Industry (SIC 8734)
- Absorbents
- Plastic
- Sulfuric acid

Adhesive Resin Manufacturer (SIC 2891)
- Methanol*
- Sodium hydroxide*
- Steam

Newspaper (SIC 2741)
- Absorbents
- Ink
- Rubber blankets

Offset Printer (SIC 2752)
- Absorbents
- Rubber blankets
- Wood

Wastewater Treatment Plant (SIC 4952)
- Carbon*
- Methanol*
- Wood chips*

Flour and Corn Products Producer (SIC 2051)
- Absorbents
- Drums
- Ink

Flooring Manufacturer (SIC 2493)
- Absorbents
- Wood

Electronic Component Collection Center (SIC 3681)
- Wire
- Wood

Industrial Oven Manufacturer (SIC 3589)
- Blasting media
- Paint

Hydraulic Log Loader Manufacturer (SIC 3553)
- Absorbents
- Paint

Automotive Component Manufacturer (SIC 3714)
- Absorbents
- Paint

Pharmaceutical Manufacturer (SIC 2834)
- Hydrochloric acid*
- Paint

Electric Transformer Manufacturer (SIC 3677)
- Copper
- Wire

Electrical Control Panel Manufacturer (SIC 3625)
- Copper
- Fiberglass

Metal Forger (SIC 3462)
- Absorbents
- Steel

Swimming Pool System Manufacturer (SIC 3589)
- Fiberglass
- Paint

Compost Producer (SIC 2875)
- Wood
- Wood fluff*

Tractor Manufacturer (SIC 3524)
- Food waste
- Water - unheated

Lab Animal Breeder (SIC 0279)
- Absorbents
- Wood chips*

Machine Part Manufacturer (SIC 3599)
- Absorbents
- Packaging*

Brick Manufacturer (SIC 3251)
- Coal ash
- Foundry sand

Valve Manufacturer (SIC 3491)
- Paint
- Steel

Hazardous Waste Management Provider (SIC 9511)
- Blasting media
- Sawdust*

Upholstered Furniture Manufacturer (SIC 2599)
- Furniture fluff
- Packaging*

Toxicological Research Center (SIC 8733)
- Absorbents
- Plastic

Semiconductor Manufacturer (SIC 3674)
- Acetone*
- Sulfuric acid

Copper Powder Manufacturer (SIC 3399)
- Absorbents
- Copper

University (SIC 8221)
- Rubber blankets
- Steam

Plastic Manufacturer (SIC 3089)
Acetone*

Electrical Switch Manufacturer (SIC 3643)
Ink

Foam Rubber Insulation Manufacturer (SIC 3069)
Ink

Street Sweeper Manufacturer (SIC 3499)
Drums

Cookie and Cracker Manufacturer (SIC 2052)
Absorbents

Electronic Capacitor Manufacturer (SIC 3675)
Absorbents

Industrial Gas Producer (SIC 8731)
Blasting media

Wood Furniture Manufacturer (SIC 2521)
Wood ash*

Soap and Detergent Manufacturer (SIC 2841)
Hydrochloric acid*

Satellite Dish Manufacturer (SIC 3663)
Fiberglass

Water Reclamation Facility (SIC 4941)
Absorbents

Fabricated Plate Manufacturer (SIC 3443)
Steel

Measuring Device Manufacturer (SIC 3829)
Absorbents

Electric Utility (SIC 4911)
Coal ash

Computer Assembler (SIC 3577)
Packaging*

University (SIC 8221)
Coal ash

Medical Center (SIC 8062)
Absorbents

Electrical Control Manufacturer (SIC 3491)
Absorbents

Industrial Relay and Control Manufacturer (SIC 3625)
Paint

Cabinet Maker (SIC 2434)
Sawdust*

Non-woven Fabric Manufacturer (SIC 2824)
Absorbents

Jet Engine Assembler (SIC 3724)
Plastic

Iron Foundry (SIC 3322)
Foundry sand

Crushed Stone Manufacturer (SIC 1429)
Conveyor belts

Sign Manufacturer (SIC 3993)
Absorbents

Electronic Component Manufacturer (SIC 3679)
Sulfuric acid

Commercial Printer (SIC 2752)
Rubber blankets

Tobacco Stemmer and Warehouse (SIC 2141)
Absorbents

Commercial Printer (SIC 2752)
Rubber blankets

Pharmaceutical Manufacturer (SIC 2834)
Sulfuric acid

Upholstered Fabric Manufacturer (SIC 2221)
Furniture fluff

Gauge Manufacturer (SIC 3829)
Absorbents

Plumbing Products Manufacturer (SIC 3432)
Copper

Sheet Metal Fabricator (SIC 3444)
Drums

PVC Tubing Manufacturer (SIC 3083)
Absorbents

Medical Equipment Manufacturer (SIC 2835)
Drums

Wastewater Treatment Plant (SIC 4952)
Absorbents

Mobile Home Manufacturer (SIC 2451)
Wood

Plastic Molder (SIC 3089)
Fiberglass

Non-woven Fabric Manufacturer (SIC 2297)
Furniture fluff

Sheet Metal Fabricator (SIC 3444)
Paint

Wood Furniture Manufacturer (SIC 2511)
Wood

Resin and Paint Manufacturer (SIC 2851)
Plastic

Contract Research Facility (SIC 8731)
Paint

Shipping Service Provider (SIC 7331)
Packaging*

Chemical Distributor (SIC 2842)
Drums

Fiberoptic Cable Manufacturer (SIC 3357)
Plastic

Cabinet Manufacturer (SIC 2434)
Wood

Test Equipment Manufacturer (SIC 3829)
Plastic

Commercial Printer (SIC 2759)
Rubber blankets

Computer Terminal Manufacturer (SIC 3573)
Ink

Pottery Importer/Distributor (SIC 5023)
Packaging*

Public School (SIC 8211)
Plastic bags*

Section Four: Lessons and Conclusions

Industries are interested in sharing information

A high level of local industry interest in the project was demonstrated by the fact that 75% of the 343 facilities invited to participate expressed an interest in participating. Fifty-three percent of these 343 facilities followed through by completing a survey booklet and a subsequent interview. Most instances of failure to follow through on the part of facilities that expressed an initial interest were due to schedules too busy to allow participation during the time frame of the project.

Issues regarding liability and confidentiality did not appear to be concerns significant enough to preclude participating in the project. No facility invited to participate declined due to concerns regarding either issue. The project team and the survey booklet emphasized that facilities were being invited to share only the information they felt comfortable sharing. This approach seemed to be effective in achieving a high level of participation. Only one participant expressed a desire to keep responses confidential, and this participant subsequently changed its position once it learned that it was the only one of 182 facilities to request confidentiality. With regard to liability, one company representative stated that eliminating the middleman and transferring his company's byproduct directly to another user would probably reduce his overall liability.

Sharing information proved valuable

Of the 182 facilities that shared information, 48% discovered probable or possible partners for cost-effective sharing of materials, water, or energy. This percentage would have been higher had the project time period not been so limited.   The potential partnerships identified by the project involve 36 different types of materials, water, or energy.

Reasonably accurate forecasts of potential annual cost savings were produced for eight new partnerships that have been implemented already or could be implemented in the very near future. The cost savings for all the involved facilities combined is estimated at $221,516 per year.

The estimated reduction in carbon emissions corresponding to all of the foregoing eight partnerships combined is 56.14 tons per year.

Local chamber of commerce and economic development commission representatives also expressed enthusiasm for the value of the information gathered by the project. Responses to presentations to these groups regarding project results included the following:

- "This is a tremendous asset."

- "This is very impressive."

- "This data is very useful."

The value of the information is primarily for existing local businesses, but the information was also helpful in local development of new businesses. In one instance, a company considering establishing a new plant in the region told a project team member that its company would have a particular byproduct, and the project team was able to provide half a dozen ideas for local users of that byproduct due to the information in the database. Moreover, discussions with project participants revealed possible new local enterprises for using several byproducts: absorbent material, wood, plastics, and coal ash. Further work with clusters of industries using similar materials may uncover additional opportunities for creating new complementary enterprises.

Creative thinking about byproducts can be increased

The list of 46 readily reusable items in the survey booklet seemed effective in convincing facilities that they might have or use items that are reusable. This list was therefore useful in increasing the level of creativity regarding byproducts reuse.

Another means of increasing creative thinking about byproducts was to foster interaction with people from outside individual facilities. When the interviewers sat down to review the survey booklet with facility representatives, the discussion usually resulted in the identification of promising items to add to survey responses. When the interviewer was able to take a tour of the plant, yet more reusables were usually identified. The creative process was further boosted by discussions between two or more potential partners. Following are two examples of excited brainstorming resulting from such meetings:

- Two representatives from a tool manufacturing company visited an amino acids manufacturing plant to discuss a potential acids partnership. After they determined that an acids exchange might be feasible, the tool manufacturing company representatives asked, "What else do you have that we might be able to use?" This query resulted in a walk to where waste fiberboard drums were stored. These drums were lined with plastic bags, and they were originally packed with pouches of desiccant inside to keep the contents dry. The tool manufacturing representative thought his company might be able to use some of the drums, and the two men started enthusiastically brainstorming about who else might be able to use the plastic bags and desiccant pouches. The tool manufacturer suggested the Adopt-A-Highway program for the plastic bags and marinas for the desiccant.

- At a sawdust partnership meeting, a cabinetmaker and a hazardous waste management company representative determined that the latter's company could use the cabinetmaker's sawdust to pack hazardous waste bound for an incinerator. The two men went on to discuss how the sawdust might be used as a spill absorbent as well. This led to animated brainstorming about ways to make socks filled with sawdust for this purpose.

The role of images in heightening creativity also deserves mention. When shown the diagram of the industrial ecosystem in Kalundborg, Denmark, facility representatives often appeared more reflective and sometimes thought of new ideas for partnerships. The same was true of the diagram of existing local partnerships. One might argue that these images engaged the right side of the brain, which views things more holistically, thus provoking new ideas for local connections.

The image of a long list of locally available and needed materials was also helpful in engaging people in a search for reuse opportunities. While the viewer's left brain was linearly scanning down the list, looking for particularly useful items, his or her right brain was probably saying, "Wow! My community is full of opportunities for connections!"

The GIS maps were another way to use pictures to provoke new images of future connections. The GIS maps allowed viewers to see the big picture of company locations that might be connected through partnerships. People who can visualize a web are arguably more likely to try to create a web.

GIS maps are useful in locating partners

The GIS maps were not merely a means of adding visual interest to the information in the database, although their use was justified by that value alone. They were also used to query the database for facilities with particular inputs or byproducts and to then locate all such facilities within a particular radius of another facility. They were also used to calculate distances between facilities in order to calculate potential cost savings.

Wastewater treatment facilities make great collaborators

When the project team began to search for public information about industries in the region, it discovered that the most valuable source of public information is the wastewater discharge permit applications for significant industrial users of water. These permits, required by federal regulation, are typically filed with the local wastewater treatment facility. Collaborating with these facilities can make access to this information easier to obtain.

Wastewater treatment plants are also users and producers of numerous items that could be the subject of partnerships. The following items were listed as either inputs or byproducts in the survey responses from wastewater treatment plants participating in the project:

- biosolids/sludge
- lubricant
- sodium hydroxide
- alum
- phosphoric acid
- acetic acid
- polymer
- methanol
- sulfur dioxide
- activated carbon
- calcium oxide/lime
- chlorine
- calcium nitrate
- UV lightbulbs
- potassium permanganate
- ferrous sulfate
- hydrofluorosilic acid
- citric acid
- ammonia
- sodium bicarbonate
- absorbents

During the limited period of the project, possible partnerships were identified for several of these items: methanol, absorbents, activated carbon, and biosolids.

Wastewater treatment plants also make great collaborators because they are located in every community and, as public entities, they are likely to have an interest in promoting a more sustainable community.

Businesses can underestimate their partnership potential

For 22 companies that declined to participate in the project because they did not think they had relevant inputs or byproducts, probable or possible partnerships were found for other companies with the same four-digit SIC code. Company representatives therefore sometimes underestimate the partnership potential of their companies.

Starting with the big picture might not be effective

This project did not begin with a high-profile kickoff featuring speakers about industrial ecology and sustainability and related topics. Early in the project, however, industry representatives who had expressed an interest in the project were invited to a breakfast with Ray Anderson, Chairman of Interface, Inc., and noted proponent of creating sustainable businesses. There was no interest in attending this breakfast. This experience suggests that plant representatives find it more fruitful and inspiring to spend time working with representatives of other industries on specific partnerships; these people are too busy to come to a big picture, global view presentation to introduce them to a project. Tying in the local success stories with the big picture later on would probably be a more effective use of time for people engaged in this work.

Revisions would improve the survey instrument

The project's survey form, which appears in Appendix A, could be improved with a few modifications:

- Add a few categories to the readily reusables table. Glass, ammonia, and fabric were reported by many survey respondents, and these categories did not appear on the table.

- Eliminate the questions about how much electricity and water are used by survey respondents. Responses to these questions did not prove useful in identifying potential partners, and tracking down these responses involved unnecessary time on the part of respondents.

- Add a question about the use of compressed air. Nearby industries might want to share a source of compressed air.

- Emphasize more prominently that the materials listed in the readily reusables table are only examples and that respondents may use or discard numerous reusables not on the table. Also emphasize, however, that the survey is not interested in paper, cardboard, beverage containers, or similar items that are part of traditional recycling programs.

Local infrastructures can be created

Local infrastructures can be created to support and promote industrial ecosystem development. The experience of this project is that a local infrastructure would have at least five elements: a local website, warehouse space, a byproducts transportation service, a facilitator, and funding.

A local website could be a forum for identifying potential byproducts partnerships. Ideally, such a website would act as more than a waste exchange. Waste exchanges rely on listings submitted by those who want or have particular items. An industrial ecosystem website would go beyond this service by providing users with examples of possible producers of and customers for particular byproducts. For example, if a company has methanol as a byproduct, it could use the website to find out that possible customers include certain types of plants. The website would also have a GIS map showing the location of all the plants of these types within the local area. (CD-ROMs with location and contact information for businesses listed by SIC code are readily available and could be used as a starting point for developing this type of local information.) The GIS map could be used to calculate distances between plants. A worksheet could be added to allow the user to translate mileage and landfill tip fee avoidance into cost savings.

Only one of the 182 survey respondents in this project mentioned using a waste exchange. (Although the survey booklet did not ask about this, one of the follow-up questions asked in interviews was whether the plant was involved in any local transfers of excess materials, water, or energy.) This was surprising, since the Southeast Waste Exchange is a successful waste exchange that has been in operation form Charlotte, North Carolina, for many years. Perhaps the reason for this failure to use an existing waste exchange is that the listings in the waste exchange cover such a large geographic area. It is difficult to get a thorough picture of what materials are available and wanted within any particular locality when the geographic area is large. For example, a recent issue of the Southeast Waste Exchange’s catalogue listed 166 items available from or wanted by firms located in North Carolina. (There were many other items listed by firms outside North Carolina.) Among these items, there were no 55-gallon drums listed as available within North Carolina; however, several of the 182 facilities involved in this project have these drums available for reuse, and many more local companies also have them.

An industrial ecosystem website would complement existing waste exchanges by focusing on depth within one locality rather than breadth. It would aim to create an image of a local area rich with opportunities for partnerships involving water and energy as well as materials. For those interested in a wider focus, links could be provided to waste exchange websites and other useful sites.

Another way an industrial ecosystem website would be useful is that it would include an idea forum so that any visitors to the site could add ideas regarding the reuse of any listed items.

The second and third elements of a local infrastructure are warehouse space and a transportation service. This project discovered several instances where facilities with reusable materials sent these materials to landfills because they did not have on-site storage space for them until users could be found. A warehouse and taxi service could solve this problem. Liability concerns would have to be addressed, and hazardous materials would probably not be handled this way. On the other hand, a representative from one of the industries involved in this project said that his plant sometimes has leftover but new and unopened material that must be disposed of as hazardous waste if another user cannot be found; he expressed interest in a local reuse operation that would provide a small vehicle for hazardous waste transportation to another user. There are several models for a general warehouse and reuse operation. For example, Habitat For Humanity operates construction material resale stores in several locations in the United States.

The most important element of an industrial ecosystem development infrastructure is a facilitator. A facilitator is proactive, making connections and bringing people together. Most of the potential partners involved in this project would not have made connections had it not been for the project acting as a facilitator. The main reason is that the partners would not have been aware of each other had it not been for the facilitator. In addition, some of the potential partnerships were not so financially compelling as to motivate facilities to pursue them without the facilitator providing encouragement. Even where potential partnerships were very lucrative, the role of the facilitator was important. In one such instance, the facilitator was persistent in making sure one partner didn't miss an opportunity by failing to respond to another facility in a timely manner.

A facilitator's role in convening ongoing meetings of groups of nearby or like industries is critical. Face-to-face discussion between potential partners is the single most important key to promoting byproduct reuse. It is well-known that the industrial ecosystem in Kalundborg, Denmark, arose from informal meetings between the key parties. One of the Danes involved in the Kalundborg network has stated, "You need to know what is going on in your neighbor's business to be able to take advantage of any opportunities. In this small town people know each other and we are always talking." (*The Financial Times* (London), November 14, 1990, Section I, p. 15.) Unless we live in small towns, we need a facilitator to make these meetings happen.

With few resources, the easiest way for a facilitator to begin this work would be with a few clusters of industries. The facilitator could invite plant managers, operations managers, and/or environmental safety and health managers from six or eight industries within a quarter mile of each other to a meeting at one of the plants to discuss the idea of saving money by finding partnerships. With additional time and resources, additional cluster groups could be convened. Due to time constraints, this project did not convene groups based on product rather than geography, but this will be a next step. In this project's region, one such promising group identified by survey results is producers of industrial gases; another such group is laboratories.

Finally, an industrial ecosystem development infrastructure needs funding. Several institutions within local communities are likely to be interested enough in this work to contribute financially to sustaining it. One such institution is local government solid waste management departments. Given that two-thirds of landfilled waste originates from industrial, institutional, and commercial facilities, local governments have a stake in promoting reuse rather than disposal. Ten years ago, very few local governments had recycling coordinators; now most local governments have them. Perhaps ten years from now most local governments will have industrial ecosystem facilitators.

Another group likely to invest in this infrastructure is the businesses that could directly benefit from it. In one of the group meetings of representatives from a cluster of neighboring industries, all the representatives present stated that their firms would probably be willing to pay to continue having access to the assistance and information provided by the project. Economic development and chamber of commerce organizations might also be willing to assist with funding.

Local utility companies might also be interested in providing financial assistance in order to establish local industrial ecosystem development infrastructures. With electricity deregulation, utility companies are focusing more heavily on preserving their existing customer bases by expanding customer services in numerous ways. Promoting cost-effective partnerships that could also increase local employment might be attractive to these companies.

Trade associations might be another source of support. At one of the chamber of commerce presentations regarding this project, one of the chamber members suggested exploring a partnership with the American Production and Inventory Control Society.

Each local area will also have its own likely sources of funding in addition to the foregoing. These sources might include, for example, local and state water resources departments, local and state programs related to energy conservation and pollution prevention, and local foundations.

A final word should be said about national-level assistance in creating and sustaining an industrial ecosystem development infrastructure. Financial and technical assistance would be of obvious help. It would also be very useful to establish a website with a nation-wide collection of summaries of successful reuse partnerships and reuse ideas. These could be in a database format that could be searched quickly, and the results could be linked to more detailed narratives with background and links to further sites regarding the material involved. Once local industrial ecosystem development websites are established, they could be linked to this national information.

Next steps for this project

During its first two years, this project has been funded primarily by the U.S. Environmental Protection Agency. Now that this source of funding has ended, the project is seeking new sources of financial support in order to continue the work begun in the first phase of the project. In its next phase, the project hopes to establish an interactive website that could be used by those outside the region as well as by local facilities, produce a business plan for establishing a byproducts warehouse and taxi service, and continue the role of facilitating connections between potential partners already identified and between new partners yet to be discovered.