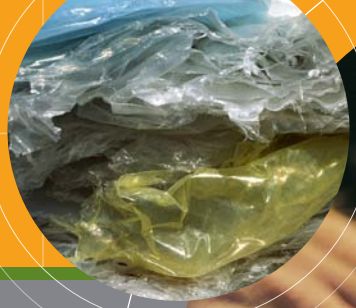

PREPARED FOR:
Capital Area Council of Governments

Market Analysis of Recoverable Materials

FINAL REPORT | SEPTEMBER 2007

R·W·BECK

Mind Powered: Insight with Impact.

This study was funded through a solid waste management grant provided by the Texas Commission on Environmental Quality through the Capital Area Council of Governments. This funding does not necessarily indicate endorsement of the study's findings and recommendations.

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Market Analysis of Recoverable Materials

Capital Area Council of Governments

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Project Purpose

The purpose of this project is to provide general strategy recommendations to aide the Capital Area Council of Governments (CAPCOG) and its member jurisdictions in fostering the development of markets for potentially recyclable materials in order to increase diversion from area landfills. Rather than focus this analysis on materials that are currently being recovered and diverted from area landfills, the Solid Waste Advisory Committee (SWAC) of CAPCOG chose 10 materials that do not have developed markets in the Capital Area region. These 10 materials are listed as follows:

- Fluorescent lighting
- Food waste
- Plastic film
- Glass beverage containers
- Scrap tires
- Asphalt shingles
- Concrete
- Carpet
- Gypsum drywall
- Untreated wood

The primary goal of recycling market development is to promote the long-term vitality of recycling programs by increasing demand for recovered materials, increasing revenue generated from recycling, and improving marketing practices. However, recycling market development also provides secondary benefits such as local job creation, strengthened local businesses, and increased waste diversion.

Government Roles in Recycling Market Development

In Texas, landfill disposal prices are relatively low compared to many areas of the United States, particularly those on the east coast and west coast. As such, diverting material from landfills is often a challenge, at least initially. Infrastructure has been developed to collect and dispose of material as waste in an efficient manner; therefore, inducing change is in many cases a more expensive proposition. Government at all levels has the ability to influence changes in the way resources are managed. The ways that government can influence resource management include establishing rules and regulations, providing subsidies, and educating the public, to name a few. The ability of government to influence change varies at each level of government, thus, strategies for minimizing waste should be tailored accordingly.

State Government

Although the state government can participate in cross-material recycling market development, two of the specific materials included in this report would benefit from government involvement at the state level.

The State of Texas operated a waste tire recycling program from 1992 through 1997. When the tire program was eliminated, the associated revenues generated through the $2.00 recycling fee were no longer available for the clean-up of illegal dump sites or the ongoing collection and processing of scrap tires. Currently, tire dealers are allowed to set their own fee for the disposal of scrap tires, although individuals may choose not to pay the fee and may take their scrap tires away with them. As such, there are opportunities for these tires to be improperly disposed or illegally dumped. If a particular municipality or region establishes a waste tire recycling program, it is possible that tires will be illegally dumped in surrounding areas. In addition, most states that have extensive waste tire recycling programs have state-mandated taxes to provide funding for these programs. The State of Texas can participate in market development by creating a state-wide funding mechanism (e.g., a retail tire recycling tax) to support scrap tire collection and recycling programs.

Recovered asphalt shingles may be used in the production of Hot Mix Asphalt (HMA), which represents 90 percent of asphalt that is produced in the United States. However, under current Texas Commission on Environmental Quality (TCEQ) regulations, only scrap shingles generated from shingle manufacturing plants may be used for this application. Consumer tear-off shingle scrap from new construction and roofing replacements may not be used in HMA. Further air emissions tests are needed in order for TCEQ to authorize the use of consumer tear-off shingle scrap in HMA. Although these tests will likely be conducted by private industry or by a public-private partnership, the state government will need to recognize these tests and make regulatory change as soon as satisfactory testing results are achieved.

Regional Government (CAPCOG)

Regional governments can influence diversion programs in a number of ways, as discussed in Section 4. For CAPCOG, resources dedicated to solid waste are limited, and their ability to provide grant funding to public sector entities or public-private partnerships is one of the primary tools it has to further diversion goals. The COG should identify priority areas for grant funding to supplement existing recycling programs or help initiate new programs.

Local Governments

Unlike CAPCOG, local governments have the ability to pass ordinances to help influence the direction, or existence, of diversion programs. Local governments vary greatly in size within the Capital Area region, and what may work well for the City of Austin, for example, may not work well for a smaller community. Each local government needs to determine, based on solid waste infrastructure and available resources, which programs or strategies may work best for them. The City of Austin

controls its residential collection and has the ability to change what materials are collected at the curb and what collection methods are used. Smaller communities may have more success with Buy Recycled programs or source reduction programs (e.g., green building). Section 4 contains a more detailed list of potential strategies for local government.

Strategies for Diversion

Section 2 of this report contains a detailed review of each material included in the study. For each of the 10 materials, R. W. Beck presents the key diversion barriers and strategies for overcoming them. Each material-specific section is organized as follows:

- Overview
- Potential Markets and Uses
- Current Practices in the Capital Area Region
- Barriers to Recycling
- Strategy Recommendations

Each material discussion provides several strategy options for overcoming barriers and increasing diversion. This Executive Summary highlights several of the strategies R.W. Beck believes are most promising in the Capital Area region.

Waste Diversion and Minimization Strategies

Based on a review of the draft report with the SWAC, R. W. Beck developed this summary discussion to highlight those strategies that have the most potential increase diversion in the Capital Area region. R. W. Beck divided the discussion into material specific strategies and cross-material strategies, which are strategies that affect more than one of the 10 materials.

Material Specific Strategies

Carpet

Carpet recovery and recycling appears to be in its infancy in the Capital Area region, but it represents an opportunity for waste diversion. Currently, most excess carpet from installation, or carpet removed from renovation or demolition projects, is being disposed in the region's landfills. However, there are companies in the region that accept recovered carpet for free and haul it to processors for reuse or recycling. One limitation to this practice is that some carpet types are more easily recycled than others. Therefore, there is a need for carpet handlers (e.g., installers) to be able to identify the types of carpet removed from a site. There are several methods to identify the type of carpet fiber, including:

- Back stamp (not required and therefore not always present)
- Burn test

- Chemical test
- Handheld carpet identification analyzer

The simplest method, if present, is simply looking at the back stamp on the carpet, which should identify the type of fiber. However, since this is not required, it is not a reliable method. Handheld carpet indemnification analyzers are a new development in the industry and allow for quick determination of carpet type. However, these devices are relatively expensive[1] and therefore are not yet a practical option for every carpet installer. The best option currently is to utilize carpet recyclers that will accept all types of carpet. Carpet installers need to be cognizant of the costs associated with landfilling old or excess carpet and weigh that against the incremental transportation cost of hauling the material to a company that accepts the materials for no charge.

Concrete

Concrete is a highly reusable material. There are processors in the Capital Area region that have the ability to accept concrete from construction and demolition projects and process it for use in a variety of applications, including fill material and road base. However, one of the barriers R. W. Beck identified is that many design projects specify to use virgin material when possible. As such, the design of the project is based on the properties of those virgin materials. Encouraging the use of recycled material in the design specifications will ensure that the use of recycled material is considered at project initiation rather than as an afterthought. Specifically, local governments that issue or influence design specifications should consider the use of recycled concrete whenever possible.

Untreated Wood

Untreated wood is also highly reusable material. One of the more common uses for untreated wood in the Capital Area region is for mulch or compost. Untreated wood includes tree limbs, brush and scrap lumber that has not been chemically treated. Loads of clean brush are not typically landfilled since this material can be ground as used within the landfill for road stabilization, erosion control, etc. Additionally, the City of Austin collects brush as part of its residential curbside collection program and uses it as feedstock for mulch and compost. Wood waste from construction and demolition projects (e.g., scrap dimensional lumber, plywood) represents an opportunity for increased diversion of untreated wood waste. This is discussed in more detail in the cross-material discussion of construction and demolition (C&D) debris.

Food Waste

According to U.S. Environmental Protection Agency (EPA) estimates, food waste represents approximately 12 percent of the waste stream, yet diversion of this material is limited in the Capital Area region. One of the common issues with managing food waste is the odor typically present in and around temporary storage containers (e.g., dumpsters). However, many cities that have achieved high recycling rates have

[1] Based on conversations with industry professionals, R. W. Beck estimates a cost of $20,000 to $25,000 per unit.

developed collection programs for food waste and have taken steps to minimize odor issues. Areas that already collect yard waste and brush for composting, like the City of Austin, could leverage the existing collection infrastructure to also collect food waste. The City of Seattle, Washington, for example, recently began accepting food waste in its curbside yard waste collection program. Additionally, many restaurants and institutions already have daily collection of waste since the waste generated by these establishments has organic waste content. Converting some of the collection containers to organic only would enable that material to be collected daily and hauled to a composting operation.

Asphalt Shingles

When roofing companies install a new asphalt shingle roof on a home or business, the old shingles are typically disposed in the landfill. Currently, there is not a significant alternate use for asphalt shingles in the Capital Area region. One of the potential uses, which occurs in other states, is using the asphalt shingles in HMA. However, at this time, additional testing related to air quality needs to be completed before the TCEQ will allow consumer tear-off asphalt shingles to be used in HMA. Coordination at the regional or state level may help initiate the testing needed to allow this use for asphalt shingles. Local governments should inform area HMA manufacturers of the potential economic benefits associated with use of shingles in HMA. In addition, CAPCOG could give grant funding priority to any public-private partnerships that form to conduct the necessary air emissions testing.

Plastic Film

Although plastic film does not represent a significant portion of the waste stream by weight, plastic bags can be a visible nuisance at landfills since they are easily caught by the wind and blown from the working face of landfills. Plastic film is easily recyclable once collected. Grocery stores, retail stores, and industrial facilities that use stretch wrap can bale this material using the same equipment that is used to bale cardboard. Plastics recycling companies will haul the baled material. Additionally, grocery stores and other consumer stores can reduce the amount of bags generated by encouraging the use of reusable bags. CAPCOG and its member jurisdictions can encourage recycling of plastic film by increasing public education. In addition, local governments can consider including plastic bag recycling in curbside and drop-off recycling programs that currently accept cardboard.

Cross-Material Strategies

Buy Recycled Programs

Buy Recycled programs are one of the easiest ways for municipalities, counties, and states to encourage the use of recycled materials. Buy Recycled programs simply specify the purchase of recycled-content products during procurement. For example, specifying the purchase of recycled-content paper will increase the demand for the material and therefore help sustain continued recovery and recycling efforts for paper. Local governments can implement Buy Recycled procurement programs in order to sustain markets for recoverable materials.

Green Building Programs

Green Building programs, like the EPA Leadership in Energy and Environmental Design (LEED) program and the City of Austin Green Building Program, encourage better management of resources in construction, demolition, and renovation projects. Encouraging or requiring builders and contractors to comply with these programs is a way for local governments to reduce waste generated from construction, demolition, and renovation projects. In addition, these programs may encourage the incorporation of recycled-content materials into building design. R. W. Beck has completed several recent studies relating C&D diversion in the North Central Texas region. These studies are available on the North Central Texas Council of Governments (NCTCOG) website.[2] CAPCOG should coordinate with the City of Austin Solid Waste Services and the Austin Green Building program to maximize C&D diversion and avoid duplicated efforts to increase C&D diversion. Section 3.2.6 provides additional local government strategy recommendations to encourage green building practices.

Mixed C&D Diversion

While green building programs have gained momentum in the Capital Area region, particularly within the City of Austin, there are barriers to C&D diversion at some job sites. Reuse of building materials and reduction of C&D waste at job sites should be the primary goals. However, the C&D waste that is generated should be recycled rather than landfilled. This is commonly done through source separation. For source separation, multiple containers are required (one for each material type), which takes up additional space at the site. Since open space is often limited at sites, this represents a constraint to using source separation. However, once material is mixed into one container, it is difficult to separate later and thus it is typically landfilled. If a C&D material recovery facility (MRF) was developed in the region, mixed loads of C&D debris could be accepted. The mixed loads would be separated at the MRF into the various "commodity" materials and marketed to the appropriate processors or end users. Materials from this study that might be recovered in a C&D MRF include carpet, untreated wood, concrete, asphalt shingles and gypsum drywall. The development of a C&D MRF, along with restrictions on landfilling the material, may represent a way to divert a significant amount of the waste stream from landfills. In order to facilitate increases C&D diversion, CAPCOG can place grant funding priority on projects that evaluate the feasibility of constructing this type of facility in the Capital Area region. Section 3 contains additional discussion on this topic.

Composting

Compost is a mixture of various organic decaying substances that is used for fertilizing soil. Composting promotes sustainability by using materials that might otherwise be landfilled to create a usable product. Composting is a potential use for three of the materials targeted for this study:

- Food waste;
- Untreated Wood; and

[2] http://www.nctcog.org/envir/SEELT/reduction/studies.asp.

- Gypsum drywall.

All three of these materials can be incorporated into composting operations and therefore diverted from disposal. However, there are barriers to collection for all three of these materials. Untreated wood, such as scrap lumber, and gypsum drywall from construction sites must be separated from other C&D debris in order to be composted. In addition, residential and commercial food waste collection poses challenges associated with odor and sanitation, as previously discussed. Local governments should consider options for integrating food waste recycling into the current solid waste collection structure.

Road Applications

As discussed in Section 2, there are several types of recyclable materials that are suitable for use in construction of roadways and roadway embankments. These are summarized in Table 1 below.

Table 1
Roadway Uses

Material	Example Roadway Related Uses
Scrap tires	Paving applications (e.g., permeable friction course, chip seal, crack sealer); lightweight fill; embankment construction and repair; molded rubber products (e.g., guard rail spacer blocks); landscaping and erosion control
Glass	Road base, glasphalt, reflective paint, salt or sand mixes for ice prevention
Asphalt Shingles	Cold patch, dust control, temporary surfacing, hot mix asphalt
Concrete	Road base, retaining walls, erosion control, non-structural concrete
Untreated wood	Landscaping and erosion control

Potential users of these materials include the Texas Department of Transportation (TxDOT), local public works departments, parks and recreation departments, and private road construction and maintenance contractors. Many of these uses are economical or could become economical through public efforts to address infrastructure barriers.

Roadway construction and maintenance is highly resource intensive. Consequently, use of recyclable materials in roadway construction and maintenance offers tremendous potential to consume large quantities of recyclable materials. However, such projects demand suitable quality and quantity of material supply at an affordable price.

In order to facilitate use of recycled products in roadway construction, local governments can provide information and technical assistance to transportation and public works department staff, design engineers, and construction and maintenance contractors. CAPCOG can place grant funding priority on projects that aim to build acceptance of recycled materials in road applications, such as demonstration projects.

Section 3.3.4 provides additional local government strategies to increase use of recycled materials in road applications.

Section 1
Introduction

1.1 Project Purpose

The purpose of this project is to provide general strategy recommendations to aide CAPCOG and its member jurisdictions in fostering the development of markets for potentially recyclable materials in order to increase diversion from area landfills. Rather than focus this analysis on materials that are currently being recovered and diverted from area landfills, the SWAC chose 10 materials that do not have developed markets in the region. These 10 materials are listed as follows:

- Fluorescent lighting
- Food waste
- Plastic film
- Glass beverage containers
- Scrap tires
- Asphalt shingles
- Concrete
- Carpet
- Gypsum drywall
- Untreated wood

Figure 1-1 is a map that depicts the 10-county region that is CAPCOG's geographic area of responsibility (Capital Area region). The market development recommendations identified by this study are specific to this region.

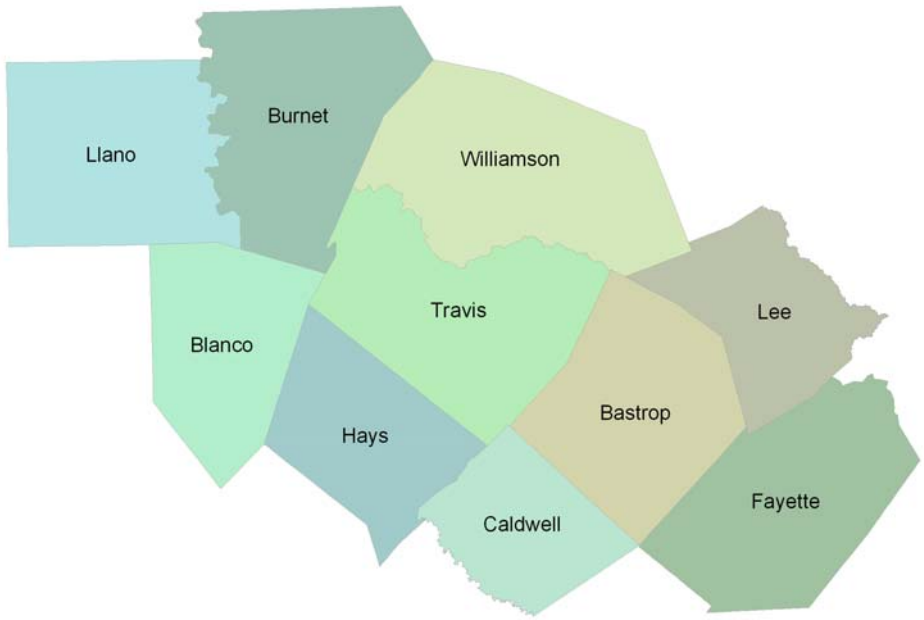

Figure 1-1: Capital Area Region

1.2 Overview of Recycling Market Development

The primary goal of recycling market development is to promote the long-term vitality of recycling programs by increasing demand for recovered materials, increasing revenue generated from recycling, and improving marketing practices. However, recycling market development also provides secondary benefits such as local job creation, strengthened local businesses, and increased waste diversion.

Recycling market development work entails identifying market strengths, weaknesses, and barriers. Understanding market weaknesses and barriers enables the identification of opportunities to overcome these barriers. Once specific opportunities are identified, the next step in recycling market development is to develop specific strategies to realize those opportunities. Planning-level strategies for CAPCOG and its member jurisdictions are identified in this report. The last step in recycling market development is to create institutional capacity to execute the strategies.

Effective recycling market development programs utilize a variety of tools and strategies aimed at overcoming market barriers. Types of barriers that will be discussed in this report include:

- Operational and infrastructure;
- Economic;
- Regulatory;
- Educational and informational; and
- Perceptional.

Strategies for overcoming barriers can be employed on a commodity-specific basis, as well as on a cross-commodity basis. Material-specific tools and strategies to overcome barriers to recycling include the following:

- **Information** – Providing market participants with information, such as market data, recycling business directories, information regarding product availability and performance, technical information, training, referrals, etc.
- **Technical assistance** – Providing technical assistance to participants in the supply and demand chain to increase efficiencies, reduce costs, and enhance product opportunities and properties.
- **Facilitation** – Bringing market players together through stakeholder forums, waste exchanges; linking purchasers with manufacturers; identifying appropriate financing; making referrals to legal, technical, and business assistance, etc.
- **Financial** – Providing incentives, such as loans and grants, to encourage or discourage certain behaviors.
- **Procurement** – Promoting greater use of state and local government purchasing power and procurement systems to increase the purchase of recycled products, using, if needed, tools such as prices preferences, set-asides, modifying of bid specifications etc.

- **Regulation** – Recommending policies such as tax incentives, landfill bans, minimum content requirements, or preferential procurement requirements that will influence desired behaviors.

General or cross-material strategies include:

- **Feedstock conversion** – Helping existing Texas manufacturers to convert from virgin to secondary materials to the extent that technology and markets allow.
- **Technology development and commercialization** – Encouraging the successful development and commercialization of innovative recycled products and manufacturing technologies for recycled products.
- **Support of existing recycled product manufacturing businesses** – Providing existing recycled product manufacturers with access to the financial, professional, educational, and infrastructure resources necessary for expansion of sales, profits, and jobs.
- **New recycled product manufacturing business development** – Encouraging and supporting the startup and recruitment of new final and intermediate recycled product manufacturing businesses, including non-profit and for-profit enterprises.
- **Buy recycled** – Promoting the purchase of recycled products by government, businesses, institutions and other consumers, particularly those manufactured in Texas and the Capital Area region.
- **Collection and processing best practices and technology development** – Supporting the development and adoption of collection and processing technologies and best practices that reduce the cost and improve the quality and availability of secondary materials needed by recycled product manufacturers.
- **Identification of new recycled product opportunities** – Identifying opportunities for new products that can be made from recyclable materials, assessing market demand, and finding manufacturers to make the product.
- **Education and outreach** – Effectively conveying information on market development and available services to target audiences.

In addition, effective recycling market development programs provide both "retail" (client-specific) services, such as one-on-one technical assistance, as well as "wholesale" services aimed at groups of businesses or other target audiences, such as training and distribution of educational publications.

1.3 Methodology

R. W. Beck interviewed several individuals in the Capital Area region that represent both the public and private sectors. In conducting the interviews, R. W. Beck inquired about current practices and potential opportunities in the Capital Area region related to recovery and marketing of the materials addressed in this study. R. W. Beck performed literature reviews and internet-based research and drew upon the results of previous markets assessment and market development projects to assess market

opportunities and identify strategies aimed at realizing these opportunities in the Capital Area region.

The majority of this report provides specific strategies for the development of recycling markets for certain materials. In addition, R. W. Beck provided recommendations for increasing the recovery of certain materials that have viable markets.

1.4 Report Organization

Presented in the next section of this report are the material-specific findings with respect to key diversion barriers and strategies for overcoming them. Each material-specific section is organized as follows:

- Overview
- Potential Markets and Uses
- Current Practices in the Capital Area region
- Barriers to Recycling
- Strategy Recommendations

In Section 3, we provide a discussion of recycling market development tools and mechanisms that are cross-material in nature. Section 4 closes with a discussion of institutional recommendations for local, regional, and state government.

Section 2
Market Analysis

2.1 Overview

As described in Section 1, this section provides a general discussion of each material targeted for this study. R. W. Beck identifies both barriers and impediments for increasing the diversion of these materials and provides suggested strategies for overcoming them. Each material-specific section is organized as follows:

- Overview
- Potential Markets and Uses
- Current Practices in the Capital Area region
- Barriers to Recycling
- Strategy Recommendations

2.2 Fluorescent Lighting

2.2.1 Overview

For the purposes of this project fluorescent lighting components include:

- Compact fluorescent bulbs and fluorescent tubes; and
- Ballasts.

These materials do not comprise a significant component of the municipal solid waste (MSW) stream. However, use of fluorescent lamps – particularly compact fluorescents – is rapidly increasing, due to environmental as well as cost saving benefits. Fluorescent lamps are four to five times more energy efficient than incandescent bulbs. Reducing energy use saves money and also cuts down on routine power plant emissions of mercury and carbon emissions that contribute to global climate change, acid rain and smog.

Interest in recycling fluorescent lamp products is a result of their hazardous nature. All fluorescent lamps contain mercury. It is important that lamps and other products containing mercury be properly managed to protect public health and the environment. Lamp ballasts manufactured prior to 1978 likely contain polychlorinated biphenyls (PCBs). When released into the environment, PCBs persist for many years and bioaccumulate in organisms. Any ballast containing PCBs is a dangerous waste that needs to be disposed according to state and local regulations. Ballasts without PCBs are generally accepted along with fluorescent tubes and bulbs.

Reasons for recycling fluorescent lamps and ballasts are as follows:

- Keeps mercury-containing products out of the waste disposal stream and ultimately the environment;
- Is consistent with solid waste disposal bans and partial bans in some states;
- May be managed under U.S. EPA's Universal Waste rule if recycled, which is typically less costly, simpler from a tracking and enforcement standpoint, and may result in lower Superfund liability than if managed as a hazardous waste;[1]

Commercial and industrial users of mercury-containing lamps, account for about two-thirds of the lights in use while residential users account for the remaining third.[2] With respect to commercial users, both small and large companies are required under the U.S. EPA's and Texas's Universal Waste Rules to either dispose of spent bulbs in hazardous-waste landfills or send them to recycling facilities. Businesses that produce less than 220 lbs of universal waste per month have the option of handling their universal waste either under the universal waste regulations or as a Conditionally Exempt Small Quantity Generator (CESQG).[3] (The U.S. EPA estimates that it takes approximately 350-450 4-foot long lamps to equal 220 lbs, depending on the diameter.) Household users of efficient mercury containing fluorescent lamps, including compact fluorescents, are typically exempt from special disposal requirements, although a few states and localities ban homeowners from disposing of such lamps in normal household trash.

Industry estimates indicate that only around 28 percent of mercury from lamps generated by commercial and industrial sources is now being recycled. Residential users recycled only approximately two percent. There is growing interest in establishing more recycling programs for fluorescent bulbs and tubes, due to the nationwide push to convert from incandescent to fluorescent for energy conservation reasons. For this reason, we are focusing this report section on recycling of bulbs and tubes specifically.

2.2.2 Potential Markets and Uses

The general process for recycling fluorescent lighting consists of processing and physical separation of fluorescent lamps containing mercury. The lamps are separated by component: lamp end caps, phosphor powder, glass, and elemental mercury. Processing equipment may consist of a crusher, trommel and drum screens, magnetic separators, and particle and vapor filtration systems. The resulting materials generated from this activity (end caps, glass, phosphor powder) are transported off site for further processing, recycling, or disposal. The end caps are analyzed for mercury content and marketed as aluminum material. The ferrous filaments are removed by a magnetic separator. The glass is sampled and analyzed for mercury and sent for

[1] The Universal Waste Rules for the State of Texas are located in Title 30 Texas Administrative Code, Chapter 335, Section 335.261, Division 5 – Universal Waste Rules.
[2] Source: "Shedding Some Light on Mercury Lamps," *Science News*, September 13, 2006.
[3] The State of Texas provision for Conditionally Exempt Small Quantity Generators may be found in Title 30 Texas Administrative Code, Chapter 335, Section 335.78.

recycling or disposal, depending on the current market. The phosphor powder is further separated from glass fines and collected in containers and shipped off-site for further processing. Using a heat process, the mercury is vaporized to free it from the powder. The vaporized mercury is then condensed back into a liquid. This commodity grade of mercury is further distilled and sold on the domestic market as Technically Pure Mercury for sale to companies that manufacture mercury salts, mercury-containing devices, or utilize the mercury in electronics and various research and development applications.

The TCEQ maintains an online directory of recyclers for various recyclable commodities, including light bulb and fixtures markets. [4]

For the most up-to-date list of companies that recycle lamps by state, visit the lamp section of the National Electrical Manufacturers Association (NEMA) website[5] to provide a one-stop source of information about spent fluorescent and high intensity discharge lamp recycling. Under Federal hazardous waste laws, lamp users are responsible for complying with disposal standards. A partner organization is the Association of Lighting and Mercury Recyclers (ALMR) a national organization that represents lamp recyclers.[6] Many of the listings on the NEMA site are recyclers listed with ALMR. Many companies, such as Air Cycle Corporation, accept ballasts as well as fluorescent bulbs and tubes for recycling.[7]

2.2.3 Current Practices in the Capital Area Region

With regard to residentially generated fluorescents, City of Austin and Travis County residents may take fluorescent lamps to the City's permanent hazardous household waste (HHW) facility. The City contracts with Phillips to process the lighting and recycle the mercury recovered from the lamps.

Additionally, R. W. Beck spoke with Air Cycle Corporation, which provides a range of products and services for recycling fluorescents. They indicated that "many" companies in Austin and the surrounding area use their products and services for recycling fluorescents. More information is available on the Air Cycle website.[8] Air Cycle is one example of a company that provides this service and R. W. Beck is aware that others may exist.

2.2.4 Barriers to Recycling

Economic

- In essence, there is no shortage of handlers or processors of fluorescent lamps and ballasts. However, lamp recycling is not self-supporting and it is not likely to

[4]Source: http://www.cleantexas.org/index.cfm?fuseaction=public.memberprofiles_bymembername_rtolquery2
[5] Source: http://www.lamprecycle.org
[6] Source: http://www.almr.org/
[7] Source: http://www.lamprecycling.com
[8] Source: http://www.aircycle.com/

become self-supporting. Spent lamps have no intrinsic market or energy value. The recovered mercury has some value; however the cost of recycling lamps is relatively small compared to the cost savings realized from using energy efficient lighting.

- For exempt generators (small quantity commercial generators and households) the motivation to recycle lamps is primarily environmental as opposed to economic.

Educational and Informational

- Regulated fluorescent lamp generators often lack information regarding their recycling options and the benefits of recycling lamps.

2.2.5 Strategy Recommendations

ALMR collaborated with Solid Waste Association of North America (SWANA), and NEMA to prepare a Guide for Waste Managers promoting mercury-containing lamp recycling, funded by the U.S. EPA.[9] This 120-page guide focuses primarily on means by which local governments can influence the practices of commercial, institutional and industrial generators. However, lamp collection programs can be designed for residential as well as non-residential generators. Strategies recommended for consideration are as follows:

1. **Provide for lamp and ballast recycling for residents as a component of HHW collection days or at permanent HHW facilities.** Direct individuals and small quantity generators to take their lamps and ballasts to these locations.
2. **For medium to large quantity generators, work with a local collection service provider to arrange milk-run style pick-ups on a fee basis.** The lamps and ballasts can be consolidated for shipment via common carrier to accumulation facilities throughout the country, where they are further consolidated for shipment to destination facilities. Very large generators can have their materials picked up in trailer loads as needed.
3. **Seek out business partners to set up collection points, and hire local contractors or hazardous waste firms to recycle the spent lamps**.
4. **Establish a web site and produce outreach materials for various generator audiences.** In particular, inform small quantity commercial and institutional generators that they can recycle their lamps using a "box program," where a container is provided that, when full, can be sent to a designated recycler via ground mail shipment. This is generally a prepaid program and labels and shipping papers are provided. King County, WA developed an effective website promoting recycling of fluorescent lamps.[10] This would most cost effectively be done at the COG level, with hotlinks from individual jurisdiction web sites.
5. **Once a recycling infrastructure is fully in place, ban fluorescent lamps from disposal and provide for monitoring and enforcement**.

[9] Source: http://www.swana.org/extra/lamp/lropmanualfinal.pdf
[10] Source: http://www.metrokc.gov/dnrp/swd/wdidw/category.asp?CatID=21

6. **Ensure that solid waste collection service providers know their responsibilities under state and Federal law, and what to do if they encounter violations regarding lamp disposal.** As mentioned previously, spent mercury-containing lamps are considered hazardous unless they come from a household or conditionally exempt small quantity generator.

2.3 Food Waste

2.3.1 Overview

Food waste is a highly variable waste material due to the variety of foods and the numerous commercial and household activities involved in processing and preparing foods for consumption. Generators are numerous and diverse, including residential dwellings, commercial and institutional kitchens, restaurants, grocery stores, and food product manufacturers. For the purposes of this project, R. W. Beck has categorized food waste into the following four categories related to primary uses for food waste:

- Surplus food fit for human consumption,
- Food waste suitable for animal consumption,
- Compost products, and
- Industrial and manufacturing plants.

According to the EPA, food waste represents approximately 11.9 percent of the total MSW stream. Of that amount, approximately 2.4 percent is recovered. Some estimates indicate that up to one-fifth of food in the United States goes to waste each year, with an estimated 130 pounds of food per person ending up in landfills. Since food waste is a significant portion of the waste stream and only a limited amount is typically recovered, the opportunity exists to find markets to recycle or reuse food waste. Additionally, a reduction in the amount of food waste generated can have a significant impact on the amount of food waste that must be recycled or reused.

2.3.2 Potential Markets and Uses

The abundance of available food in the United States has reduced the incentive to monitor or reduce food residual. However markets to reuse or recycle food wastes do exist. This section discusses the four primary uses of food waste mentioned above.

Surplus Food Recovery for Human Consumption

After waste reduction, the first priority for food waste is recovery for human consumption. One of the primary beneficiaries of such food recovery programs are food banks and other charitable organizations that supply food to those in need.

The U.S. Department of Agriculture (USDA) Food Recovery and Gleaning Initiative provides a resource guide on food recovery programs for businesses, community-based profit or nonprofit organizations, private citizens and public officials. The publication describes some of the prominent food recovery activities already taking

place, and suggests how a community, a business, or an individual can support existing programs or begin new efforts. A copy of the report can be found on the USDA website.[11]

Animal Feed

The two main ways to divert food to animal feed are (1) direct feed to animals, and (2) processing into manufactured animal feed pellets or meal.

Direct Animal Feeding

Direct animal feeding of human food waste is a traditional farming practice and can offer the following benefits:

- Decreasing disposal costs;
- Assisting local governments in meeting mandated waste reduction goals;
- Earning payment for food residuals;
- Enhancing food generators' public image; and
- Supporting local farmers, dairies, or livestock producers.

The most common practice for direct animal feeding is swine feeding. Current regulations in Texas with regard to swine feeding define two classes of garbage; restricted garbage and unrestricted garbage.[12] Restricted garbage includes animal refuse and waste, or commingled garbage containing animal matter. The feeding of restricted garbage to swine, or provision of restricted garbage to another for the purpose of feeding swine, is prohibited except that a Texas Department of Criminal Justice facility may use restricted garbage that is treated according to federal requirements. Unrestricted garbage is limited to refuse and waste from food containing only vegetable, fruit, dairy, or baked goods refuse matter. A person may feed unrestricted garbage to swine if the person is registered with and secures a permit from the Texas Animal Health Commission.

Manufactured Animal Feed

Manufactured animal and fish feeds are highly consistent products that have very low moisture content. They may be either pelletized or a meal. Animal feeds are generally produced for the agricultural market, e.g., poultry pellets and cattle feed supplements. These markets are the most amenable for feeds derived from food waste, in contrast to pure grain feed products for animals like horses. Manufacturing feed requires feedstock consistent in terms of content and moisture. These requirements place constraints on the types of food waste amenable to feed manufacturing, (e.g. consistent characteristics and relatively low moisture content.) Rendering facilities represent the largest industry which produces animal feed from animal by-products.

[11] Source: http://www.usda.gov/news/pubs/gleaning/content.htm
[12] Source: Texas Administrative Code, Title 4, Part 2, Chapter 55.3

Compost

Food waste that is not fit for human consumption can be used for composting with great success. Fruits, vegetables, dairy products, grains, bread, unbleached paper napkins, coffee filters, eggshells, meats and newspaper can generally be composted. Items such as red meat, bones and small amounts of paper are usually acceptable, but they take longer to decompose. Contaminants that should be avoided include plastics, grease, glass, metals, plastic utensils, condiment packages, plastic wrap, plastic bags, foil, silverware, drinking straws, bottles, polystyrene and chemicals.

Residential food waste can be composted, using back yard compost bins or vermi-compost units that contain worms to aid in the composting process. There are a number of composting technologies that can be used to compost food waste at commercial sites, and on a commercial scale, including windrow, in-vessel, and vermi-composting. In-vessel composting and vermi-composting systems are often used for on-site composting, due to their relatively small space requirements. Most large composting operations use windrows. Whatever technology is used, the composting operation must produce a stable and consistent quality product in order to meet market requirements. Microbial (and/or worm) action breaks down the organics, creating heat in the process, and turning the matter into compost. At the end of the process, the material may be screened to remove larger pieces of material.

Food waste has unique properties as a raw compost agent. Because it is high in nitrogen content, and has a high moisture content and low physical structure, it is important to mix fresh food waste with a bulking agent and materials with high carbon content to absorb some of the excess moisture, improve the carbon-to-nitrogen ratio, and add structure to the mix. Untreated wood, ground into a mulch product, can be used as a bulking agent; leaves are often used for their carbon content.

In metropolitan areas, the primary markets for compost and vermi-compost are landscape contractors, soil blenders, bulk suppliers, and public agencies. In rural areas and small towns, the primary markets are citizens, public agencies, and agriculture.

Industrial and Manufacturing Products

Current commercial scale activities utilizing food waste are limited primarily to rendering plants, which process animal tissue into useful materials. Rendering plants utilize fat and bone, grease trap waste, and used cooking oils to generate products such as tallow, meat and bone meal, and yellow grease. Tallow is used in manufacturing soaps, cosmetics, and pharmaceutical creams. Meat and bone meals and yellow grease are used in manufacturing animal feeds and pet foods.

2.3.3 Current Practices in the Capital Area Region

Surplus Food Recovery for Human Consumption

One example of surplus recovery efforts in the Capital Area region is the Meat and Perishable Food Rescue Program of Capital Area Food Bank of Texas (CAFB), who collects fresh foods from area grocers and wholesalers and distributes them to the

community. In 2006, the CAFB recovered more than 800,000 pounds of food through the Meat and Perishable Food Rescue Program.

Compost

Texas Disposal Systems (TDS) composts a large quantity of food waste and has the capacity to take significantly more material. Companies such as Whole Foods and Michelangelo's (a food product manufacturer) bring spoiled food waste on a regular basis. TDS has containers on site at those locations to collect and also haul that material on a contract basis. They also have some feedstock from prisons. According to TDS, the primary barrier is actually capturing the material from the waste stream.

Travis County was recently composting food waste at the county jail through in-vessel composting. They are not currently composting due to the fact that their equipment was in need of repair and they have not been able to procure the resources to repair it.

Cooking oil waste is currently recycled in Williamson County between the various end users without county intervention. Additionally, there has been an increase in activity to recover used cooking oil in the production of biofuels, such as biodiesel.

The City of Austin Solid Waste Services Department has information about backyard composting on its web site.

Animal Feed and Industrial/Manufacturing Products

R. W. Beck did not focus its efforts on better understanding existing activities with regard to food and animal waste in the use of animal feed and industrial/manufacturing products. These are longstanding industries with well-established infrastructures and R. W. Beck believes that there are greater opportunities for diversion of food waste in other applications of the material.

2.3.4 Barriers to Recycling

Operational and Infrastructure

- Composting operations if not managed properly can create public nuisance level odor and pest issues. At businesses and residences, composting containers must be maintained and actively managed in order to reduce these issues as much as possible.
- While the supply of potential food waste is significant, the recovery of the food waste is limited due to a lack of infrastructure for collection and handling, especially for residential food waste. There are currently no curbside food waste collection projects in the Capital Area region and there is little incentive for residents to increase diversion through back-yard composting.
- In metropolitan areas, it is difficult to develop large scale food waste recycling facilities (either composting or feed manufacturing) because of the lack of cost-competitive collection infrastructure, low cost disposal options, and difficulties in

siting facilities. At the same time, transferring food waste to more rural sites may not be cost effective due to the transportation costs.

Economic

- Food banks, like CAFB, are often dependant on donations for operations since the food is generally given to those in need and therefore is not a profit-driven program. While these programs can typically accept more surplus food, they are typically limited in their marketing budgets that would help increase awareness.
- On-farm composting requires a level of management largely beyond that which farmers are willing to undertake without economic incentives. In addition, food waste can contain more contaminants than farms are typically willing to address.

Regulatory

- State compost regulations require that significant design and operational procedures be integrated into any large scale food waste composting facility in order to adequately control potential environmental impacts. These regulations result in increased development and operating costs which may offset the revenue generated by the sale of end products. It is likely that large composting operations, such as TDS, are able to overcome these costs because of economies of scale.

2.3.5 Strategy Recommendations

As the overall recovery of food waste from the MSW stream is low, many opportunities exist to increase diversion.

1. **Increase public awareness of the magnitude of the food waste problem to encourage reduction in food waste.** CAPCOG and its member communities can work to inform the general public as well as food services operations about the extent of food waste and potential savings in avoided disposal costs through food waste reduction.
2. **Encourage backyard composting. Through backyard composting, food waste does not enter the waste steam to begin with.** CAPCOG and its member communities can provide backyard composting information, distribute backyard composting bins, establish demonstration sites and create a Master Composters technical assistance program. Some CAPCOG communities are already practicing some of these techniques to a limited extent.
3. **Encourage ICI (industrial, commercial and institutional) establishments to perform on-site composting of food wastes and other suitable organics.** CAPCOG and its member communities could develop best practices guidance for ICI establishments and provide small-scale in-vessel composting demonstration sites. In addition, city and county governments can "walk the talk," by establishing such programs for food waste generated through COG and local government operations, including employee break rooms, prisons, and public school cafeterias.

4. **Increase recovery of food waste via additional or expanded food recovery programs.** CAPCOG can facilitate additional recovery through these channels with the following strategies:

   - Promote further awareness and support of food recovery programs within the residential and industrial sectors. Increased food donations and grant funding would help support these programs while increasing diversion of food from the waste stream.
   - Work with grocers and other generators to get corporate commitment to food waste recovery.
   - Work with existing local food recovery organizations in documenting their progress and identifying additional ways to facilitate maximum recovery.

5. **Explore opportunities for supplying food waste for animal feed.** Although there are a number of challenges to developing the market for dried commercial animal feeds, it is considered to have a higher added value than the compost market. Therefore it is recommended that the size of the animal feed market in Travis County and neighboring communities should be quantified to help determine the viability of this market opportunity.

6. **The use of food waste as a feedstock in compost is both technically and economically feasible, although economic challenges still remain with regards to cost effective collection and handling**. CAPCOG and its constituencies can take steps to increase the amount of food waste that is captured from the waste stream.

   - Establish curbside collection of residential food waste. The City of Austin provides its own collection of residential waste. The City could add collection of food waste to the yard waste collection program to supplement materials for the City's composting program. Many of the communities in the region, excluding the City of Austin, contract with private solid waste collection companies for the collection of residential waste. In requesting proposals for service, local governments could request that these private companies provide curbside collection of food waste.
   - Explore means to increase collection and utilization of commercial food waste. While collection of commercial food waste (e.g., restaurants) occurs in the region, this activity could be increased to allow more waste to be diverted from area landfills. Large-scale generators (such as food manufacturers, supermarkets, and food processing industries) tend to have the greatest incentive to separate food waste because they have a significant potential to lower overall solid waste management costs. CAPCOG could sponsor one or more stakeholder forums to bring together generators, equipment vendors, compost facility operators and other relevant parties to explore opportunities and strategies for advancing them.
   - Consider the role of the COG and local government in developing multiple regional composting centers to reduce the impact of transportation costs. Such facilities could be advantageous if they fill a needed infrastructure gap, but

could be disadvantageous if they compete with existing facilities. The COG could fund a study to assess the available composting infrastructure in the region to determine whether and where infrastructure gaps exist.

- Local governments can consider enacting ordinances that require recycling of food waste. For instance, the City of Seattle, WA recently mandated that all residents enroll in a food waste recycling program. After the program is fully operational, the city expects to ban residents from placing any food waste into the garbage. Residents who compost at home are exempt from the program. Once sufficient collection infrastructures are in place in Capital Area communities, local governments can begin to consider mandating recycling of food waste.

2.4 Plastic Film

2.4.1 Overview

Plastic film is made from a variety of plastic resins including polyethylene, polypropylene, ethyl vinyl acetate (EVA), and flexible polyvinyl chloride (PVC). For the purposes of this project, plastic film is grouped into two categories:

- **Residential film** – includes retail and grocery store carry out sacks; bread, sandwich and bulk food bags; dry cleaning bags; diaper outer bags; frozen food bags; and over wrap for toilet tissue and paper towels. Films are the most common type of plastic packaging and are found in bags and stretch wrap, derived primarily from commercial sources.
- **Stretch wrap** (also called pallet or shrink wrap) – derived from non-residential sources. Stretch wrap is widely used in the transport and storage of commercial goods.

These materials do not comprise a significant component of the MSW stream (less than 3 percent of U.S. MSW, according to the EPA); however, they are a significant and highly visible percentage of the plastics waste stream and they are highly marketable if clean and densified. Consequently, plastic film is increasingly being targeted by recycling programs, and by legislation throughout the United States.

In many areas of the country, residential film plastics are collected by consumer returns to chain grocery stores. Those films, along with pallet wrap received by the grocery stores, are returned by backhaul to the warehouse and distribution center for the grocery chain where they are baled and marketed. Other commercial generators of film plastics, such as general warehouse and distribution centers, also separate, bale, and market film plastics that have been used to protect or unitize shipped products. In most instances retail store collection of film is limited to retail carry out sacks, but this is not always the case. For example, Rhode Island has a statewide plastic film retail take back program for all types of residential film plastics.

Some communities collect plastic film in their curbside and drop off programs. Many such communities are located in California. Contamination issues associated with

curbside film, however, have recently prompted one the nation's largest end user of film (Trex – discussed in Section 2.4.2) to refuse acceptance of any curbside-generated supplies of film.

Several states have either enacted or are considering laws targeting plastic carry out bags in particular. Legislative initiatives include requiring use of compostable bags, requiring grocers to collect bags for recycling and requiring grocers to offer alternatives to plastic bags, including reusable shopping bags or bins.

2.4.2 Potential Markets and Uses

The demand for clean, baled plastic film is strong, both domestically and internationally. The primary end use for recycled film plastics sold to domestic markets is plastic/sawdust composite lumber products that are used primarily in building low-maintenance patios and decks. The sawdust and plastic are usually used in nearly equal parts and are blended together as part of an extrusion process. Another, less common, use of film plastics is in manufacturing new film plastic products (such as garbage bags and trash can liners).

The TCEQ online directory of recycling markets lists 11 buyers of plastic film packaging serving the Austin area. These are a combination of brokers and processors, with only one end user listed (Trex).

Trex is one of the nation's largest composite lumber product manufacturers in the United States, making decking and railing products. Their lumber contains approximately 50 percent sawdust or other recycled fiber and 50 percent post-consumer plastic film, including stretch wrap, plastic grocery and dry cleaning bags. The firm is headquartered in Virginia and has two other manufacturing locations, including one in Nevada. They accept only baled polyethylene film primarily from grocery stores and non-residential sources and claim to consume approximately 50 percent of the plastic bags available in the marketplace.

Another large consumer of plastic film, not listed in the Texas directory but serving Texas suppliers, is Advanced Environmental Recycling Technologies, Inc. (AERT), which also produces plastic decking and lumber products. AERT has two manufacturing facilities including one in Junction, Texas, and buys film from suppliers throughout North America.

2.4.3 Current Practices in the Capital Area Region

Cycled Plastics, located in Austin, is a processor of multiple plastics grades, including stretch wrap and grocery bags. Cycled plastics works with generators to arrange for transport of plastics supply and provides a drop-off site for use by the public in recycling certain plastics including grocery bags. Given the value of stretch wrap and the availability of processors serving the Capital Area region, it is likely that many companies are recovering stretch wrap, but there is certainly room for more firms to participate.

Large national retail chains, such as Wal-Mart, are known to be baling plastic film. The bales are then backhauled to central distribution centers for consolidation and shipment to market. It is likely that this practice is prevalent in the Capital Area region as it is in other parts of the country.

With respect to residential films, H-E-B works with public schools to collect grocery bags. Participating schools collect the bags, roll them tightly, and then pack them into liners. H-E-B takes these bags and packs them into shipping containers. Participating schools earn up to one dollar per pound of plastic bags that are collected. When the containers are full, shipments are arranged by Enviro-Bag®, the buyer of the recovered bags, located in South Carolina. Enviro-Bag® uses the bags as a feedstock in the manufacture of trash bags. Other area grocers (e.g., Randalls, Whole Foods) will accept returned plastic bags from customers.

2.4.4 Barriers to Recycling

Operational and Infrastructure

- Post-consumer secondary plastic film can be contaminated with food, paper, sticky labels and other items.
- Storage may be an issue for businesses that want to recycle stretch wrap, since enough material needs to be stockpiled to arrange for pick up or transport to market cost effectively.
- Many generators may be unaware that the balers they have for cardboard can also be used to bale stretch wrap.
- Retail stores have limited storage space, and may be reluctant to accept film for recycling – particularly residential film other than retail carry out sacks.
- The City of Austin does not collect plastic film with its curbside recycling collection program since its MRF is not equipped to efficiently separate this material from the stream of mixed recyclables.[13] Other local governments that may take material to the MRF are therefore not allowed to include plastic bags in their collection programs.

Educational and Informational

- Generators of shrink wrap may not be aware that this material can be recycled economically.
- Opportunities to recycle residential sources of film may exist but are often not publicized; therefore, many residents may be unaware of these opportunities.

[13] The City of Austin is considering measures to limit or better manage plastic bags in the City. Additionally, the City is pursuing the development of a new single-stream recycling facility that could have the ability to sort plastic bags collected at the curb.

2.4.5 Strategy Recommendations

1. **Encourage businesses to recycle their film plastic, and provide information on processors that are interested in purchasing these materials.** CAPCOG and its member communities could provide best practices guidance and information on the benefits of recycling film plastic via websites, meetings, articles and distribution of printed materials.
2. **Implement a public information and promotion campaign to boost the recycling of film collected through the schools, drop-off centers and retail locations accepting film.** The goal would be to have all residents in the region aware of film recycling opportunities and understanding of what is and is not acceptable for recycling.
3. **Add collection of plastic film to public drop off centers that have balers for old corrugated cardboard (OCC).** Communities that accept OCC for recycling will generally have the processing capability to also accept plastic film. Given the value of this material, it will likely be cost effective for communities to operate a plastic film collection program.
4. **Consider passing an ordinance requiring retail establishments (or at least all local grocers) to accept plastic film for recycling.** Such policies are becoming increasingly common in North America, and are preferred over policies mandating use of compostable bags, which can actually interfere in plastics recycling, given compostable bags are a contaminant to film in the recycling process.

2.5 Glass Beverage Containers

2.5.1 Overview

For purposes of this project, glass beverage container components include flint (clear), amber (brown), green, blue, and other colors of glass bottles. Used glass containers can be captured from households through curbside recycling programs, drop off recycling centers, and container redemption programs. Glass containers are also generated by commercial sources such as bars, restaurants and other food service establishments. In addition, some glass containers are generated by industrial sources, for example broken or surplus glass container inventory. Approximately 11 million tons of glass bottles and jars from container packaging were generated in the United States in 2005. Of these 11 million tons, approximately 2.76 million total tons (or 25.1 percent) were recovered through recycling programs.[14]

In the United States, there are four different types of glass beverage and food containers: flint, amber, green, and blue and other colors. All four types of glass are made from silica, sand, soda ash, limestone, and recycled glass cullet. Cullet is broken or crushed glass that is suitable for re-melting.

[14] Source: "Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2005," U.S. EPA, October 2006

2.5.2 Potential Markets and Uses

Glass Beverage Container Manufacturing

The primary and most common end market for recycled glass beverage containers is in manufacturing new glass beverage containers. Glass recycling facilities perform a glass beneficiation procedure in which they use air classification, screening, metal separation, vacuum extraction, and dust control to remove contaminants such as paper, plastic and metal, before they crush the glass into cullet. The processor sells the cullet to a container manufacturer where it is used to produce new containers.

There are at least three operating glass manufacturing plants in Texas as well as at least three cullet processors. These companies are listed in Table 2-1.

Table 2-1
Glass Beverage Container Recycling Companies

Company Name	Activity	Location	Street Address	Phone Number
Owens-Illinois	Glass manufacturing	Waco	5200 Beverly Dr.	(254) 754-9500
Saint Gobain	Glass manufacturing	Waxahachie	2400 I-35 East	(972) 455-4500
Longhorn Glass Corp	Glass manufacturing	Houston	4202 Fidelity St.	(713) 679-7500
Strategic Materials	Cullet beneficiation	Houston	1919 Goodyear	(713) 472-2449
Strategic Materials	Cullet beneficiation	Midlothian	3240 Robinson Rd.	(972) 723-2422
Dlubak Glass	Cullet beneficiation	Waxahachie	400 Mushroom Rd.	(972) 938-0865

Recycled glass processed at cullet beneficiation facilities can be substituted for up to 70 percent of material inputs at glass manufacturing plants. Utilizing recycled glass in manufacturing offers two primary benefits:

- Reduction in energy costs and emissions; and
- Extension in the life of plant equipment (such as furnaces).

There is relatively stable pricing and demand for color-sorted clear and amber glass delivered to processors. The price offered is typically in the range between $15 and $25 per ton. However, processors are reluctant to accept green glass and may even charge communities to dispose of this commodity. The reason for this is that green glass bottles are not typically manufactured in the region, and therefore there is no end use for green glass cullet.

Aggregate Material

Glass cullet can be used as aggregate in many applications, including aggregate base for road construction. In 1995 the Texas Tech University College of Engineering evaluated the use of glass in roadways, and results showed that cullet appeared to be an excellent supplement or replacement for gravel in many construction applications. In addition, depending on the market conditions of a given location, glass cullet can be competitive in price or even less expensive then virgin aggregate.

Other aggregate applications for recycled glass are listed below. Most of these applications utilize mixed glass cullet, which avoids the expense of color sorting. For more detailed information on these applications, see Appendix A.

- **Cover for landfill roads:** Recycled glass may be used to provide dust control for temporary roads at landfills.
- **"Glasphalt" road material:** Five to ten percent recycled glass may be mixed with asphalt and aggregate for road surfacing.
- **Sand or salt mix for roads in cold weather:** Recycled glass may be mixed with sand, salt or magnesium chloride to apply to roads and sidewalks in winter.
- **Striping:** Recycled glass may be used as reflective material in road stripes or cross walks.

Filtration, Sand and Abrasive Uses

Glass cullet may also be used for many filtration, sand and abrasive uses. Potential applications of this nature are listed below. See Appendix A for more detailed information on these applications.

- **Pipe bedding and septic system mounds:** Crushed glass is laid below pipes when installing or building septic mounds
- **Sand:** Glass may be pulverized to a fine grain to be used at beaches, golf courses, and playgrounds
- **Industrial abrasives:** Recycled glass may be used as an abrasive for cleaning, scouring, and blasting of various surface types.

Landscaping, Tile and Other Uses

There are potential applications for glass cullet in landscaping and tile. These applications are listed below. See Appendix A for additional detail.

- **Landscaping material:** Crushed glass can be used as landscape ornament to surround stepping stones and act as mulch to various plants, such as succulents.
- **Trail bed:** Glass is pulverized into sand and used to cover trail beds.
- **Compost:** Crushed glass can be used as an additive in compost.
- **Glass-epoxy flooring:** Recycled glass can be made into a counter top or flooring material.
- **Kiln process:** Recycled glass may be integrated into conventional ceramic processes to make tiles and countertops.

2.5.3 Current Practices in the Capital Area Region

Table 2-2 summarizes the current recycling activity of glass beverage containers in the Capital Area region.

Table 2-2
Use of Recycled Glass for Landscaping, Tile and Other Uses

Jurisdiction	Collection	Processing	Market or End Use
City of Austin	City of Austin MRF accepts glass material from residential curbside programs in San Marcos, Buda, Kyle and Austin (mixed glass, no color sorting). Color sorted glass collected through Green Guy and Ecology Action drop off centers (flint and amber glass only).	Color-sorted glass sold to Dlubak in Waxahachie Green and mixed glass is pulverized by the City of Austin	Dlubak processes color sorted glass and end product is used in new glass containers. Mixed glass cullet is given to TDS and marketed as ornamental landscaping material by TDS Some mixed cullet is used as landfill for dust control
Blanco County	Drop off collection center Accept material from Johnson City and Hays County	Crush with pulverizer Equipment purchased with CAPCOG grant	Use in road base
Fayette County	Drop off collection center; Accept material from Lee County	Crush with pulverizer Equipment purchased with CAPCOG grant	Use in road base Have capacity to use more material
Hays County	Transfer station and citizens collection station	Take containers to Blanco County Blanco County shares processed material Hays County covers some maintenance costs	Use in road base
Lee County	Drop-off recycling center	Containers are taken to Fayette County Fayette County shares processed material Jars are set aside for use in canning	Use in road base Have capacity to use more material
Travis County	Ecology Action drop off centers	Take glass to City of Austin facility	See City of Austin

Several communities use pulverizing equipment to process glass beverage containers. Blanco County and Fayette County purchased glass pulverizers with CAPCOG grant funds.[15] These counties process material collected at drop off recycling centers and use the mixed glass cullet in road base. Blanco County processes the glass for both Hays County and Johnson City, and these communities help defray the operating costs of the crushing operation. Fayette County processes glass material from Lee County.

[15] R. W. Beck did not speak with representatives from each community in the Capital Area region. As such, it is likely that similar recycling activities are occurring in other communities in the region.

Both counties report to have excess capacity in terms of how much material they could potentially use.

Glass containers are collected at curbside for recycling in many jurisdictions in the Capital Area region. For example, the City of Austin collects glass beverage containers as part of its single stream curbside program. The city also accepts mixed glass material from the cities of Kyle, Buda, and San Marcos. The city uses a pulverizer to crush the mixed glass and hauls the material to the TDS facility. TDS processes the glass a second time and resells the final product as landscape rock.

The TDS glass operation is unique in that TDS processes, manufactures, and markets the material. By maintaining control of both processing and final product distribution, TDS can provide for quality control and market the product to meet the specifications of target markets. TDS representatives describe recycled glass landscape rock product as coarser than sand but smooth enough to walk on with bare feet. The recycled glass rock product sells for $23.00 per cubic yard and is suitable for both ornamental landscaping as well as for dust control on driveways. TDS is able to sell the majority of the material that they receive from Austin as landscape rock.

The City of Austin contracts with Ecology Action for drop off recycling centers that collect color sorted glass. Because markets are limited, green glass is processed with the mixed glass and marketed as mixed cullet. The city sells color sorted amber and flint glass to Dlubak Glass in Waxahachie for $15 per ton. Dlubak processes the color sorted glass and sells the processed material to be used in glass beverage container manufacturing.

2.5.4 Barriers to Recycling

Operational and Infrastructure

- With the shift toward single stream recycling programs in the Capital Area region, it is increasingly difficult to market glass beverage containers as color sorted material. The Allied Waste MRF does not accept glass bottles, so there is no viable method of sorting mixed glass bottles by color.
- Contamination is often an issue with both curbside and drop off center collection programs. Participants may place ceramics, Pyrex, and other non-container glass items into the recycling container. While dual-stream curbside collection systems allow for some curbside screening for contaminants, collection of glass containers through single-stream programs and drop-off centers provide less opportunity for quality control and removal of these contaminants.
- Most of the communities in the Capital Area region are seeking to market their glass as mixed color material. In order to market mixed loads to the beverage container manufacturing industry, processors must have optical sorting equipment. There are currently no processors in Texas that have this equipment; therefore, processors do not accept loads of mixed color, whole glass bottles.

Economic

- Recycled glass is a low value material that competes with other readily available virgin material in the marketplace, such as sand and gravel. Consequently, increasing transportation costs limit the viability of transporting recycled glass from the Capital Area region to end users elsewhere in the State.
- The glass processing and manufacturing facilities in Texas are located in North Central Texas and in the Houston area. Because of the distance of these facilities from the Capital Area region, transportation costs are generally high.
- Markets for mixed glass cullet generally do not generate revenue, making it difficult to recover the high operating costs of glass pulverizing equipment.

Perceptional

- Public works officials, residents, and private company representatives have concerns regarding the safety of handling and using recycled glass.

2.5.5 Strategy Recommendations

Listed below are specific strategy recommendations that R. W. Beck has developed on how CAPCOG can increase diversion of glass beverage containers. In addition, The Glass Packaging Institute (GPI) provides strategic recommendations to maximize glass recycling. Specific recommendations from the GPI are included in Appendix A.

1. **Market glass as color sorted when possible.** Collecting clear, brown, and "other colors" glass in separate containers at drop-off centers or collecting color sorted glass from commercial establishments are two ways to capture color sorted glass in a cost effective manner. As the only revenue generating application for this material, CAPCOG and its member communities should take every opportunity to market material in this way, so long as transportation costs make it economically viable.
2. **Closely follow market developments in mixed glass.** There are currently no glass processing companies in Texas that have optical sorting equipment. However, Strategic Materials is currently in the process of upgrading their Midlothian plant to operate optical sorting equipment. According to company representatives, this upgrade should be complete within the year. With the new equipment, the plant will be able to accept loads of mixed color, whole glass bottles.
3. **Hold stakeholder forums for mixed glass cullet.** CAPCOG should consider holding a stakeholder forum to bring together suppliers, processors, existing end users and potential end users of mixed glass cullet. It is through such venues that value chain players can learn about each other's needs and concerns, explore opportunities to work together to overcome barriers, and pursue opportunities of mutual benefit.
4. **Work to increase use of glass as aggregate in road construction.** The jurisdictions of the Capital Area region can work to ensure that local public works

projects make use of opportunities to use recycled glass as appropriate in pipe bedding, road base, glasphalt, and other applications. Demonstration projects could be implemented to help address application and performance concerns.

5. **Advocate for the use of recycled glass by TxDOT.** There are many opportunities for TxDOT to use more glass in its projects than are currently being realized. CAPCOG and its member jurisdictions provide a powerful voice with the potential to influence TxDOT practices. Furthermore, CAPCOG jurisdictions could explore cooperative marketing opportunities to meet the supply needs of specific TxDOT projects.
6. **Continue public education efforts.** CAPCOG and its member communities should make a concerted effort to educate residents on what types of glass are recyclable in current programs. Further education efforts will prevent contamination of future materials. This will become especially important if CAPCOG jurisdictions market their mixed glass to Strategic Materials upon the implementation of the optical sorting equipment.

2.6 Scrap Tires

2.6.1 Overview

According to the TCEQ, approximately 19 million tires are discarded each year in Texas. Based on a population of approximately 24 million, that equates to approximately 0.8 tires per year per person. Applying that same ratio to the Capital Area region, there are approximately 1.3 million tires generated in the Capital Area region.

The TCEQ considers generators of scrap tires to be:

- Tire dealers,
- Junk yards,
- Fleet operators, and
- Other (e.g. residents, commercial businesses)

About 80 percent of all scrap tires are handled by retail tire dealers. The remaining 20 percent are handled by generators. While tire dealers do not actually produce scrap tires, they collect and store tires until they are picked up by transporters. Transporters maintain records using a manifest system, and must notify the generator of any changes to a manifest. Transporters are required to submit an annual report of the manifest information to the TCEQ. A signed registration application must be submitted to the TCEQ before a transporter begins collecting tires. There are no application fees or annual fees. Exemptions from registration include generators hauling their own tires, on-site sewage facility installers hauling shreds, MSW collection vehicles, local government vehicles, and retreaders. These transporters typically take the tires to retreaders, reclaimers, processors grinders or slitters or to tire disposal sites (landfills, tire stockpiles, or illegal dumps).

2.6.2 Potential Markets and Uses

The potential uses of scrap tires have been well documented. Studies like R. W. Beck's study for the New York State Department of Economic Development provide extensive detail about the potential uses of scrap tires. This section provides a brief overview of the uses. The R. W. Beck study completed for New York State is available online and provides an additional resource to supplement the information provided in this report. [16]

Reuse

Tire reuse is primarily in the form of retreading. Retreading involves removing the tread of a worn tire, and affixing a new tread to the tire to extend its life. For most passenger tires, retreading is no longer considered to be cost-effective, as passenger tires have actually become relatively less expensive to manufacture and purchase than retreads over the past thirty years. Exceptions include fleets owned by governments and other large institutions, which sometimes contract for retread tires. Retreading remains highly economical to truck and industrial tire consumers, however. Tires that are partially worn, especially airplane tires, medium truck tires and off-the-road (OTR) tires, are frequently retreaded. To be retreaded, the tire casing must be in good condition and the tread worn down but intact.

One additional reuse option for tires is the resale of partially worn tires such as tires salvaged from wrecked vehicles that still have useful life. This practice is not as common in the United States, but such opportunities do exist. In addition, many such tires are exported for sale in other countries.

Crumb Rubber

Crumb rubber is typically defined as ground rubber that has been reduced to a particle size of 3/8 inch or less which has been processed to remove the steel belting and other non-rubber material. There are various grades of crumb rubber, depending on the end use. Some typical uses of crumb rubber include:

- Road construction (e.g., rubberized asphalt, binder, crack seal)
- Recreational surfaces (e.g., playgrounds, running tracks)
- Molded products
- Rubber and plastic compounding
- New tires (very limited)

Tire-Derived Aggregate

Tire-derived aggregate (TDA) consists of tires that are chipped or shredded to various sizes depending on their end use application. Wire is also removed to varying degrees, depending on the application. The term "TDA" is used to emphasize that this

[16] Source: http://www.nylovesbiz.com/pdf/polution_prevention_recycle/tirereport06.pdf.

scrap tire material is a direct substitute for rock and other natural aggregate materials. The primary uses for TDA are:

- Landfill applications (e.g., leachate and landfill gas collection systems)
- Road construction (light weight fill, permeable friction coarse, erosion control, landscaping, etc.)
- Septic drainage
- Playgrounds and landscaping

Baled Tires

The University of Texas at Austin has been conducting research for TxDOT to place bales of tires in stacks under ground to repair or construct embankments. This application appears to have promise.

Fuel Use

Scrap tires can be used by manufacturing facilities as a fuel source and/or raw material supply in the production of value added products. The main candidates are steel mills using electric arc furnaces and cement kilns (both of which use tire-derived fuel and also for the material's intrinsic properties) and pulp and paper mills (which use tire-derived fuel only).

Many electric utilities and some industrial facilities use circulating fluidized bed (CFB) combustors. CFBs burn solid fuel by circulating large amounts of ash or other inert material, effectively suspending the fuel in the upwardly moving stream of air and ash. This process promotes complete combustion, under conditions of high heat transfer at relatively low combustion temperatures (approximately 1600 degrees F). The benefits of CFBs over other solid fuel combustors include flexibility in fuel selection and reduced air emissions. CFB combustors can generally burn tires efficiently, due to the inherent fuel flexibility of their design. Tires need to be chipped typically into 2-inch minus size in order to fluidize in the combustor.

2.6.3 Current Practices in the Capital Area Region

R. W. Beck interviewed landfill operators in the Capital Area region as a part of a waste minimization study for CAPCOG in 2005.[17] During those interviews, the landfill operators indicated that they preferred to recycle tires rather than dispose of them in landfills. Most CAPCOG landfills keep tire disposal to a minimum. However, these used tires must be processed in some way to avoid the creation of used tire stockpiles.

Based on that information, scrap tires do not currently have a significant impact on disposal capacity in the region. However, proper management of scrap tires is still a key issue for both local governments and disposal locations, since there are costs associated with transporting and management of these tires. Recycling and reuse must

[17] Source: "Waste Minimization and Landfill Alternatives." R.W.Beck, prepared for CAPCOG in June 2005. Document is located at http://www.capcog.org/crd/solidwaste/.

keep pace with the amount of used tires that become available to avoid stockpiling and illegal dumping. Further, demand for recycled tires must continue to grow to ensure that a market exists for these recycled tires.

Private firms mentioned as collecting tires from CAPCOG jurisdictions, per R. W. Beck interviews with local representatives are Able Tire in San Antonio and Green Guy Recycling in San Marcos. The final disposition of tires collected by these firms is not known.

2.6.4 Barriers to Recycling

Economic

- Unprocessed tires have a negative market value. Consequently, there are costs associated with transport of tires to market as well as processing of tires for marketing and end use.
- Funding for clean-up of tire stockpiles and illegally dumped tires is limited.
- Although markets exist for scrap tires, the cost of using recovered material from these tires often does not offer a significant financial advantage over the use of virgin rubber material. However, as the cost of oil increases, it becomes more financially feasible to reuse and recycle scrap tires. In addition, some applications of tires offer advantages over alternative feedstocks (e.g. use of chipped tires as lightweight fill material).

Regulatory

- Lack of State Tire Management Program. The State of Texas operated a waste tire recycling program from 1992 through 1997. When the tire program was eliminated, the associated revenues generated through the $2.00 recycling fee were no longer available for the clean-up of illegal sites or the ongoing collection of used tires. Currently, tire dealers are allowed to set their own fee for the disposal of scrap tires, although individuals may choose not to pay the fee and may take their scrap tires away with them. As such, there are opportunities for these tires to be improperly disposed or illegally dumped.

Educational and Informational

- Many potential users of scrap tires are not aware of the benefits of doing so.

2.6.5 Strategy Recommendations

1. **Promote reinstatement of State scrap tires management program. Management of scrap tires is difficult to address at the local or regional level.** If one county or region develops a comprehensive scrap tire management and enforcement program, the illegal dumpers would be able to simply dump in a nearby area that does not have such a program in place. Therefore, communities in the Capital Area region would benefit from a statewide program that is designed

to comprehensively address the issue of scrap tire disposal. Examples of scrap tire management programs in other states are listed as follows:[18]

- **Arkansas:** Regional solid waste authorities in the State are required to establish collection centers for scrap tires. All programs are funded through a $1.75 retail tire tax that is assessed on individuals when they purchase new tires. Regional authorities are also allowed to implement a tax for truck tires of no more than $4 per tire.
- **California:** The State of California collects a $1 fee on all tires at the point of sale for the California Tire Recycling Management Fund. This fund is used to provide grants and loans for tire recycling efforts around the state. Whole tires have been banned from landfills in California since 1993.
- **Oklahoma:** The State of Oklahoma has a retail tire tax of $1 for car tires and $3.50 for truck tires. Tax funds are deposited in the state's Waste Tire Indemnity Fund to fund cleanup of illegally dumped tires and reimburse facilities that process scrap tires.

2. **Promote local, regional and state use of crumb rubber from tires in roadway construction.** According to a TxDOT representative, a potential application of crumb rubber from tires is in making permeable friction course, a roadway construction product that increases the permeability of road surfacing which has environmental benefits. CAPCOG jurisdictions could promote this roadway application in local public works projects as well as encourage the State to increase its use of tires in road construction applications both in and outside the Capital Area region. Local governments in the Capital Area can explore the possibility of enacting mandates for the use of tires in roadway applications.
3. **Investigate opportunities for crumb rubber producers to accept tires generated in the Capital Area region if CAPCOG will agree to purchase the end product.** Crumb rubber producers are located in Baytown and Midland-Odessa. It is possible that a toll processing partnership could be developed where tires are supplied in exchange for product purchased back from the crumb rubber producer (suggested by the TxDOT representative interviewed for this project.)
4. **Investigate Austin cement kiln opportunities.** There appears to be TCEQ support for burning of tires in cement kilns. While this activity cannot be classified as recycling, use of scrap tires as fuel in manufacturing operations offers environmental benefits over disposal.
5. **Promote civil engineering applications for TDA.** This is an area with much room for growth. The key to this strategy is demonstrating the benefits and safety of using TDA in this fashion. CAPCOG and its member jurisdictions could sponsor demonstration projects as well as host stakeholder forums in which industry experts, suppliers, specifications drafters, and potential users convened to discuss technical issues and concerns and solutions for addressing them.

[18] Source: *State Scrap Tire Programs: A Quick Reference Guide*, EPA 1999. Document may be found at http://www.epa.gov/epaoswer/non-hw/muncpl/tires/scrapti.pdf.

6. **Encourage public school system use of tire products in playground, synthetic turf, and athletic track and field surfacing.** Financial incentives such as grants would help to stimulate this activity. This approach has been employed successfully in California.
7. **Encourage use of retreads in government-owned fleets and vehicles (non-passenger tires).** This is a common practice for local government vehicle fleets in the United States.

2.7 Asphalt Shingles

2.7.1 Overview

Approximately 11 million tons of scrap roofing shingles are generated each year in the Unites States.[19] Between seven and 10 million tons of this material is generated by commercial and residential roof replacements (post-consumer) and the rest comes from shingle manufacturing facilities (post-industrial). Historically, 95 percent of roofing scrap material has been landfilled.

Asphalt shingles are composed of asphalt and aggregate, making them a viable ingredient in materials that also require those two components, such as HMA, cold patch, and aggregate road base. The following subsections contain a more detailed discussion of these three uses.

2.7.2 Potential Markets and Uses

Hot Mix Asphalt

The largest market for recycled asphalt shingles is the production of HMA, which represents 90 percent of all asphalt produced in the United States. HMA is composed of approximately 95 percent aggregates and five percent asphalt cement by weight.[20] When using recycled shingles in producing HMA, the shingles are ground and mixed with the aggregate before introducing the virgin asphalt binder.

Studies have found several benefits to using recycled shingles in the production of HMA, including:

- **Decreased demand on virgin asphalt:** Decreased demand on virgin asphalt offers an economic and environmental benefit. The use of recycled shingles offers an economic advantage to HMA producers as the price of virgin asphalt is driven by the increase in petroleum prices. In addition, since asphalt is petroleum-based, decreased demand conserves a non-renewable resource.

[19] Source: "Year of the Recycled Roadway: Roofing Shingles," Texas Department of Transportation. Document can be found at ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/yrr_april.pdf.
[20] Source: National Asphalt Pavement Association, http://www.hotmix.org/aboutnapa.php.

- **Decreased demand on virgin aggregate:** The use of recycled shingles also reduces demand on virgin aggregate, as the aggregate contained in the shingles supplements the aggregate content of the cement.
- **Improved properties of asphalt pavement:** A study in North Carolina found that the use of post-industrial roofing material in HMA can produce a pavement that performs equal to or better than HMA.[21] The same study found that rutting resistance was improved in pavement containing recycled shingles.

Cold Patch

Traditional cold patch is a mixture made of asphalt, aggregate and a solvent, and may be applied to patch potholes, construct sidewalks, and repair driveways, ramps, bridges and parking lots. In place of virgin asphalt, post-industrial or post-consumer shingles can be used to make cold patch. Shingles must be ground to one-quarter inch and mixed with aggregate material. If post consumer shingles are used, then a solvent must be added to the mixture. However, if post industrial scrap is used, a solvent may not be necessary. Recycled shingle cold patch may be applied by unskilled labor. To apply, one must merely fill the pothole with material and either tamp down with a shovel or drive over the area. Traffic can be allowed into the area immediately after applying the patch.

Using recycled shingle cold patch offers many benefits, including:

- **Improved performance compared to traditional cold patch:** Multiple tests in New Jersey found that recycled shingle cold patch performed better than traditional cold patch product.[22]
- **Less dense than traditional cold patch:** Recycled shingle cold patch is less dense than other patch material, making it easier to handle.[23]

Aggregate Base

Shingles may also be used in the aggregate base or sub-base in road construction. Shingles are ground and then added to asphalt or concrete to make the base. It is suspected that using recycled shingles in road base may improve compaction of the material, but this has not been conclusively demonstrated with testing. There has been little research done in this area.[24]

Dust and Erosion Control and Temporary Surfacing

Recycled asphalt shingles may be ground coarsely and mixed with gravel to cover low-traffic roads such as rural lanes and farm roads. In addition, shingles can be

[21] Source: Evaluation of Roofing Shingles in HMA, Ross and Associates, 1997
[22] Source: "Asphalt Roofing Shingles in Asphalt Pavement," CIWMB Publication #431-97-033, California Integrated Waste Management Board, December 2006
[23] Source: "Asphalt Roofing Shingles in Cold Patch," CIWMB Publication #431-98-013 California Integrated Waste Management Board, December 2006
[24] Source: "Asphalt Roofing Shingles in Aggregate Base," CIWMB Publication #431-97-032, California Integrated Waste Management Board, December 2006

ground and run through a magnetic separator to remove the nails and then spread and compacted on driveways, parking lots and low-traffic dirt roads.

2.7.3 Current Practices in the Capital Area Region

R. W. Beck did not identify any recycling activity of asphalt shingles in the Capital Area region. Companies that actively recycle construction and demolition materials reported that they typically landfill asphalt shingles for lack of a viable market or end use. In addition, due to regulatory barriers to be discussed in subsequent subsections there are few, if any, active shingle recycling companies in the state of Texas.

2.7.4 Barriers to Recycling

Regulatory

- According to current TCEQ regulations, only post-industrial shingle scrap may be used in the manufacturing of HMA. This regulation is due to lack of conclusive data on the air emissions quality of HMA plants when recycled shingles have been used. Industry needs to conduct further air emissions tests in order to provide sufficient data for TCEQ to authorize the use of post-consumer shingle scrap in HMA. Because of these market conditions, there are few, if any, active shingle recyclers in the state of Texas.

Operational and Infrastructure

- Recovered shingles may contain contaminants, such as polycyclic aromatic hydrocarbons (PAH) and asbestos, that could be released into the air when processed in HMA application. The extent to which these contaminants are present is unknown. Further air emissions testing is needed in order to determine if these contaminants are present in shingles and in what quantity.
- R. W. Beck did not identify any active processors of roofing shingles in Texas. This is potentially due to the current TCEQ regulations that prevent the use of post-consumer shingle scrap in the production of HMA due to lack of industry data on air emissions.
- The Capital Area region does not have a MRF for C&D materials. Therefore, shingles would need to be recovered at construction sites and hauled to a processing facility in order to be recycled. See Section 3.2 for a more detailed discussion of this barrier.
- R. W. Beck did not identify any shingle manufacturing facilities in the Capital Area region. Therefore, there are no sources of potentially recyclable post-industrial roofing shingles.

Economic

- Applications such as dust control and temporary surfacing are low value added and may not be economical depending on site locations relative to the source of shingle material.

Educational and Informational

- Local governments and public works officials may not be familiar with how to use recycled shingles for applications such as cold patch, dust control and temporary surfacing.
- Local government public works officials may be hesitant to explore this use of the material without first-hand knowledge of how it works

2.7.5 Strategy Recommendations

1. **Encourage use of shingles for cold patch application.** Based on the findings of this study, R. W. Beck sees cold patch as the most viable end use for recycled asphalt shingles for the CAPCOG member communities in the short term. R. W. Beck recommends the following courses of action to further develop this application of shingle material.
   - Interview local government public works officials to assess the level of demand for cold patch.
   - Coordinate one or more demonstration projects to inform local public works officials on the use of shingles in cold patch. This project could involve graduate students from the University of Texas in order to conduct performance testing and develop a specification for recycled shingle cold patch.
   - Continue to support education for developers and contractors on recycling of construction and demolition materials. See Section 3.2 for a more detailed discussion on opportunities for construction and demolition recycling.
   - Companies that have grinding equipment with magnetic separators, such as TDS, could process asphalt shingles, but would need a reliable source of shingles and end users to accept the processed supply. CAPCOG could facilitate building the supply and end use network to support shingles processing in the region, then work with one or more processors to add shingles to the list of materials that they handle.
2. **Promote use of shingles in dust and erosion control and surfacing applications.** Although limited, there are beneficial uses for shingles in dust and erosion control and surfacing applications that could be pursued if clean, ground shingles were available through a processor in the Capital Area region. CAPCOG could provide promotion and education assistance to boost use of shingles in these applications, beginning internally with local public works departments and their contractors.

3. **Promote regulatory change regarding HMA application.** Local governments in the Capital Area region can be active players in conducting the research necessary to prompt the TCEQ to modify its regulations on use of tear off asphalt shingles in HMA applications. CAPCOG should place grant funding priority on public-private partnerships that plan to conduct this research. In addition, local governments can assess what data may exist from research conducted in other states with respect to best practices as well as air emissions quality. CAPCOG and its member jurisdictions could hold a stakeholder forum in order to inform industry players of the potential economic and environmental impact of using recycled shingles in HMA.
4. **Closely follow developments in asphalt shingle recycling.** The shingle recycling industry is a relatively new but rapidly developing field. In order to most effectively develop the market for recycled shingles, R. W. Beck recommends that CAPCOG and its member communities continue to follow developments in the shingle recycling industry. Listed below are resources that will aid in this task.
    - The EPA is in the final stages of developing two resource documents to address technical and environmental issues regarding recycling. The first is "Recycling Tear-Off Asphalt Shingles–Best Practices Guide," and the second is titled "Environmental Issues Associated with Asphalt Shingle Recycling." Both of these resource documents will be available in the fall of 2007.
    - The third annual Asphalt Shingle Recycling Forum will be held in Chicago in November 2007. This forum will cover the latest in technology, research, policy, and regulations regarding shingle recycling.
    - Additional information regarding shingle recycling, as well as registration information for the forum can be found at www.shinglerecycling.org.

2.8 Concrete

2.8.1 Overview

According to the EPA, concrete is the largest component material in C&D waste. National estimates are that concrete comprises between 40 and 50 percent of total C&D related debris. The concrete waste is generally classified as either infrastructure or building related C&D debris. The proportion of the two materials is virtually even nationally with some significant regional variances depending on ongoing demolition projects. Large road and highway projects can significantly increase the amount of concrete waste attributed to infrastructure. Due to the on-site customization nature of concrete, virtually all of the waste comes not from construction but from demolition activities, as construction waste can be minimized.

Nationally, between 50 and 57 percent of concrete is recycled and used in applications in place of virgin material. The Construction Materials Recycling Association has estimated that 100 million tons of concrete are diverted from landfills every year. In

regions with strong recycling programs such as the State of California and King County, WA the proportion of concrete in C&D waste has fallen to second place behind wood waste.

Processing requirements for recycled concrete are similar across different applications. The material must be crushed and then all rebar removed with a magnetic separator. The remaining aggregate material is screened according to the end use. This separation is done through filters according to the size of the needed end material. Pieces that are too large are fed back through the crusher.

Projects of significant enough size can recycle concrete on site. This can create a significant cost savings by creating usable material at a reduced price while eliminating the tipping fees for the recycled material. Processing material on site eliminates the transportation costs that pose a significant barrier to many concrete recycling efforts. It is necessary that the project be significantly large in order to take full advantage of the significant capital cost associated with on-site processing. Mobile processing is usually used in road construction projects as the old material can be processed on site and used for the replacement road.

2.8.2 Potential Markets and Uses

Flexbase

Flexbase and cement-stabilized base for roads are two of the most common uses of recycled concrete. The crushed aggregate is useful as base for concrete or asphalt pavement. The material is virtually identical to virgin base, and in many instances material can be processed on-site using mobile crushing equipment, saving on transportation costs of virgin material from the quarry and waste material to the landfill. The cost of tipping fees at the recycling facility is also avoided.

Subgrade Stabilization

Subgrade stabilization for road construction is an additional use for recycled concrete. Crushed aggregate can be mixed with subgrade to increase the load bearing capacity of soil. Use of crushed aggregate changes the water susceptibility of the soil which increases its stability.

Erosion Control

Erosion control is the easiest use for recycled concrete as it can be accomplished without the use of capital intensive crushing and separating machinery. Used concrete can simply be collected and stored then used as erosion control simply through placement of the material at the desired location.

2.8.3 Current Practices in the Capital Area Region

Lee County uses old concrete for erosion control. Contractors with concrete waste contact the county for pickup. The contractors then load the waste concrete into county containers to be hauled by the county. The county stores the material until

needed for erosion control projects. Potential erosion control projects are construction sites and creek beds. There is no need for processing as the used concrete is in adequate condition in its collected form. Due to the relatively low capital costs and universal need for erosion control, this can be an excellent use provided the size of demolition projects is relatively small and there is a sufficient demand for erosion control.

TxDOT currently has specifications that allow crushed concrete to be used in flexbase, cement stabilized base, and riprap. In order to justify the use of recycled concrete in their projects, TxDOT has performed a number of studies on the material and has found that the recycled material has performed well. In these studies, no adverse effects were found when recycled concrete material was used in the construction of reinforced concrete pavement. TxDOT is currently using recycled concrete in base, pavement, and retaining walls. Because studies have found some degradation in structural specifications, TxDOT is currently not using recycled aggregate in applications with a structural component. Structural concrete is any application in which the concrete must be designed to carry a load.

973 Pit Materials is the largest concrete processor in the Capital Area region. This company takes concrete and asphalt from the City of Austin, Travis County, TDS, and a number of private contractors in the area. The company also received material from the old and new Austin area airport projects, the University of Texas football stadium renovation, and Palmer auditorium projects. The company currently recycles approximately 500,000 tons of concrete material annually. Key staff members report that there is a sufficient supply of material. However, the company reports that it has faced challenges in getting approval of recycled materials for use in projects in the region.

TDS accepts concrete at their landfill along with other C&D materials such as drywall, scrap metal, and scrap lumber. TDS crushes the scrap concrete material and uses it as road base in the construction of roads at the landfill. It is likely that other private solid waste facilities in the Capital Area region offer similar services.

2.8.4 Barriers to Recycling

Economic

- The low cost of virgin material, especially in the Capital Area region, significantly decreases the economic benefit of using recycled concrete over virgin material. The costs associated with crushing the used concrete and separating the steel rebar and other contaminants can decrease the economic viability of using recycled material. Economic benefits can still be achieved, but the decision to use crushed aggregate over virgin stone is not as clear as in other regions.
- The geologic makeup of the Capital Area region hampers the economic viability of concrete recycling. Due to the high deposits of limestone, virgin material is cheap and readily available. There are a number of stone crushing companies in the Capital Area region, which reduces the transportation costs for stone and

economic benefits associated with using recycled concrete aggregate in place of crushed stone. The end result is that it is more difficult to encourage the use of recycled aggregate over virgin material.

- Low tipping fees do not create enough of an incentive to keep used concrete out of the landfill. Concrete is a relatively heavy material, comprising a significant portion of C&D waste, but the cost associated with disposal of this material is low. For many contractors, the costs associated with separation are greater than the tipping fees incurred.
- Due to its weight, the cost of transporting concrete is significant. This creates problems for concrete recyclers because they must cover costs of transporting the material to their facility for processing as well as transport the aggregate to the end customer. This cost must be recovered through tipping fees to the supplier of material or price of material to the end user. While transportation costs can be avoided through portable concrete processors, these are only viable in larger projects with a sufficient amount of concrete waste and enough demand for aggregate.
- Concrete recycling requires a significant level of capital investment. Crushing, separating, and the sheer size of required storage and collection facilities create a significant entry barrier. While there is some opportunity for mobile recycling on various roadwork projects, the machinery still requires a significant capital outlay. A sizable supply of waste concrete and a substantial demand for the recycled aggregate is needed to make the recycling of concrete economically viable.

Educational and Informational

- While crushed aggregate is an excellent substitute for virgin stone in a number of applications, there are differences in the materials. Engineers and contractors may not be familiar with appropriate uses and may be reluctant to use alternative materials.
- In instances where engineered plans and specifications call for the use of virgin material, allowing for the use of recycled concrete can negatively impact the schedule and budget of the project. It is only through inclusion of recycled material from the beginning of the project that these costs can be avoided.

2.8.5 Strategy Recommendations

1. **Use recycled concrete for public projects:** The uses for recycled concrete are such that the market for the material is well in excess of the supply. While not large, there are often economic advantages to using recycled material. These advantages must be illustrated through the use of concrete in public projects. Inclusion of recycled concrete in the engineering and specifications of public projects can significantly increase the use of the material.
2. **Work to establish recycling facilities that accept source-separated C&D materials:** Such C&D recycling facilities would significantly increase the amount of material reclaimed. Contractors will be more motivated to recover concrete as

well as other C&D materials for recycling if sites are conveniently located and the cost of recycling is lower than the cost of disposing of these materials. Section 3.2 contains additional recommendations regarding promotion of C&D recycling.

3. **Provide for storage of concrete for use in erosion control:** Use of waste concrete as erosion control remains the easiest way to divert concrete from landfills. Once collected, there is no processing necessary. The material simply needs to be collected and stored until a suitable erosion control project comes about. Sites are needed for stockpiling this material for intermittent use as projects develop. Rural areas seem most fitting for such sites. Given that there are not sufficient erosion control projects to divert all concrete from landfills, it will be important to manage the receipt and distribution of concrete to ensure stockpiled supply remains in balance with available applications.

2.9 Carpet

2.9.1 Overview

According to Carpet America Recovery Effort (CARE), 5,261 million pounds of carpet was discarded nationally in 2006. Of that 240 million pounds were recycled and a total of 261 million pounds were diverted from landfills, the difference going to reuse, waste-to-energy programs, and cement kilns. Post consumer carpet is tracked separately from manufacturing carpet waste as the recycling rate for carpet manufacturing waste is significantly higher. While this represents a recycling rate of only 4.6 percent, it is more than four and a half times the rate for 2002 when CARE began operations. Carpet recycling was virtually nonexistent nationally five years ago, but now is making significant progress. The same growth can be seen in the Capital Area region.

Carpet is a composite product made from face fibers that are bonded to a backing material. Manufacturers make different brands of carpet from different face fibers, which makes carpet recycling programs more challenging because most carpet recyclers only accept carpet made from one or two types of face fiber. The most common face fibers are nylon 6.6, nylon 6, polypropylene, polyester, and other (such as wool).

Once collected, the various materials can be separated using a laser handheld device that uses the reflective properties of the carpet. This advancement has significantly increased the ease at which the materials can be sorted which is a crucial part of the process as the various materials require significantly different recycling procedures. Currently nylon 6 and polypropylene are relatively easy to recycle and can be viably processed through either carpet manufacturers or the various independent groups using reclaimed material for alternative products. While nylon 6.6 and polyester based carpets have historically been much harder to recycle, there have recently been advances in the reclamation efforts for both materials.

There are several major methods of recycling carpet: chemical, waste to energy, fiberizing, and mechanical. With the chemical method, the nylon is broken down in

order to process it into new carpet fiber. Once chemically broken down, the carpet can be used as resin for new carpet or other products. Waste to energy converts the material into fuel pellets or gas to be burned to create steam energy. Not only does this process reclaim waste materials, it also creates an energy source that burns more cleanly than traditional fossil fuels. Fiberizing harvests material and converts it into padding and matting for new carpet. Mechanical separation physically separates the "usable" carpet material from the "scrap" material. What is considered "usable" versus "scrap" will depend on the processor and available markets. The "usable" carpet is typically recycled into new fiber while the "scrap" is often used for products such as fiberboard, sod reinforcement, and geotextiles.

2.9.2 Potential Markets and Uses

Carpet recycling is in its infancy in the United States. The carpet recycling industry is driven primarily by certain resin producers seeking a low cost feedstock material and by certain large carpet manufacturers. While there are a number of recycling facilities and a number of uses for the reclaimed material, the carpet recycling industry is primarily scattered and unorganized.

While most of the companies involved in carpet recycling are not local, many of them are able to accept material on a national level. A number of them will even take on the cost of collection and transportation of reclaimed material. The Table 2-3 illustrates a number of the potential uses for carpet.

Table 2-3
Potential Uses for Carpet

Company	Uses	Website
Shaw	New Carpet	www.shawfloors.com
Mohawk	New Carpet	www.mohawkcarpet.com
LA Fiber	Carpet Backing and Pads	www.lafiber.com
Nycore	Shingles	www.nycore.com
Wellman, Inc.	Auto Parts	www.wellmaninc.com
I-Rock Composites	Landscaping and Sound Barrier brick, Erosion Control, Railroad Ties, Pavers, and Industrial Flooring	www.irockmi.com
Infiltrator Systems	Drainage Chambers for Septic and Stormwater Management	www.infiltratorsystems.com
MDM Fibers	Cement Reinforcement	www.mdmfibers.com
GeoHay	Erosion Control	www.geohay.com

While all of these companies may not currently have local outlets, there may be opportunities for local companies to access these companies, as discussed in the strategy recommendations section for carpet. The greatest opportunity locally is for

collection centers to sort, collect, and bale the various materials, then coordinate with the above companies for delivery of material.

2.9.3 Current Practices in the Capital Area Region

Nationally carpet recycling is in its early stages but growing rapidly, and the Capital Area region mirrors the national trend. There are currently no available statistics on regional recycling as most of the efforts in the region are new. While the organizations involved in collection are not well established, they are continuing to reach out to contractors and have been able to collect increasing amounts of carpet and padding waste that would otherwise go to the landfills.

R. W. Beck was able to identify three companies willing to accept carpet material: G&R Recycling, V&N Carpet, and Balcones Resources.[25] Since this is not a comprehensive list of processors, these three companies may not be the only processors in the region. G&R only recently began collecting nylon 6 carpet and polyurethane foam. They do not accept other carpet types or rubber foam. V&N Carpet accepts additional carpet types but is not able to recycle them all. The carpet can be distinguished using a handheld sorting tool, but there is generally no manner in which it can be sorted by the contractors removing the material.

R. W. Beck spoke with Capital Area region installers and retailers and learned that carpet is being delivered to these facilities when convenient. When it is not, the material ends up in the landfill. The costs associated with delivering the old material to the reclamation facilities in some cases can be greater than those of landfill tipping fees, or organizational constraints do not allow for the resources to deliver the carpet to the reclamation sites.

While the type of carpet is important, the condition of the material is generally not as important. The carpet is sorted and separated during collection. Due to the high capital costs associated with the carpet recycling process, these reclamation and collection centers typically rely on larger recycling facilities for processing of the material.

CARE is an organization that is attempting to aid in the carpet recycling effort through facilitating the flow of information between recovery centers and recycling facilities. CARE acts on a national level to increase the awareness of recycling and encourages the development of the various technologies associated with reclaiming carpet materials. Balcones Resources represents CARE in the Capital Area region, but they primarily focus on paper recycling and have a relatively limited carpet recycling presence. In addition to Balcones Resources, Texas Carpet Recovery works with CARE throughout Texas to encourage and increase carpet recycling in the state. Their presence is primarily focused on the Houston and Dallas markets.

[25] G&R Recycling is located at 4606 Burleson Road, Austin, TX 78744. V&N Carpet is located at 404 West Powell Lane, Austin, TX 78753. Balcones Resources is located at 2416 East 6th Street, Austin, TX 78702/

2.9.4 Barriers to Recycling

Operational and Infrastructure

- Carpet is difficult to recycle as each of the various materials used in the face fibers, as well as the different materials in the backing system, require different processes to recycle. Carpet materials must be sorted by type prior to recycling. The varying value across the different types of carpet combined with the difficulty of separating these types creates a significant barrier to recycling. This creates a problem not only with recycling the difficult materials but also with the collection of all carpet. Installers are less likely to bring all carpet to a collection center unless they know it will be accepted and avoid the inefficiency of a second trip to the landfill.

Economic

- Due to its weight and bulk, transportation costs play a significant roll in the viability of carpet recovery and reclamation projects. Given the relatively thin margins associated with carpet reclamation, the costs associated with active collection threaten the viability of many reclamation organizations. In order to avoid these costs, the majority of collection facilities either collect only large quantities of material or simply do not offer collection service. The larger of the national recycling facilities will collect carpet, but they will only collect separated and baled materials.

2.9.5 Strategy Recommendations

1. **Promote carpet leasing over traditional carpet purchase.** Carpet leasing programs, in which carpet manufacturers take responsibility for carpet throughout its useful life then reclaim and recycle the material into new products, provide a method by which carpet is actively recovered. Leasing is a relatively new concept and primarily only viable in commercial applications, but it offers a reduced up front cost to the end user and allows carpet manufacturers to maintain control of the material. Under leasing, the carpet can even be removed, cleaned, restored, and reused thereby diverting 100 percent of the material. CAPCOG and its member communities could explore carpet leasing for all public facilities and could promote use of carpet leasing by commercial and institutional entities in the Capital Area region.
2. **Promote the availability of local recycling outlets for carpet and the benefits of recycling carpet.** CAPCOG-sponsored awareness and education programs targeting carpet retailers and installers as well as business and industrial entities that might generate carpet could significantly help direct material to the drop off locations and keep them out of the landfills. Carpet recycling is currently in its very early stages, and the processes to share information and facilitate the process are not yet in place. This deficiency was evident as the various reclamation facilities in the area were not even fully aware of each other. For example, the regional arm of CARE was aware of the efforts in the Capital Area region. There

are mechanisms in place to handle a large amount of this material, but these mechanisms are not being fully utilized.

3. **Coordinate drop off facilities, installers, and retailers to assist with collection and separation.** Collection of carpet is difficult due to the need to separate the various carpet types and the inability to easily differentiate between them without specialized equipment. There are financial incentives, in the form of avoided tipping fees, in place for installers to bring their carpet to the drop off locations. There are operational and financial issues associated with the uncertainty of possibly having to make duplicate trips to the collection facility and the landfill for different carpet types. Coordination with the collection facilities to allow for single location drop off would significantly increase the amount of diverted material.

As with other C&D-related materials, collection of the material is often a challenge. Section 3.2 presents additional recommendations regarding recycling of C&D material.

2.10 Gypsum Drywall

2.10.1 Overview

Gypsum drywall is composed of a plaster like substance that is made from gypsum and attached to a paper backing. Gypsum is composed of calcium sulfate dihydrate and is mined from natural deposits as a material for many uses, including manufacturing of gypsum drywall.

There are two primary concerns with depositing waste drywall into the landfill. First, gypsum drywall can comprise a significant percentage of the C&D waste stream. For example, a recent visual waste characterization conducted by R. W. Beck in the Dallas-Fort Worth Metroplex showed that drywall made up approximately 3.9 percent of the C&D waste stream.[26] In addition, scrap drywall can also cause odor problems at C&D landfills when the gypsum is reduced to hydrogen sulfide gas, a toxic, colorless gas with a distinctive "rotten egg" odor. For these reasons, municipal and state governments have in recent years begun to investigate strategies to divert this material.

2.10.2 Potential Markets and Uses

Portland Cement

Portland cement is the most commonly used type of cement, and is made from limestone, sand, clay, shale, water and gypsum. Gypsum is used as an additive to control the setting time of the cement. Virgin gypsum is used in the manufacturing of Portland cement and typically represents five to 10 percent of the total material input. In order for gypsum recovered from drywall to be suitable for use in cement

[26] Source: "Construction and Demolition Material Recovery Facility Feasibility Study," prepared for the North Central Texas Council of Governments, R. W. Beck 2007.

manufacturing (as a substitute for virgin gypsum) it must be removed from the paper backing and ground into a fine powder. The ground drywall is mixed with virgin material before being introduced into the manufacturing process.

During the conduct of the "Construction and Demolition Material Recovery Facility Feasibility Study," R. W. Beck identified one private recycling processor in the Pacific Northwest that collects and processes recovered drywall for use in Portland cement manufacturing.[27] This processor developed a proprietary processing system based on the specifications of the primary customer and sells all of its processed product to this cement manufacturer. This particular customer reports two primary benefits to using recycled wallboard in cement manufacturing. These benefits are listed below:

- **Satisfactory performance:** The cement manufacturer reports that recycled gypsum performs as well as virgin material for this application. The customer uses 66 percent recycled gypsum in the production of Portland cement and believes that up to 100 percent recycled content could be used.
- **Significant cost savings:** The manufacturer is able to achieve substantial cost savings by using the recycled product as opposed to virgin material.

New Drywall

Recovered gypsum drywall may also be used in the manufacturing of new drywall; however, many manufacturers will only use their own material generated from the manufacturing process in order to adhere to quality control standards. To prepare recovered drywall for reuse, the paper backing must be removed and any metal pieces (e.g. nails) must be removed with a magnet. When recycled drywall is used, the finished wallboard typically contains 10 to 20 percent recycled material. R. W. Beck did not identify any drywall manufacturing plants in the Capital Area region, but there is a drywall manufacturing facility in McQueeney, Texas, which is located in Guadalupe County.

Agriculture

Agricultural applications also hold significant potential for utilizing recovered drywall. Listed below are four potential applications for scrap drywall in agriculture:[28]

- **As a plant nutrient:** Gypsum contains two essential plant nutrients: calcium and sulfur. Virgin gypsum is commonly used as a commercial fertilizer to provide these nutrients to certain crops. Experiments have been conducted based on the hypothesis that ground gypsum drywall can be used in place of commercial gypsum fertilizers as a source of these nutrients to certain crops. For example, crushed drywall waste was found to be similar in effectiveness to commercial gypsum fertilizers when applied to potato crops in Wisconsin.[29]

[27] Source: "Construction and Demolition Material Recovery Facility Feasibility Study," prepared for the North Central Texas Council of Governments, R. W. Beck 2007.
[28] Source: "Innovative Drywall Recycling Grant" prepared for Orange County and Seminole County, FL, R. W. Beck and SCS Engineers 2003.
[29] Source: "Utilization of Crushed Gypsum Drywall Waste for Potato Production in Wisconsin," Richard Wolkowski, February 1998.

- **Improving soil structure:** The calcium in gypsum can improve the structure of clay soils. The addition of gypsum loosens the soil, allowing water and air to penetrate, which improves root growth and plant strength.
- **Soil reclamation:** Gypsum is added to sodium-rich soils to remove sodium and replace it with calcium. This process provides a better environment for crops.
- **Correction of subsoil acidity:** Gypsum can be applied to agricultural land to alleviate subsoil acidity, a condition in which soil has a toxic level of aluminum and deficient amounts of calcium.

Compost

Scrap gypsum drywall may also be used as a bulking agent in compost. Scrap drywall is ground and then incorporated into the composting operation. The paper backing to the drywall will biodegrade, however, the gypsum will not biodegrade and will be incorporated into the final compost product. The end result is compost that is rich in calcium and sulfur. As previously discussed, TDS has been successful in composting drywall and has the capacity to accept more material.

2.10.3 Current Practices in the Capital Area Region

TDS actively recycles gypsum drywall at its mulching and composting facility. TDS accepts loads of source-separated drywall from construction, renovation and demolition job sites, although most of the collected material comes from new construction. This company also offers roll-off container service to builders and contractors that wish to divert this material. The drywall is ground into a mulch-like consistency and incorporated into the compost product. A magnetic separator is used to remove any nails. This facility handles thousands of tons of drywall annually and has the capacity to significantly increase the amount of drywall that they accept.

2.10.4 Barriers to Recycling

Operational and Infrastructure

- In order to be processed at the composting facility, the drywall material must be separated at the construction site and stored in a roll off container. Builders and contractors often are reluctant to have multiple roll-off containers on site to store recyclable materials.
- Although the TDS processing facility is relatively centrally located in the Capital Area region, in the southeast part of Travis County, the site may not be within an economic haul distance of the outer areas of the region.
- Gypsum drywall agricultural applications may not be needed in the Capital Area region due to high calcium content of native soils.

Economic

- Operators in the Capital Area region that are involved in composting drywall charge a price for composting that is may not be competitive with the cost of disposal.

Educational and Informational

- Local governments and contractors may not be familiar with how gypsum drywall waste can be managed and diverted.
- Potential end users in agriculture may not be aware of the satisfactory performance and potential economic savings associated with using crushed drywall in place of commercial gypsum fertilizers.

2.10.5 Strategy Recommendations

1. **Promote C&D recycling.** In order to capture a greater amount of material for use in existing applications for drywall, CAPCOG and member communities can educate builders and contractors on the potential economic and environmental benefits associated with recycling drywall as well as how to implement a drywall recycling program. In addition, CAPCOG member communities could explore policy mechanisms to provide incentives for drywall recycling as well as recycling of other C&D materials. Section 3.2 contains additional recommendations regarding promotion of C&D recycling.
2. **Approach potential end users in agriculture.** CAPCOG and its member communities can work with private companies to approach potential users of ground drywall for agricultural applications. Specifically, local farms that commonly use commercial gypsum fertilizers should be approached and informed of the potential economic and environmental benefits to utilizing waste drywall as fertilizer. Facilitation assistance could be provided to match generators with farmers seeking to use drywall as a fertilizer substitute or soil amendment, and to determine how to process the drywall for agricultural applications.

2.11 Untreated Wood

2.11.1 Overview

Untreated wood consists primarily of wood waste from C&D activity and land clearing. Untreated wood can also include wooden shipping pallets, furniture shop cut offs, wood waste from other wood product manufacturers, and residential yard trimmings. Before being recycled, untreated wood from C&D waste, such as scrap lumber, must be separated from other wastes then cleared of contaminants such as nails and screws. Untreated wood waste from land clearing activity can be easier to recycle because source separation is not necessary and the risk of contamination is very low.

C&D wood waste represents a substantial and growing percentage of the solid waste stream. For example in a 2007 study,[30] R. W. Beck found that wood waste represented 13.4 percent of the C&D waste stream in the Dallas Fort Worth Metroplex.[31] The following subsections describe current and potential applications of this material for the Capital Area region.

2.11.2 Potential Markets and Uses

Compost

Most finished compost requires a bulking agent in order to aid in the digestion of organic feedstock, such as food waste or biosolids. While it is possible to create compost without addition of ground, untreated wood, the volume, quality and marketability of the end product increases when ground wood is added.

Mulch Feedstock

Untreated wood can be ground into mulch and sold to customers bagged or in bulk. Mulch is primarily used in landscaping as an agent to reduce erosion, increase water retention, replenish soil nutrients, and improve appearance. As discussed in Section 2.10.3, untreated wood is currently being used for this application in the Capital Area region. Mulching operations in the Capital Area region charge between $3.00 and $5.00 per cubic yard for disposal of wood waste. This amounts to between $19.29 and $32.15 per ton, prices that are generally competitive with landfill tipping fees.[32]

Engineered Wood Production

Engineered wood products are made from small pieces of wood that are bound together by a resin or glue (e.g., particle board, laminated wood, and plywood). This is a high value added application for untreated wood waste. R. W. Beck did not identify any manufacturers of engineered wood in the Capital Area region. Many of the sawmill and wood product manufacturing operations in Texas are concentrated in the eastern region of the state.

Boiler Fuel

Wood waste, when burned, can be a source of liquid or gaseous fuel. The processing requirements for use of wood waste as boiler fuel are similar to requirements for use in mulch and compost. The wood waste material must be ground and removed of all potential contaminants, such as nails. R. W. Beck did not identify that this is a common use of wood waste material in the Capital Area region.

[30] Source: "Construction and Demolition Material Recovery Facility Feasibility Study," prepared for the North Central Texas Council of Governments, 2007
[31] This 13.4% is composed of 7.4% scrap lumber, 3.3% brush, and 2.7% wood packaging.
[32] This calculation is based on a conversion rate of 311 lbs per cubic yard of wood waste.

Animal Bedding

Ground wood waste can be used as bedding for domestic animals. The absorbent quality of the wood mulch creates an ideal bedding material as it is inexpensive and eases the cleaning of animal waste. Some varieties of wood are also especially useful in reducing odor. Cedar chips are also effective as a natural insect repellant.

2.11.3 Current Practices in the Capital Area Region

The City of Austin has a dedicated residential collection program for brush and yard waste. The City grinds all wood waste and incorporates the material into compost that contains wastewater biosolids. This municipality obtains wood waste for this operation through the city's curbside yard waste collection program. The city markets the compost generated from this operation through landscape and garden supply retailers.

R. W. Beck identified two counties in the Capital Area region that are actively involved in wood waste recycling.[33] Travis County grinds tree trimmings and brush and uses the processed material in compost as well as road base. The county also takes used shipping pallets to auction for resale. In addition, Fayette County collects yard trimmings as part of the dedicated brush and bulky collection program. The county contracts with a private company for grinding of this material and resell mulch product to the public. Neither of these counties accepts scrap lumber for use in their mulching operation, but only brush and branches.

R. W. Beck identified three private companies in the Capital Area region that grind untreated wood waste into mulch. These companies are Austin Wood Recycling, TDS and L&M Wood Recycling. These companies charge between $3.00 and $5.00 per cubic yard for disposal of untreated wood waste at their facilities. TDS also provides roll-off containers in which to collect the material at construction or land clearing sites and hauls the material to its facility. Private companies market their mulch material to the public as well as landscape supply retail stores (e.g. Home Depot). A representative from TDS specifically mentioned that they could significantly increase the amount of untreated wood that they accept.

2.11.4 Barriers to Recycling

Operational and Infrastructure

- Contamination can occur when untreated wood is mixed with treated wood.
- Some municipalities in the Capital Area region have dedicated yard waste collection programs in place to capture and recycle untreated wood from residential yard trimmings. However, most of the smaller communities in the

[33] R. W. Beck did not speak with representatives from every municipality in the CAPCG region. Therefore, it is likely that similar activities are occurring in other counties and cities within the Capital Area region.

region do not have dedicated yard waste collection programs due to lack of economies of scale.

Economic

- In order to be recycled, untreated wood waste from C&D job sites must be separated from other materials and stored in a roll-off container. Builders and contractors are often reluctant to dedicate space on the job site for an additional roll-off container. Also, many are unwilling to incur the labor costs associated with source separation.
- Low tipping fees create a barrier to recycling this material. The relatively light weight of wood means that it is not prohibitively expensive to dispose of in landfills rather than redirecting it to mulch processing facilities. This is especially true in the Capital Area region since there is typically a charge associated with recycling wood waste. The financial incentive is extremely small especially considering the costs associated with separation and transportation to the drop off facility.

Educational and Informational

- Concerns regarding wood waste quality may impede its use as mulch or as a feedstock for certain applications.

2.11.5 Strategy Recommendations

1. **Promote C&D recycling through education and incentives.** As previously discussed, developers and contractors are often unwilling to participate in recycling due to concerns regarding source separation. CAPCOG and its member communities can work to promote C&D recycling through education efforts and policies that provide incentives for C&D recycling. See Section 3.2 for a more detailed discussion of opportunities for C&D recycling.
2. **Coordinate a regional diversion effort for untreated wood.** For those communities that do not have dedicated residential yard waste collection, it can be a challenge to capture and process that material. CAPCOG and its member communities can work to coordinate regional collection events for brush and yard waste material on a seasonal basis. CAPCOG member communities that have staffed sites accepting yard waste could consider adding untreated wood waste to the materials accepted for processing.

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Section 3
Cross-Material Strategies

3.1 Overview

Throughout this report, several strategies have been identified to increase diversion and recycling of the specific materials addressed in this study. In this section, R. W. Beck offers additional strategy ideas that address several if not all of the materials, rather than being material specific. It is important to note that some of these ideas may not be appropriate for all communities. However, they have been included to provide local governments with a list of possible options.

3.2 C&D Waste Diversion Strategies

According to the fiscal year (FY) 2006 data reported to the TCEQ from the Capital Area region landfills, there were approximately 731,500 tons of C&D materials that were disposed in landfills in the region. This represents approximately 28 percent of the 2.6 million tons of MSW disposed in area landfills for FY 2006. Much of this material can be diverted from landfills, including four materials discussed in Section 2 of this study:

- Untreated wood
- Concrete
- Carpet
- Asphalt shingles

While there are markets for these materials, they often get mixed into roll-off containers in new construction, renovation, and demolition projects. Once mixed, the material not as easily reused and the material is often taken to landfills rather that reused or recycled. This section provides strategies that can employed for the diversion of C&D materials. The strategies are focused on the following aspects of diversion:

- Green Building and LEED
- Source separation
- C&D MRF
- On-Site Grinding and Reuse
- Reuse Programs

Additionally R. W. Beck included discussion on public sector initiatives and strategic planning with regard to C&D diversion.

3.2.1 Green Building and LEED

Green building is an environmentally responsible approach to land development, construction and demolition activities, and management of associated wastes in an effort to conserve natural resources and minimize release of toxics to the environment. A green building approach can involve virtually every aspect of design and construction. Municipal green building programs, including the one developed by the City of Austin, have traditionally focused on residential projects. The U.S. Green Building Council (USGBC) developed LEED as a set of green building guidelines for commercial development. The USGBC is currently developing LEED standards for residential developments.

LEED and other green building programs share common goals for reducing the impact of developments on the environment, including:

- Sustainable site development
- Water savings
- Energy efficiency
- Materials selection
- Indoor environmental quality.

For the purpose of this study, the focus is on the sustainable site development and materials selection. LEED can be implemented for different types of projects, including:

- **New Construction** - During new construction, choosing materials that contained recycled material creates demand for those materials. Minimizing waste and diverting waste that is produced reduces the impact to landfills.
- **Deconstruction** - Deconstruction is the selective dismantlement or removal of materials from buildings for reuse or recycling. As an alternative to demolition, deconstruction can serve as an effective way of reducing a significant amount of waste from landfills.
- **Renovation** - Renovation is generally defined as the modification or rehabilitation of the interior and/or exterior of an existing structure. Green building practices may be applied to renovation activities through recycling, reusing or recovering the various building materials generated during a renovation project. This process can serve as an effective way of reducing the amount of recoverable materials from entering the waste stream.

Source separation, a C&D MRF, and on-site grinding and reuses may be employed in the pursuit of green building goals.

3.2.2 Source Separation

Source separation is simply the act of keeping reusable waste materials from construction, renovation, and demolition projects separate so that can be used by processors or other users without the need of removing contaminants. For example, if

all clean, untreated wood is kept separate from other materials, it can be taken to processor (e.g., mulching or composting operation). If the wood was mixed with other C&D waste, the wood processor would not be able to easily use the wood. Materials are often not source-separated since it requires multiple containers onsite, which has the potential to increase the cost of the roll-off or container service to the site. Additionally, site workers must be properly trained to identify and segregate recoverable materials from wastes. However, if subcontractors are made responsible for the hauling and disposal of their own wastes instead of using common waste containers, there is substantial opportunity for source separation and diversion. First, many subcontracted operations, such as roofing and dry wall or carpet installation, generate relatively source-separated materials to begin with. Second, if lower cost alternatives exist for the disposition of source-separated C&D materials, the contractors and subcontractors may have adequate economic incentive to do so.

3.2.3 Establishment of a C&D MRF

A C&D MRF is a processing center that accepts mixed C&D waste, and then sorts it by material type. The concept is similar to MRFs that process recyclable material from the MSW stream. While several C&D MRFs exist in the U. S., none are in Texas. The advantage of a C&D MRF is that it can accept mixed loads of C&D waste as well as source-separated materials. The equipment and personnel at the MRF sort the materials into the recoverable commodities to market to users of the recovered material. There are significant costs associated with constructing C&D processing facilities and procuring the equipment, in addition to the annual operating expenses of such facilities. Consequently, additional investigations would need to be performed to determine the feasibility of a C&D MRF in the Capital Area region.

3.2.4 On-Site Grinding

On-site grinding is the practice of grinding and crushing appropriate building materials for use on site as a soil amendment, erosion control or fill material. From a waste minimization perspective, on-site grinding can effectively divert certain C&D waste materials generated from construction and demolition project. These materials may include drywall, brick and block, concrete, and untreated wood waste. If the contractor is large enough and has a significant number of projects, owning a grinder may be financially feasible. Otherwise, a subcontractor could be employed to provide grinding services.

3.2.5 Reuse Programs

Reuse programs encompass more than C&D materials. In some instances, reuse programs may be in the form of an exchange, whereby individuals can drop off materials that still have a useful life and take materials in return. This may include materials from construction projects, as well as household hazardous waste items (e.g., paint, pesticides) and other household items.

Additionally, there are resale programs like the Habitat for Humanity Restores (two are located in Austin). Contractors and individuals donate surplus building materials or reusable materials from renovation or demolition projects. Habitat for Humanity and other such establishments then sell these items to generate revenue for their nonprofit or business activities.

3.2.6 Public Sector Strategies

The public sector has many strategy options for promoting C&D waste diversion:

1. Make it public policy to renovate existing and construct new public buildings using green building practices, and encourage others to do the same;
2. Provide building permit rebates for contractors that meet green building or green development goals;
3. Fast track permitting for contractors with green building goals and C&D recycling plans;
4. Establish collection sites and charge tipping fees that are lower than landfill fees for receipt of designated source-separated C&D materials (in instances where the private sector is not doing so);
5. Enact C&D diversion ordinances that involve incentives as well as punitive measures.
6. Provide government grants to private sector organizations with winning proposals for furthering C&D diversion;
7. Provide information and technical assistance to building contractors, and engineers and architects to encourage use of recycled content building and road construction materials and to provide for diversion of C&D waste associated with their projects;
8. Conduct demonstration projects to build awareness and acceptance of using recovered C&D materials and other recycled content products in various common local applications (e.g., use of asphalt shingles for dust control or cold patch).

3.3 Strategies Related to Road Construction and Roadways Maintenance

As discussed in Section 2, there are several types of recyclable materials that are suitable for use in the construction of roadways and roadway embankments. These are summarized in Table 3-1 below.

Table 3-1
Roadway Uses

Material	Example Roadway Related Uses
Scrap tires	Paving applications (e.g., permeable friction course, chip seal, crack sealer); lightweight fill; embankment construction and repair; molded rubber products (e.g., guard rail spacer blocks); landscaping and erosion control
Glass	Road base, glasphalt, reflective paint, salt/sand mix for ice prevention
Asphalt Shingles	Cold patch, dust control, temporary surfacing, hot mix asphalt
Concrete	Road base, retaining walls, erosion control, non-structural concrete
Untreated wood	Landscaping and erosion control

Potential users of these materials include TxDOT, local public works departments, parks and recreation departments, and private road construction and maintenance contractors. Many of these uses are economical or could become economical through public efforts to address infrastructure barriers.

Roadway construction and maintenance is highly resource intensive. Consequently, use of recyclable materials in roadway construction and maintenance offers tremendous potential to consume large quantities of recyclable materials. However, as is true regardless of the source of feedstocks, such projects demand suitable quality and quantities of material supply at an affordable price. What follows is a brief discussion on these needs.

3.3.1 Ensuring Material Quality

Transportation and public works officials are historically very conservative when it comes to developing specifications. Their tendency is to prefer specifying conventional materials that are known well and are regarded as safe and reliable from a performance standpoint. It is a slow and difficult process to modify specifications – particularly in areas where public health and safety may be at risk. Equally conservative are construction and maintenance contractors who also prefer to use products that they know are safe and reliable. Stakeholders throughout the supply and

use chain need awareness and understanding of specification requirements and appropriate uses for as well as best practices associated with the use of recyclable materials.

3.3.2 Ensuring Sufficient Quantity

Roadway projects are intermittent. But when such projects are active, they need large supplies of materials at specific sites at specific times. Therefore use of recyclable materials as feedstocks will require that suitable material is stockpiled in convenient locations and readily available when needed.

3.3.3 Ensuring Affordability

Given the magnitude and cost associated with roadway projects, there is little interest or opportunity for substitution of feedstocks that have higher upfront costs. Exceptions to this are when there is a distinct performance advantage, either short or long term or use is mandatory. The latter may be the case when organizations have multiple objectives such as exists with respect to the State of Texas working to eliminate scrap tire stockpiles. With fuel prices continuing to rise, the transportation costs associated with getting materials to the job site is becoming increasingly important in procurement decisions. Low cost suitable feedstocks located within an affordable haul distance will have a distinct market advantage over product alternatives.

3.3.4 Public Sector Strategies

CAPCOG and its member jurisdictions have several options for promoting use of recyclable materials in roadway construction and maintenance.

1. **Provide information and technical assistance to transportation and public works department staff, design engineers, construction and maintenance contractors, and other appropriate stakeholders to encourage use of recyclable materials in roadway construction and maintenance.** A particular focus of this effort should be on promoting use of recyclable materials in applications where specifications have already been developed that provide for use of certain recyclable materials;
2. **Conduct demonstration projects to build awareness and acceptance of using recyclable materials in various local applications (e.g., use of asphalt shingles for dust control or cold patch).**
3. **Hold stakeholder forums to bring together suppliers, processors, and existing and potential end users of recyclable materials in roadway construction and maintenance.** It is through such venues that value chain players can learn about each other's needs and concerns, and work together to overcome impediments and pursue opportunities.
4. **Advocate for the use of more recyclable materials by TxDOT.** There are many opportunities for TxDOT to use more recyclable materials in its projects than are

currently being realized. In addition, CAPCOG jurisdictions could explore opportunities to meet the supply needs of specific DOT projects.

5. **Assess the existing infrastructure and investigate options to provide for suitable storage sites for recyclable materials for use in local roadway construction and maintenance projects.** Sites will need to be in convenient locations relative to the location of projects that will use the material. Temporary sites may be an option.
6. **Investigate opportunities to revise procurement policies and specifications to allow for greater use of recyclable materials in roadway projects**.

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Section 4
Institutional Recommendations

4.1 Overview

Effectively implementing the recycling market development strategies outlined herein requires a strategic approach to program development and implementation. In essence, CAPCOG and its member jurisdictions will need to expand the institutional capacity in the region to undertake this work. Provided in this section are strategy recommendations for building this capacity. R. W. Beck has listed the strategy recommendations for each level of government in order of recommended priority.

4.1.1 State Government

State government can play a significant role in developing markets for at least two of the specific materials included in this report. Strategy recommendations for scrap tires and asphalt shingles are listed as follows:

- **Establish a statewide funding mechanism (e.g., a retail tire tax) to fund scrap tire collection and recycling programs.** This funding could be distributed to the regional COGs and passed through to local governments that plan to develop scrap tire recycling programs.
- **Recognize research or testing done by either private industry or public-private partnerships on use of asphalt shingles in HMA.** When private industry produces conclusive air quality test results, the State regulatory agency will need to approve the use of post-consumer shingle scrap in HMA.

4.1.2 Regional Government

The primary means for CAPCOG to influence market development for any of the materials included in this report is to allocate TCEQ funding to projects and studies through the Solid Waste Grants Program. In light of this, R. W. Beck has identified recommended priority areas for grant funding based on the findings of this report. R.W. Beck would recommend that the SWAC place grant funding priority on studies that address the following issues:

- **Development of a regional communications and public awareness campaign** to promote ICI and residential use of recycled content products made from waste materials generated in the Capital Area region;
- **Local government programs that are aimed at increasing use of recovered materials in roadway construction.** Examples of potential projects include demonstration projects and technical assistance programs;

- **Organization of stakeholder discussion forums, commodity-specific roundtables, and other networking events that enhance communication between suppliers, processors, and end users of recyclable materials.** These programs help foster understanding of the needs and concerns of all stakeholders in the marketplace and develop cooperative efforts to increase diversion.
- **Public-private partnerships that aim to further develop markets for recyclable materials.** For instance, an HMA manufacturer may partner with a local government and work together to conduct air quality tests on the use of recovered shingles in HMA; and
- **Further investigate policies and incentives aimed at increasing diversion and use of the recyclable materials discussed in this report.**

CAPCOG, as the regional association of local governments, has an opportunity to take a lead role in recycling market development on behalf of the region. More specifically, CAPCOG could undertake the following:

- **Establish a subcommittee for recycling market development.** This subcommittee could coordinate the planning of recycling market development programs and services;
- **Become the regional coordinator for C&D waste minimization strategies**. Coordinate with the City of Austin Solid Waste Services and the Austin Green Building program to maximize diversion and avoid duplicated efforts to increase C&D diversion;
- **Further investigate the regional infrastructure** for recovery, processing and marketing of selected recyclable materials that offer the greatest promise for increased diversion;
- **Advocate for establishment of stronger state programs promoting recycling market development and use of recyclable materials by state agencies and state contractors;**
- **Stay abreast of recycling market development issues, needs and opportunities in the Capital Area region.** Work to foster regional cooperation as well as participate in regional recycling market development efforts;
- **Explore opportunities to work with state, regional, and national industry and trade associations in sponsoring activities of mutual benefit;**
- **Continue to provide outreach and technical assistance activities for local governments;** and
- **Develop a regional website** that provides best practices guidance and promotes recycling of fluorescent lighting, green building practices, use of recyclable materials, and other practices described in this report.

4.1.3 Local Government

Local governments that have an interest in implementing recycling market development programs can participate in regional efforts in cooperation with

CAPCOG and other local governments as well as establish programs of their own. Potential roles for local government include:

- **Participate in the CAPCOG recycling market development subcommittee**, if established;
- **Develop and implement strategies for encouraging use of green building principles internally and throughout the community.**
- **Develop methods and incentives to encourage participation among players in the recycling and construction industries;**
- **Develop and disseminate information and technical assistance** to designated target audiences and those requesting such information as appropriate; and
- **Developing and distribute public awareness materials focused on building general public acceptance and use of recyclable materials**. Examples include materials such as compost, landscape glass, and tire-derived molded rubber products.

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Appendix A
Glass Beverage Container Resources

GPI Recommendations

The Glass Packaging Institute provides strategic recommendations to maximize the collection of glass beverage containers, increase revenues from the sale or re-use of the glass product and provide alternative uses for the cullet and/or crushed glass. The following five recommendations listed below are GPI's general strategy recommendations for the developing the glass market, but may have relevance to the CAPCOG region.

1. Step up quality control.

Contamination of recovered glass can occur at the curb, during collection and processing, or shipping. Consider these tools to reduce contamination:

- **Know market specifications**—Understand the buyer's specifications and acceptance policies, ability to remove contaminants (including metals), transportation preference (truckload or rail car), and "furnace ready" requirements.
- **Conduct inspections**—Before adding newly-collected glass to stored recyclables and during loading for shipment, inspect for quality. Also check the truck bed and the tarp used to cover the load for any residue from a previous haul.
- **Protect stored cullet**—If stored outdoors, place cullet on a concrete pad—not on the ground or asphalt—to avoid contamination from dirt or gravel during loading. Cover cullet during cold or wet weather.
- **Keep cullet separated by color**—When storing multiple loads of colored cullet, keep cullet separated to avoid intermingling of colors.

2. Retain glass size during collection and processing.

- **Avoid crushing cullet—**Glass containers naturally break with handling, a trade off for economic transport. Crushing cullet, however, will not add to its value.
- **Reduced compaction—**To reduce glass breakage and expand markets for recovered glass, experiment with reducing the compaction ratio in the collection trucks. Although this may shorten collection routes a bit, it will also reduce breakage and color mixing, improving the value of the recovered glass.

3. Provide contract incentives to recycling service providers.

When developing a contract with the recycling service provider, create shared revenue or limits to encourage low residual and contamination rates. This will support more

glass being marketed to the highest value end-market—container glass. It may even be useful in a contract to prescribe the type of end-markets acceptable for the recovered glass, or exclude marketing as aggregate.

4. Add commercial collection routes (if not already in place)

A commercial collection route for bars, restaurants, and other businesses that generate high-value recyclables provides for increased glass recycling with fewer collection stops.

5. Implement new systems or technologies.

Employ or pilot test new procedures and equipment to improve the quality and amount of glass recovered for recycling:

- **Automated sorting—**New automated processing technologies can reduce overall costs and increase quality. Optical sorting, which uses air classifiers and jet streams tied to ultraviolet beams to sort crushed glass by color, and ceramic detection technology are available in about a dozen cities across the U.S. Automated equipment in most beneficiation plants is also available to separate nonferrous metals, such as bottleneck rings, from cullet.
- **Efficient transportation—**In some parts of the country, transporting cullet to locations where it can be recycled may result in prohibitively high costs. To respond, the glass container industry works with communities to explore ways to make transporting cullet less costly, such as backhauling or shipping by rail.
- **Materials exchange—**Glass container plants across the country have different color specifications. To alleviate surplus and shortages, some companies participate in a swapping program, exchanging cullet they do not need for a color they can use.
- **Cooperative marketing—** For smaller communities, pooling the glass each city collects, or materials consolidation, and then marketing it together may help to secure a higher value end use for the cullet and save costs.

Detail on Potential Uses of Glass

The following table provides additional detail on potential uses of glass.

Summary of Recycled Glass Uses

Strategy	Program	Results
Aggregate and Road Uses		
Road aggregate for base material	Some states have set specifications for road aggregates that provides for up to 10% of reclaimed glass be blended with other aggregates as a glass 5, 6 or 7 road base material.	It is common, well proven, and safe. Research has shown that recycled glass can actually improve the quality of gravel in an aggregate mix for road base, and can be used up to 100% as a base in some cases. Aggregate contractors use the same machines to crush glass as they use to produce aggregate. Can enhance permeability of road surface, and decrease stream runoff. Costs savings depends on aggregate prices.
Road cover for landfill	Use the pulverized glass at the landfill in two capacities: (1) Larger pieces can be used as a road base, (2) smaller "sand" size glass can be used as a dust control device.	Both uses are successful. As a dust control, it works better than water because it reflects the sun and keeps the ground from drying out as quickly. As a road base, the permeability of the glass is an advantage.
Road material: Glasphalt	Use 5-10% reclaimed glass mix with asphalt and aggregate for road surface.	Lifetime, wear, slippage, and cracking have been proven to be comparable to conventional surface materials. Reports of glass "popping" out of surface in heat, same as rocks, but more citizen complaints around glass.
Airport runway	10% reclaimed glass aggregate used for airport runway and apron surface.	Installed a 300 X 40' runway about eight years ago that has worked well. Used approximately 400 tons of glass in the construction of the runway. Passes inspection of state, and over time, skid resistance has actually increased.
Salt/sand mix for roads in winter	Mix with sand, salt or magnesium chloride to apply to the roads and sidewalks in the winter.	Very successful as a non-slip application, it increases traction significantly for both roads and sidewalks.
Locomotive traction sand	Railroads use the recycled glass to put directly onto the rail lines from the locomotive.	Has worked well to date, but not used in many areas. The application of the traction sand is controlled automatically from an on-board computer based on analysis of slippage and traction. Crushed and cleaned, recycled meets standards. Potential for replacing silica where silica dust raises health concerns, or where existing silica is not lean or contains high levels of clay.
Striping	Use glass as reflective material in road stripes or cross walks.	Very successful, but not using much tonnage. Some DOTs have discovered that paint adheres better to glass than other aggregates. Glass also lasts longer, and retains sparkle longer than other materials.

Strategy	Program	Results
Filtration, Sand, and Abrasive Uses		
Pipe bedding or septic system mounds	Lay below pipes when installing or build septic mounds.	Works well and studies have found it to be technically sound. Good potential for recycled because color mix, labels, and residual sugars are not an issue. Good drainage qualities.
Filter sand for pool and septic systems	Use rejected glass from windows for septic filtration, pool, and industrial applications.	Works better than silica and has many advantages. It is lighter and less volume is needed. For pools it has higher clarity than silica, reduces backwash by 21%, and saves energy. For septic it does not clog as much as silica and lasts longer.
Sand for beaches, golf courses, or playgrounds	Pulverize sand to a small enough grain to be used on a golf course or playground.	Preliminary testing on beaches and golf courses has shown the potential of this use. Public perception and cost are issues. (See "Beached Glass" in the February 2007 Issue of *Resource Recycling*)
Industrial abrasives	Used recycled glass as an abrasive for cleaning, scouring, and blasting of various surface types.	A very successful use of recycled glass. Glass as an abrasive has proven advantages.
Landscaping, Tiles and Other Uses		
Landscaping	Give away glass as a landscaping material for free at landfill.	Some communities reported liking the way it looks, while others did not. Some (fermented alcohol) odor issues not washed.
Trail bed	Cover trails in glass sand.	Generally, hikers have not liked the look of the trails. Also, the glass must be repeatedly screened to remove all labels and contamination. Has worked well in national park that had trail drainage issues.
Compost	Mixed crushed glass with compost.	Mixed success. Reports that glass would make its way to the bottom of the pile and it was also "sparkly." Can improve the drainable quality in areas with poor soils; some areas already have "sparkly" soil.
Glass-epoxy flooring	Sell pulverized glass to flooring company for seamless flooring or counter tops.	Can be potentially very successful. Limiting factors include: (1) the distance to a manufacturing plant, (2) consistent quality and color or collected materials. Life cycle in use as floor covering is strong.
Kiln process	Integrates recycled glass into conventional ceramic processes to make tiles and countertops.	Quite expensive process for not a lot of glass tonnage but very nice high and artisan product. Some technologies being patented.

Source: Liza A. Skumatz, Ph.D. and Juri Freeman (Skumatz Economic Research Associates, Inc. Superior, CO), "What do we do with these piles? Finding alternative uses for glass piles requires a closer look at lower value but cost-effective applications," Resource Recycling, June 2007