Advancing Climate Protection Planning Through Municipal Solid Waste Programs

Prepared for The City of Fort Collins

Natural Resources Department

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Executive Summary

The City of Fort Collins is determined to be proactive in reducing greenhouse gas (GHG) emissions in an effort to achieve climate protection goals for 2010 and beyond. The City has experienced that solid waste diversion strategies are valuable in achieving climate protection goals. In addition, the City believes solid waste diversion strategies are undervalued in looking at climate protection and emissions reductions and that an opportunity exists to recognize their value, calculate their value, and take this value to develop additional diversion programs.

The objectives of this study are as follows:

- Determine how much the City can divert through a set of strategies and how much implementing these strategies will cost.
- Determine the amount of CO2e reductions associated with diversion strategies.
- Determine a cost per ton of CO2e reduced related to diversion strategies.
- Explore possibilities associated with capitalizing on CO2e reductions to support additional diversion programs.

For this effort, researchers used modeling techniques to determine new waste diversion potential, tons of CO2e* reduced by proposed strategies, and costs per ton of CO2e reduced as indicated in the following table.

Year	**Diversion** (tons)	**Average Diversion Cost** (per ton per year)	**CO2e reduced** (tons)	**Average Cost of CO2e Reduced** (per ton per year)
2010	49,798	$71	118,723	$30
2015	145,610	$54	313,866	$25
2020	171,389	$54	366,332	$25

The study explored the potential for municipalities to advance solid waste diversion programs through the impetus of climate protection planning. If Fort Collins is representative, many communities are probably already achieving significant GHG emission reductions from their existing solid waste programs. For most communities, significant new diversion potential exists through a variety of strategies, 20 of which were evaluated in this study using the Waste Diversion Assessment Model (WDAM).

Results indicate that the potential climate protection impacts of these new diversion activities are quantifiable using life-cycle emissions factors available from the Local Governments for Sustainability (founded as the International Council for Local Environmental Initiatives, or ICLEI) and WARM, the U.S. Environmental Protection Agency's life-cycle model. For Fort Collins, strategies that divert construction and demolition (C&D) materials, cardboard, and

* CO_2 equivalent or CO_2e is used to express the combined impact of a number of greehouse gases, including methane, by reducing their aggregate impacts to a common unit based on the global warming potential of carbon dioxide.

newsprint were shown to be particularly beneficial toward reducing CO2e emissions. Unfortunately, implementing waste diversion strategies for achieving the new diversion potential and associated carbon reductions is not economically feasible for most communities, which must operate within set budgets and often do not have funds for new programs. To address this economic constraint, the study turned to carbon offset markets as a source of funding.

Ideally, carbon offsets from solid waste diversion would be recognized by the carbon markets that are emerging and growing rapidly world wide. These carbon markets could help to finance solid waste diversion programs that were previously not feasible for communities to implement. Unfortunately, current markets for carbon offsets, while widely recognizing offsets realized from activities such as renewable energy generation or energy efficiency, do not recognize offsets from solid waste diversion activities. There is a fundamental difference between the life-cycle methods used to calculate emission reductions from solid waste diversion and the more direct measurement that is possible with other types of projects. As a result, the process of documenting ownership and certifying emission reductions from solid waste diversion is more challenging.

Clearly there is a need to evaluate the existing tools for quantifying carbon reduction from solid waste diversion activities and establish methodologies with carbon market entry as a driving goal. These tools could be made reliable and certifiable to a level of certainty that would likely make them relevant to the developing carbon markets of the world.

The possibilities associated with capitalizing on solid waste diversion projects from a climate protection perspective are compelling and warrant further study and discussion. The community of Fort Collins should not be put off by the lack of a conventional market system to accommodate solid waste diversion reductions in CO2e. Rather, it should take the lead in establishing a local system that supports its goals and is replicable in other communities.

1.0 Introduction

The City of Fort Collins is proactive in its approach to climate protection and over the years has continued to set and achieve climate protection goals. In fact, as early as 1997, the City Council passed a resolution asserting that the City should take "a leadership role in increasing energy efficiency and reducing greenhouse gas emissions from municipal operations[1]." By 1999, the City had on file a *Local Action Plan to Reduce Greenhouse Gas Emissions* as guidance. And in November of that same year, the Council passed a resolution (Resolution 97-137) to implement GHG-reducing activities outlined in the *Local Action Plan to Reduce Greenhouse Gas Emissions* in order to reduce these emissions by at least "30 percent below predicted 2010 levels while achieving cost effectiveness in each program[2]." In addition, the City participates in the statewide initiative called the Climate Action Project, whose mission is to reduce Colorado's contribution and vulnerability to climate change as a result of GHG emissions.

In addition to GHG target reductions, the City also has developed targets for solid waste diversion – specifically a 50 percent solid waste diversion rate by 2010[3] – and already has achieved considerable success toward this target. The intriguing aspect of these two goals is the link between solid waste diversion and GHG emissions reductions.

Landfill methane emissions from solid waste represent a relatively small fraction of the total GHG produced by local communities (approximately 2 percent) compared to burning fossil fuels for energy and transportation[4]. However, what the City has learned in the past decade by monitoring GHG emissions is that waste reduction and recycling can play a major role in a community's ability to reduce its GHG emissions. In fact, in excess of 52 percent of the reduced emissions measured by Fort Collins climate protection programs in 2004 can be attributed to local recycling and waste diversion efforts[5]. This suggests a powerful role for waste management strategies in municipal climate protection efforts.

The objective of this paper then is two-fold. The *first objective* is to present the results from evaluating a set of diversion strategies to determine the following:

- Potential diversion tonnages
- Potential CO_2e reductions
- Cost per ton of CO_2e reduced

This approach takes into consideration the energy required at each step in the life cycle of a product, including extracting and processing raw materials, manufacturing the product, transporting the product to consumers, using the product, and finally, disposing of the product. In looking at this life-cycle scenario, the implications of source reduction, recycling, and diverting organics affect not only the final disposal part of the equation but many of the steps before landfilling that can significantly reduce GHG emissions.

On the basis of this evaluation, the *second objective* is to extrapolate from this information the possibility of capitalizing on the potential GHG emissions reductions that result from the diversion strategies in a way that would support or finance additional diversion programs within the community. Because there is no current market for solid waste-related GHG reductions, this paper treads in uncharted territory.

2.0 Diversion Strategies and Greenhouse Gas Impacts

In order to understand the GHG implications of new waste diversion strategies in Fort Collins, it was necessary to estimate the potential new waste diversion resulting from various strategies. Much of this work was initially completed by City staff as part of the *DRAFT Strategic Plan for 50% Solid Waste Diversion*[6] that was prepared in 2006. The results of this plan were updated and used to model the GHG impacts of the strategies presented here.

2.1 Waste Management Strategies and Program Costs

In the *DRAFT Strategic Plan*, City staff identified the following set of criteria for evaluating new waste management strategies:

1. Target materials that have the most potential to be diverted and those that represent the largest amount of volume that can be diverted.

2. Elicit waste reduction contributions from all sectors of the community, including residential, commercial, institutional (*e.g.*, the City), multi-family, and key stakeholder businesses, such as trash haulers and recycling companies.

3. Distribute costs so that no single sector is unfairly affected.

4. Optimize positive, intended consequences and interrelationships among potential new programs.

5. Anticipate market forces that will create successful opportunities for our local recycling system, which includes service providers, the business community, recycling professionals, commodity brokers, as well as local citizens and their political representatives.

6. Address concerns and needs that were expressed by citizens of Fort Collins in a community-wide survey.

Based on these criteria, the City selected 20 potential waste diversion strategies and coordinated with Skumatz Economic Research Associates (SERA) to develop a Waste Diversion Assessment Model (WDAM) for those strategies. City staff used WDAM to estimate new waste diversion tons and program costs for the 20 potential strategies evaluated in this paper. Specific model methodology is described in more detail in Section 5.1.

2.1.1 Selected Waste Management Strategies

The 20 strategies included in WDAM are described in Table 1.

Table 1. Waste Diversion Strategies

Strategy #	Description
1	Adopt the requirement for service providers to collect single stream recycling from residential customers as soon as market trends allow.
2	Provide a residential yard waste drop-off site.
3	Provide customers, upon request to their trash haulers, with optional curbside yard waste collection services on a weekly basis.
4	Enhanced short term-term education around new measures.
5	After sufficient infrastructure has been developed to accept large volumes of organic debris to be composted, add requirement for largest candidate firms (e.g., restaurants and grocery stores) to recycle commercial food waste.
6	Provide technical assistance / waste audits to businesses.
7	Amend the City's Pay-as-You-Throw (PAYT) ordinance to include all commercial customers; embed recycling fee in rates, and charge volume-based pricing.
8	Adopt ordinance making it mandatory for businesses that dispose of more than 10 cubic yards of trash weekly to install a recycling bin.
9	Make recycling mandatory for all businesses.
10	Help form recycling cooperatives for small businesses.
11	Create a refundable construction and demolition (C&D) deposit system based on square footage of project (or comparable criterion), with total deposit to be refunded upon certification of appropriate level of recycling.
12	Establish contract preferences to encourage recycling and waste reduction for City C&D jobs.
13	In the absence of appropriate private-sector facilities necessary for accepting C&D waste, ultimately create a City-sponsored drop-off site.
14	Exclude and prevent discarded computers from Fort Collins' curbside trash collection system.
15	Exclude and prevent yard waste from Fort Collins' curbside trash collection system.
16	Amend Fort Collins' PAYT residential trash rates ordinance so that rate design further enhances waste reduction efforts.
17	Implement ongoing curbside recycling program improvements, including more designated materials and standard options for larger recycling containers, etc.
18	Offer awards, grants, zero-interest loans, and incentives to businesses for waste prevention efforts.
19	Encourage multifamily housing managers / residents to adopt single-stream recycling systems.
20	Encourage private partnerships for constructing multiple community drop-offs to collect more recyclables (paper, glass, etc.).

Using WDAM, the City modeled waste diversion (tons) and program costs for each strategy for 2010, 2015, and 2020 to get a picture of quantity and costs over time.

2.1.2 New Diversion Tons and Implementation Cost

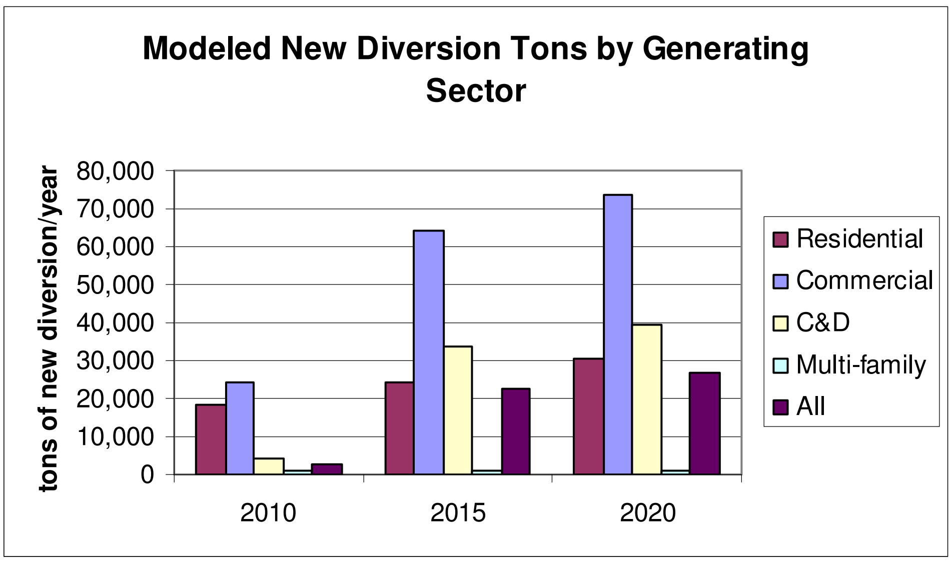
For this discussion, the tons of waste diverted and program costs associated with the selected strategies are presented in aggregate by waste-generating sector. Table 2 presents the strategies from the previous table by number and locates them within their respective sector.

Table 2. Strategies by Sector

Residential	Commercial	C&D	Multi-family	All
1, 2, 3, 4, 16, 17, 20	5, 6, 7, 8, 9, 19, 18	11, 12, 13	19	14, 15

To provide context for new diversion potential, Fort Collins generated approximately 230,383 tons of landfill waste in 2004[7]. The potential for new waste diversion by sector is presented in Figure 1. New diversion tons increase with time as programs ramp up to full effectiveness and as the generating sectors grow.

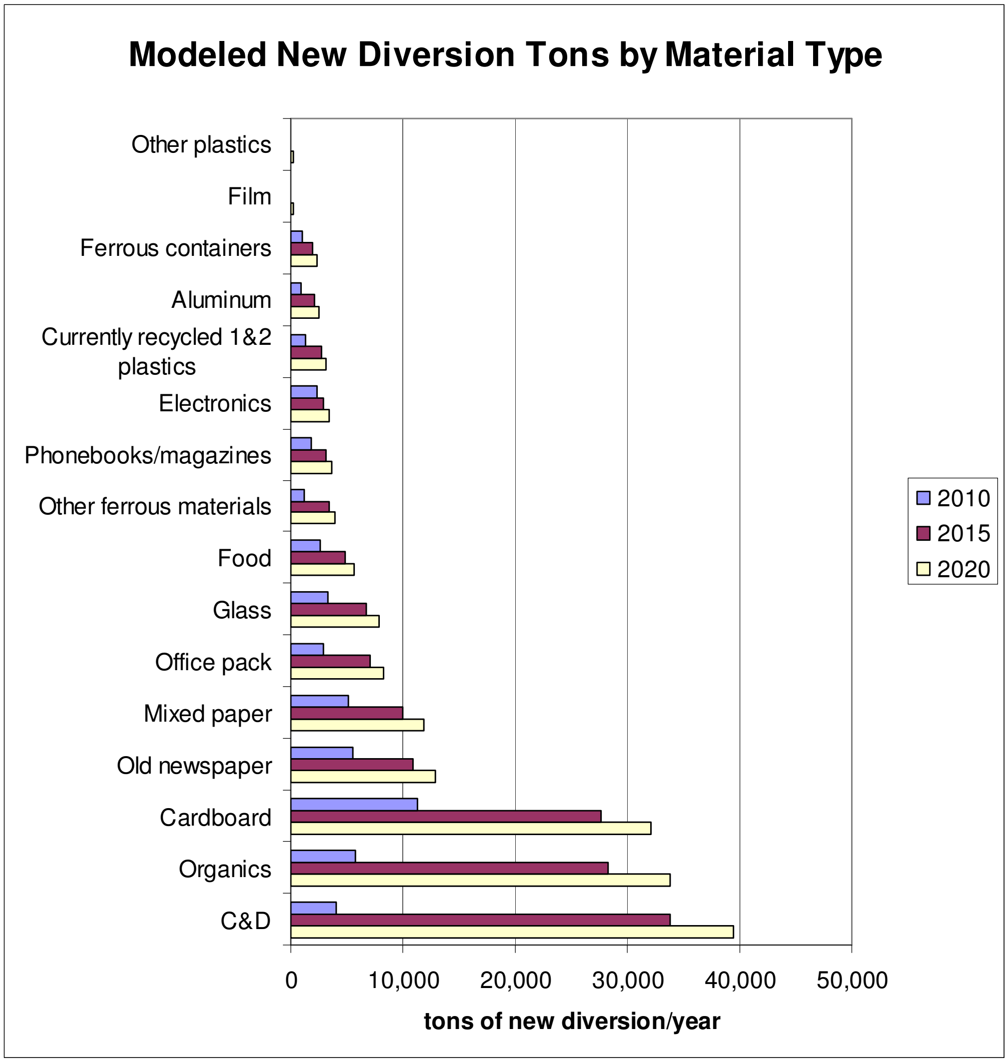
Figure 1.



As this graph shows, there is significant potential for new waste diversion in strategies that address commercial, C&D, and residential sectors, as well those strategies that broadly apply to all sectors. Multi-family has less of an impact, but it also is a smaller more isolated sector with only one waste diversion strategy specifically targeting this sector. By implementing this package of 20 strategies, the City would likely achieve the 50 percent diversion target sometime between 2010 and 2015.

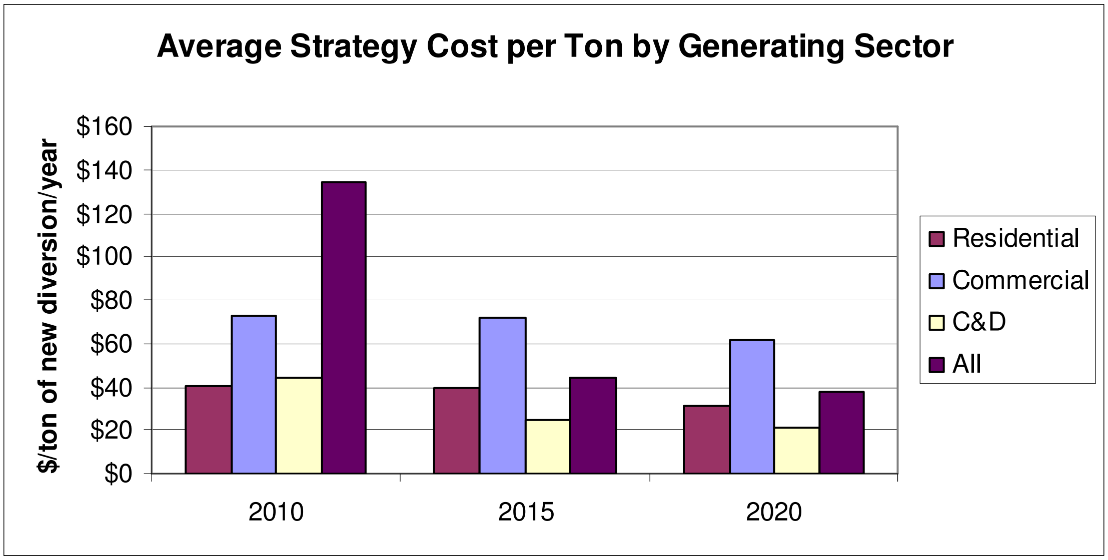
The same new diversion tons are presented in Figure 2 by material type. This figure illustrates that while there is potential to divert a variety of material types, those material types with the greatest potential are C&D waste, organics, and cardboard. In fact, in combination, these three material types represent only 20 percent of the 15 material types, but account for up to 62 percent of all new diversion in 2015 and 2020. These materials are closely linked with the most promising generating sectors shown in Figure 1.

Figure 2.



In order to fully appreciate the potential of the modeled waste diversion strategies, the City also used WDAM to determine costs to the City and the end users associated with the strategies. These costs are presented by sector in Figure 3. Note that the multi-family-related strategy, #19, has been excluded from Figure 3 because of its disproportionately high cost.

Figure 3.



Overall, the WDAM modeling indicates that the 20 selected diversion strategies would produce 49,798 tons, 145,610 tons, and 171,389 tons of new waste diversion per year in the years 2010, 2015, and 2020, respectively.

2.2 Greenhouse Gas Impacts of Selected Strategies

The next piece in the puzzle was to determine the GHG impacts of implementing the selected waste diversion strategies on the basis of the new waste diversion potential estimated using WDAM.

By diverting a material from the landfill, the life-cycle of that material is significantly altered. Depending on the particular material and diversion strategy, the GHG emissions attributed to that material's life-cycle will simultaneously be affected. By applying material-specific emissions factors that account for the differences in life-cycle emissions for various waste management strategies, a GHG emissions reduction was calculated for each of the strategies.

The City uses emissions factors and calculation methodology developed by the Local Governments for Sustainability (ICLEI), in other city programs and these factors generally are used in this study for consistency. In the ICLEI protocol, emissions are accounted for through five aspects of the material's life cycle. Take, for example, the alternative waste management strategy of recycling cardboard rather than disposing of it in a managed landfill without methane capture. In this example, relative CO2e emissions are affected as follows:

- Emissions are reduced by continued sequestration of carbon in the forest. By recycling the cardboard, producing additional virgin material through logging can be avoided.

- Emissions can be increased as a result of the upstream or manufacturing energy used to recycle the cardboard. However, for most materials the upstream energy required to recycle the material is significantly lower than that required to process virgin material (such as with aluminum). Therefore, depending on the material in question, recycling either increases or decreases emissions relative to processing virgin materials.

- Emissions are reduced as the result of upstream non-energy-related emissions. These emissions could be the result of differences in direct emissions from the varying processes associated with manufacturing the material with virgin versus recycled stocks.

These emissions would be compared to the emissions associated with the standard practice of disposing of the cardboard in a managed landfill without methane capture:

- Emissions occur as a result of methane (produced by decomposition) escaping from the landfill.

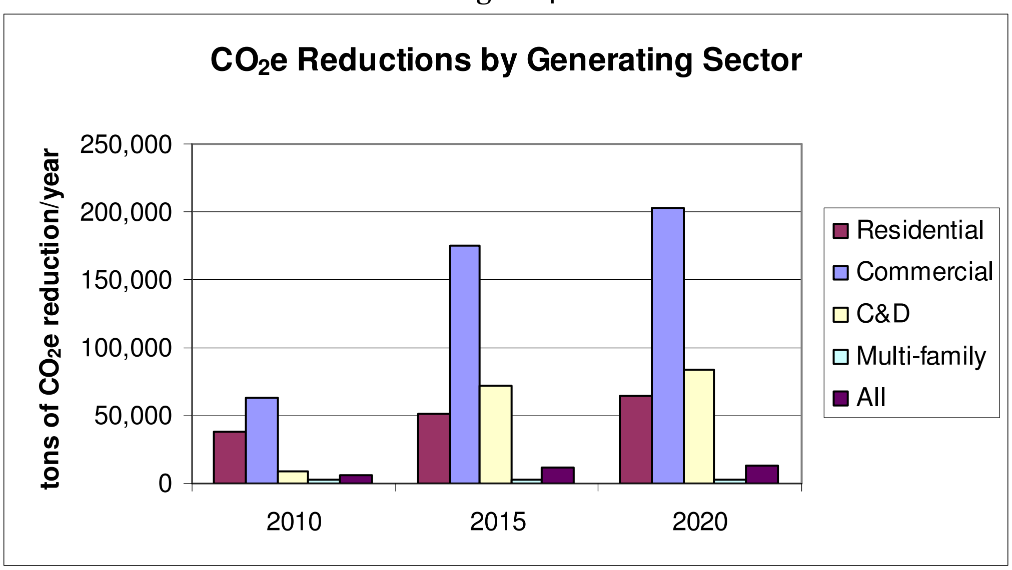
- Emissions are sequestered at the site due to the organic matter that remains, without decomposing, in the landfill.

The difference between the net emissions of the alternative disposal method and the standard disposal method represents the reduction in CO2e emissions that results from adopting the alternative disposal practice.

Section 5.2 provides additional background on the ICLEI protocol as well as a description of the methodology used for materials that did not correspond well with ICLEI's available factors.

By applying emission factors to each of the waste diversion strategies on the basis of their material composition, respective reductions in CO2e for each strategy were determined. Figure 4 summarizes the potential CO2e reductions by waste-generating sector.

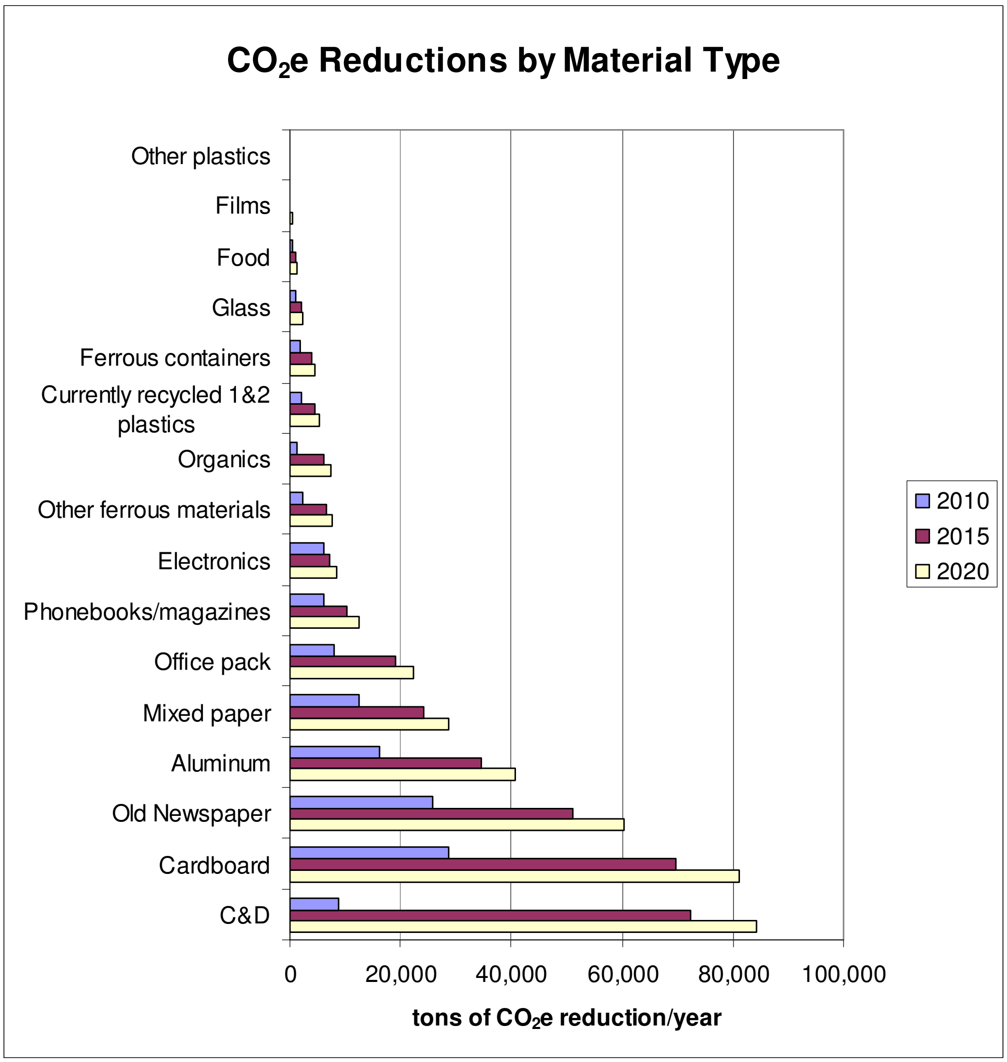
Figure 4.



It is clear that there is significant potential to reduce GHG emissions in the commercial, residential, and C&D waste-generating sectors by implementing the waste diversion strategies.

The same reductions in CO2e also are presented by contributing material type in Figure 5. It is important to recognize that, because of differences in emissions factors, the materials that significantly increased new waste diversion quantity through the selected strategies are not necessarily the most advantageous from the GHG emissions perspective. For example, organics provided a significant portion of the new waste diversion but contributed much less to GHG reduction. Similarly, aluminum was a relatively small portion of the new diversion, but contributed significantly to GHG reductions.

Figure 5.



The waste diversion strategies, taken as a whole, have the potential to provide 118,723 tons, 313,866 tons, and 366,332 tons of CO2e reduction in 2010, 2015, and 2020, respectively. These numbers are exciting for any community committed to reducing GHG emissions.

For perspective, in 1998, the City established a goal of reducing 2010 emissions by 30 percent over projected emissions for that year in a business-as-usual case – a reduction of approximately 1 million tons of CO2e[8]. By 2010, the selected strategies could account for as much as 10 percent of the City's reduction goal, or 118,723 tons of CO2e. This reduction is approximately equivalent to eliminating 1.5 million roundtrip vehicle trips between Fort Collins and Denver.

It is clear from this modeling that solid waste diversion strategies help communities achieve climate protection goals by reducing GHG emissions. It also is clear that diversion strategies require start-up capital and maintenance funding. The question then becomes how to capitalize on these reductions to support additional diversion strategies.

3.0 Current Greenhouse Gas Offset Market

Because there are significant and quantifiable carbon reductions associated with solid waste diversion strategies, the next logical question becomes whether or not there are markets for these reductions. The idea, of course, is for communities to get financial credit for their GHG emissions reductions that result from their solid waste diversion strategies. This financial credit would then be turned back into supporting existing strategies and developing new ones for additional reductions, and ultimately greater climate protection.

3.1 Regulatory Frameworks

Currently, there is no federally regulated framework for GHG or carbon trading in the United States. However, some states and regions are developing market-based policies to reduce GHG emissions. For example, the Regional Greenhouse Gas Initiative, a cooperative effort by Northeastern and Mid-Atlantic states to reduce CO2e emissions, is working to develop a strategy to implement a multi-state cap-and-trade program with a market-based emissions trading system[9].

The idea behind cap-and-trade programs is that mandatory limits (caps) are set on GHG emissions and a system is implemented for trading emissions rights and reductions (carbon credits). Carbon-reducing projects then are able to generate financing for conservation by selling certified carbon credits to GHG emitters. In order for these programs to be successful, there must be standards for monitoring emissions, rules for how to use credits, a coordinated body to track and certify credits, and some form of enforcement.

A cap-and-trade system functions on the premise of compliance with regulatory mandates. However, in a community like Fort Collins that is voluntarily setting climate protection goals for itself, a voluntary framework is a more likely scenario.

3.2 Voluntary Frameworks

Perhaps more appropriate for the Fort Collins community are the voluntary programs available in the United States and abroad for buying and selling carbon offsets. As a primer, carbon offsets offer individuals, businesses, and other organizations the opportunity to neutralize their impacts on the climate by buying GHG reductions from other sources. In other words, offsets are quantifiable reductions from emissions-reducing projects that can be sold to consumers to counterbalance their own emissions.

Currently, there are a variety of offset options and providers available to consumers. Similarly, the types of products and services available are varied and include anything from offsets for travel, to green tags (renewable energy credits) and wind power, to reforestation. The costs for products and services vary given the different ways providers offer offsets to consumers and can range anywhere from $1 per ton to $78 per ton[10]. In addition, some providers require membership and associated fees, while others do not.

Some examples of offset providers are listed below:

- Bonneville Environmental Foundation ($18-19 per ton) – green tags
- Carbonfund.org ($5.50 per ton) – renewable energy, industrial efficiency and reforestation
- TerraPass ($10 per ton) – wind energy, biomass and industrial efficiency
- Climate Care ($14.65 per ton) – international projects
- CO2e Balance ($11 – 20 per ton) – tree planting projects to sequester carbon emissions
- Community Energy ($2 per block of 100 kilowatt hours [kWh]) – wind power
- Green Mountain Energy Company (variable pricing) – renewable energy
- Native Energy ($12.00 per ton) – wind and methane sequestration on tribal lands
- Renewable Choice ($.07 - .10 per kWh) – wind power
- Solar Electric Light Fund ($10 per ton) – international solar projects
- The Carbon Neutral Company (variable pricing) – renewable energy, energy efficiency, methane capture and reforestry

Many providers offer discounted rates for businesses/organizations and may be willing to customize offset programs for specific needs.

In addition, there are organizations that allow customers to buy *and sell* offsets. The most notable of these is The Chicago Climate Exchange (CCX). CCX is a membership organization that serves as a voluntary trading forum for offsets.

This discussion certainly is not exhaustive, but it is representative of existing providers. In addition, other types of carbon markets are being considered across the country as awareness of climate protection increases.

3.3 Growing Markets

The International Emissions Trading Association and World Bank estimate that the market for carbon grew in value to US$30 billion in 2006 with approximately US$100 million in the voluntary market[11].

Efforts to forecast growth in this market are underway and at least two such efforts should publish results by the end of 2007. However, it is generally agreed that continued growth is likely given escalating concerns over climate change. With continued growth of the market, opportunities to add new, low-cost carbon offsets from projects such as waste diversion activities are likely to be favorably received.

3.4 Waste Diversion Activities and Offset Markets

As discussed previously, there is a variety of choices for purchasing offsets that support conservation projects. However, there appear to be no mechanisms or systems for certifying and trading credits related to reduced GHG emissions resulting from solid waste diversion strategies or that support solid waste diversion projects. While this is discouraging given what we know about the contributions of waste diversion to carbon reduction for the City of Fort Collins, it also is exciting because the possibilities for developing a relationship between solid waste reduction and carbon trading that could be replicable in communities nationwide are significant.

Because GHG emissions reductions associated with good waste management strategies are largely undervalued, the opportunity to develop a trading system around this type of emissions reduction is great. In fact, 52 percent of Fort Collins' GHG emissions reductions in 2004 were derived from solid waste diversion strategies[12]. Other municipalities also recognize the value of solid waste programs for meeting their climate goals. For example, in Santa Monica, California, the majority of GHG emissions reductions in recent years have occurred in the waste sector, where emissions have fallen 36 percent[13].

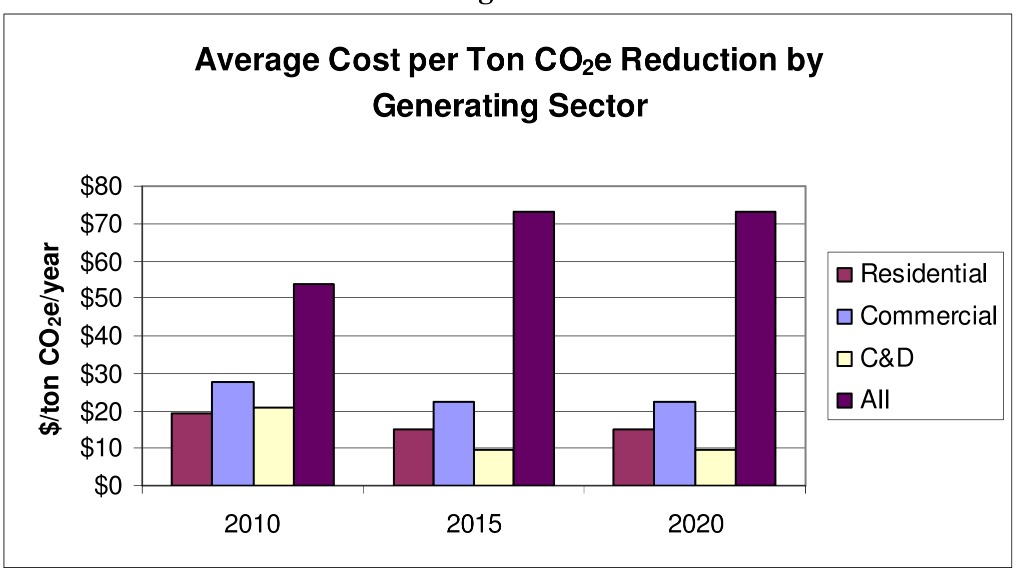
4.0 Potential Role of Solid Waste Diversion in Offset Markets

There are two primary issues in merging solid waste diversion efforts into offset markets. The first is the cost competitiveness of solid waste diversion programs against other offset methods, and the second is a functional mechanism for developing a marketable offset from diversion activities.

4.1 Cost Comparison of Waste Diversion Strategies and the Offset Market

In order for GHG, or carbon, reductions from solid waste to become marketable as carbon offsets, they first must be cost competitive with existing carbon offset options. As previously indicated, the WDAM software calculates a cost for strategy implementation that includes both City and user costs. This total cost was used to determine a cost per ton of carbon reduction, which can be compared to the current rates for other offsets.

Figure 6.



The average cost of all strategies per ton CO2e per year was $30, $25, and $25 for 2010, 2015, and 2020, respectively. There are a number of strategies that have an average cost per ton of CO2e of less than $25. This suggests that a number of the selected strategies likely would be competitive in the current voluntary carbon offset markets presented in Section 3.2.

In addition, information presented in the recently published Stern Review indicates that the cost of these diversion strategies also is competitive with the societal cost of a business-as-usual course from a climate perspective, which was estimated at $77/ton[14]. This suggests that it could be more costly to the community over time, due to all the potential externalities associated with climate change, not to implement additional diversion strategies that could reduce CO2e.

4.2 Marketing Diversion Carbon Offsets

On the basis of the cost analysis presented in the previous section, it is clear that the City of Fort Collins and other municipalities nationwide have an opportunity, through solid waste diversion efforts, to participate in the growing carbon market. The questions then become how to measure the opportunity in terms of GHG reductions and how to approach the existing carbon market for compatibility when there is no precedent for solid waste diversion generating marketable carbon instruments.

4.2.1 Measuring Solid Waste Diversion and GHG Reduction

Supposing the City of Fort Collins allocates dollars and implements a new waste diversion strategy, and as a result of this program there is a measurable increase in recycling, reduction (PAYT), or other waste diversion (organics for composting). The measurement method would vary depending on the nature of the strategy. It could be a straightforward measurement of organics diverted to a new composting or yard waste drop-off site or it might be a statistical analysis of residential recycling volumes before and after implementation of the new program.

From measured or calculated tons diverted, the GHG impact of the new diversion resulting from a particular program could be estimated, and the City would have a quantity of GHG reductions with which to approach the market. In this scenario, it is assumed that the City, as the entity funding strategies to increase diversion, would be the owner of any resulting carbon offsets. This assumption is potentially problematic as generators and recycling companies also will contribute materially and financially to generating new diversion, and have reasonable claim to the offsets as well.

The existing markets, however, are sure to be skeptical of the uncertainty related to solid waste diversion emission reductions because they are more difficult to quantify and therefore certify than reductions from other, more typical projects. For example, compare the measurability of carbon offsets from a wind energy project with a yard waste composting program. With a wind energy project, the amount of energy produced by a turbine is measured in kWh that can be directly related to kWh not required from a conventional power plant, thereby generating a clear reduction in carbon emissions. This reduction is real, measurable, and certifiable. The reductions associated with the yard waste composting project are based on life-cycle factors related to methane emissions from decomposition that might vary by location and circumstances.

So, while reductions from solid waste diversion are real and measurable to a certain degree, they are not easily certifiable and therefore do not fit nicely into the current market structure for carbon offsets.

4.2.2 The Certification Dilemma

The primary challenge in introducing solid waste diversion into existing carbon markets is certification. Most providers of carbon offsets use a third party to certify the offsets they provide. For example, many offsets generated through renewable energy are certified by Green-e. These certifications verify that the offset generator meets certain criteria, assure the offset exists, and provide some level of documentation to guard against double counting. While such certifications are widely available for energy-related offsets, there are no known certifications for carbon offsets generated by waste diversion.

A number of standards are being developed to ensure uniformity among certifications. Looking to these standards for some insight into the future of carbon certification does not suggest eminent acceptance of solid waste diversion as a method. For example, The Voluntary Carbon Standard, Proposed Version 2, prepared by the International Emissions Trading Organization (IETA)[15] outlines three guiding principles for emissions reductions:

1. **Real:** The emissions reduction in question must have already taken place. *This is challenging from the perspective of solid waste since emissions reductions are fundamentally based on changes in life cycle through diversion; therefore, all emissions reductions are anticipated to occur in the future.*

2. **Measurable**: All emission reductions must be quantifiable using accepted measurement tools and must be within acceptable margins of error. *Life-cycle emissions evaluations are not likely to be acceptable since the factors in determining the emissions vary widely (location, supply, and diversion chain).*

3. **Permanent**: Emissions reductions are not likely to be reversed. *Solid waste diversion in general, or at least certain aspects of the life-cycle emission factor, would meet the criteria of permanence.*

Solid waste diversion does not readily meet the requirements of two (real and measurable) of the three guiding principles the IETA designates for establishing carbon reductions. Therefore, in order to take advantage of the currently untapped potential of solid waste diversion projects to produce carbon reductions and marketable carbon instruments, a new certification that recognizes this potential is recommended – one that has a different set of criteria for defining a viable carbon credit:

- **Confirmed reduction** (based on a life-cycle analysis): While reductions will vary depending on location, supply, and diversion chain, on average there will be a reduction in emissions. Life-cycle analysis and program development need to be carried out with this variability in mind.

- **Measurement and certification** (based on a life-cycle analysis): Even though a life-cycle analysis adds a layer of difficulty to measurement, formal processes do exist for quantifying emission factor components, such as upstream energy, forest sequestration, and methane avoidance to an acceptable level of certainty. Under the Kyoto Protocol's Clean Development Mechanism, methodologies already have been developed that cover a number of the concept areas behind these emissions factors, including avoided landfill methane emissions and afforestation. These methodologies demonstrate the potential to address measurement and certification of the components of the solid waste emissions factor.

- **Additionality**: New diversion must result from programs that are implemented through carbon investment. In other words, these activities must take place specifically as carbon reduction projects that would otherwise not have taken place without the carbon investment.

- **Proof of ownership**: Clearly defined reduction ownership, whether tied to a municipality, a hauler, or residential and commercial customer, is possible and manageable.

- **Transaction documentation**: Auditable and transparent recordkeeping are required.

With the understanding that carbon reductions resulting from solid waste diversion projects would require a different approach to measurement and certification, but that this approach could be reliable and effective, a brief look at the possibilities of existing carbon markets is in order.

4.2.3 Market Options

For this study, three potential markets for selling the carbon offsets were considered:

1. The Chicago Climate Exchange: The CCX currently does not recognize waste diversion projects and there are no known third-party verifications that might be leveraged to encourage the CCX to move in this direction. Major policy changes and significant standards development would be required to participate in this arena, which seems unlikely at this time.

2. Existing consumer markets for carbon offsets (Terrapass, Carbonfund, etc.): While probably more flexible than the CCX, there are similar verification/certification issues in these consumer markets. In fact, with increasing scrutiny on offsets, the trend will likely be toward standardized certification protocols (standards for third-party certifiers, such as Green-e) that would preclude consideration of life-cycle-based measurements.

3. Hypothetical local market for GHG reductions from solid waste that recognizes the unique nature of these offsets. The City of Fort Collins or other municipalities could initiate programs to market these emission reductions. One possible scenario is described below:

    - The City could directly market a finite quantity of emissions offsets based on new diversion by wholly financing at least one new diversion program to provide seed offsets for this emerging market. For example, in year 1, the City could initiate residential weekly single stream recycling (program #1) to generate seed carbon reductions.

    - The quantity of offsets available for sale could be based on new tons diverted. Some derating factor might be used to account for the uncertainties of quantifying carbon reductions from solid waste. For example, maybe only 40 percent of emissions reductions would actually be offered for sale. The estimated tons resulting from new diversion for program #1 are 13,924 CO_2e. However, at 40 percent, only 5,570 tons of CO_2e could be offered for sale.

- The City could set a cost for the emissions reductions below typical market prices for carbon, perhaps at $5 per ton of CO2e. In this scenario, program #1 has the potential to generate $27,000 in revenue. This revenue would cover the City's cost to implement the program and would provide funds to implement additional programs #8, #11, and #16. These three programs could, in turn, provide additional annual revenue of approximately $64,000 to implement other programs. It is possible that user costs incurred to implement these programs could be reimbursed to more equitably distribute the overall cost impacts.

- Applying this model to all the diversion programs with total costs per ton of CO2e below $20 (#1, 8, 11, 16, 20) yields a potential annual revenue of $103,560. The total cost to the City for implementing these five programs is estimated at $20,367. Thus, the carbon offsets could actually generate excess revenue to fund additional projects or reimburse users for costs incurred from new programs.

4.2.4 Competitive Advantages of New Local Market

In the hypothetical market described in the previous section, the questions become (1) who would buy the offsets generated and (2) why would they buy these offsets instead of more conventional offsets?

Of course, the market could be open to anyone, but would be the most attractive to local residents and businesses. It would be an opportunity for those interested in or already purchasing offsets from other markets to redirect their investment to benefit their own community. It also would be an opportunity to affect progress toward local GHG reduction goals. More remotely, supporting a local offset market that implements projects within the community could potentially provide new jobs and a longer landfill lifetime.

It should be noted that the roles of supporting the City's climate protection goal and becoming a marketable instrument for any individual ton of CO2e are usually mutually exclusive. To avoid double counting carbon reductions, reductions that are applied to the City's climate protection goal cannot be sold on an open market. They could, however, be sold locally to the same community in which they were generated with the understanding that their sale would fund solid waste diversion programs with climate protection as a goal.

4.3 Next Steps

In order to introduce solid waste diversion activities into carbon offset markets, there are a number of steps to be taken.

The WARM/ICLEI models should be reevaluated with carbon market entry in mind. Aspects of these models that need further consideration include:

- Development of methodologies that accounts for regional differences and variability in supply and diversion chains that will allow for reliable carbon accounting.

- Confirmation that the methodologies used to calculate emission factor components are sufficiently rigorous to meet certification requirements for carbon accounting.

- Review of how emissions reductions upstream in the life cycle of a material are likely to be accounted for. Specifically, establishing that emissions reductions will not be counted upstream *and* at the point of diversion.

- Development of a methodology to establish ownership of emissions reductions from solid waste diversion. Specifically, the methodology should determine whether the reduction is credited to the municipality, the recycler, the hauler, the generator, or some combination of the above?

Because the possibilities associated with capitalizing on solid waste diversion projects are compelling, the community of Fort Collins should not be put off by the lack of a conventional market system to accommodate solid waste diversion reductions in CO2e. Rather, it should take the lead in establishing a system that supports its goals and is replicable in other communities.

5.0 Background

5.1 Waste Diversion Assessment Model

The City used the proprietary WDAM developed by Skumatz Economic Research Associates (SERA) to analyze the economics of the specific waste diversion strategies described earlier. WDAM is an Excel®-based solid waste program analysis spreadsheet that computes the following information:

- Forecasts of tonnage by sector (single family residential, multi-family, commercial, institutional, and self-haul)

- Waste composition by sector based on City specific data

- Program planning (scenarios on the basis of sector, materials, costs, etc.)

- Scenario settings (venue for modifying contributing factors)

- Summary of tonnages disposed by sector, disposal material, diversion level, and costs for both existing and proposed programs

WDAM incorporates a unique and proprietary database of real-world performance information that includes program designs, tonnage, costs, efficiencies, demographics, and many other factors. The model employs appropriate and well-tested statistical techniques to analyze these data to estimate the separate diversion and cost impacts of each specific design alternative. As a result, users are able to evaluate the impacts associated with changing collection frequency, adding/subtracting materials, providing containers, offering rate incentives, implementing mandatory programs, etc[16].

5.2 Greenhouse Gas Calculations

The City of Fort Collins historically has used the ICLEI Cities for Climate Protection (CPP) Campaign Greenhouse Gas Emission modeling software for calculating emissions and emission reductions for both community and municipal operations; therefore, it was logical to use ICLEI for this effort of measuring the emissions and emissions reductions of various waste management strategies. In way of background, ICLEI, or Local Governments for Sustainability, is an association of cities, towns, and countries who, as members, are committed to sustainable development. ICLEI provides technical consulting, training, and information services to its members to build capacity, share knowledge, and support sustainable development at the local level. For more information on this organization and its mission, visit http://www.iclei.org.

The proprietary ICLEI model looks at residential, commercial, industrial, and municipal buildings, transportation and fleet activity, etc., to compute GHG emissions, changes in energy consumption, and financial costs and savings related to emissions reduction initiatives. The waste management component of the model is based on research completed by the EPA and was updated in August of 2002. It should be noted that the EPA has published additional data to include more waste materials and their associated emissions factors. These data can be found at http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf.

The methodology employed by the ICLEI model assumes that GHG emissions depend on the types of waste considered and disposal methods used. The waste factors included in the model are based on the factors presented in the EPA's 2002 report and its WARM model. WARM is an EPA life-cycle model developed for waste managers to weigh GHG and energy impacts of waste management practices and covers 34 types of materials and 5 waste management options (source reduction, recycling, combustion, composting, and landfilling) http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf.

In comparison, the ICLEI model analyzes combinations of waste types (based on EPA types of materials) and disposal methods according to five emission factor components that specify tons of CO2e per ton of waste. These five components[17] are listed below :

- Methane Factor: CO2e emissions of escaped methane per ton of waste at disposal site
- Site Sequestration: CO2e maintained in the organic matter of the disposal site
- Forest Sequestration: CO2e sequestered in the forest as a result of waste reduction and recycling
- Upstream Energy: Upstream (manufacturing energy use) emissions reduced as the result of waste reduction or recycling
- Upstream Non-energy: Non-energy related emissions reduced as the result of waste reduction or recycling

It should be noted that there are some materials and waste diversion strategies not covered by the ICLEI model. For example, recycling phonebooks and composting organics are not addressed directly. In these cases, appropriate factors from the EPA's WARM model were substituted. A table is provided in Appendix A that maps the materials included in the waste diversion strategies to the source of the emissions factor used in this study.

Sources Cited

[1] City of Fort Collins. Resolution 97-137 of the Council of the City of Fort Collins Establishing a Policy to Take Cost-effective Actions that Benefit the Community to Reduce Local Greenhouse Gas Emissions. November 16, 1999. Accessed April 30, 2007 < http://www.fcgov.com/climateprotection/resolution99-137.php>

[2] City of Fort Collins. Resolution 97-137.

[3] City of Fort Collins Natural Resources Department (NRD). *DRAFT Strategic Plan for 50% Solid Waste Diversion*. March 28, 2006. Accessed April 2007 <http://www.fcgov.com/talkingtrash/pdf/DRAFT_solid_waste_diversion_plan_prelim_staff_recs_2006-0321.pdf >

[4] City of Fort Collins NRD. *City of Fort Collins 2003/2004 Climate Protection Status Report.* November 2005. Accessed June 2007 <http://www.fcgov.com/climateprotection/pdf/2003-04climatestatusreport.pdf>

[5] City of Fort Collins NRD. *City of fort Collins 2003/2004 Climate Protection Status Report*.

[6] City of Fort Collins NRD. *DRAFT Strategic Plan.*

[7] Personal communication. John Armstrong, City of Fort Collins Natural Resources Dept. June 2007.

[8] City of Fort Collins NRD. *City of fort Collins 2003/2004 Climate Protection Status Report*.

[9] Regional Greenhouse Gas Initiative. Accessed March 6, 2007 < http://www.rggi.org/>.

[10] The World Bank. *State and Trends of the Carbon Market 2007*. May 2007. Accessed May 2007. <http://carbonfinance.org/docs/Carbon_Trends_2007-_FINAL_-_May_2.pdf>

[11] The World Bank. *State and Trends*.

[12] City of Fort Collins NRD. *DRAFT Strategic Plan.*

[13] City of Santa Monica, Sustainable City Progress Report. August 2006. Accessed March 8, 2007 <http://www.smgov.net/epd/scpr/ResourceConservation/RC5_GHG_Emissions.htm>.

[14] Stern, Sir Nicholas of HM Treasury, United Kingdon. Stern Review: The Economics of Climate Change. October 2006. Accessed April 2007. <http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf>

[15] International Emissions Trading Organization (IETA). (http://theclimategroup.org/assets/Voluntary_Carbon_Standard_Version_2_final.pdf)

[16] Skumatz Economic Research Associates. *Waste Diversion Assessment Model.* December 2005. <http://www.serainc.com/> (proprietary model, not available publicly)

[17] STAPPA/ALAPCO and ICLEI. *Clean Air and Climate Protection Software: Waste Sector Primer and Coefficients.* Version 1.1, June 2005 <http://www.cacpsoftware.org/> (available to members of STAPPA/ALAPCO and participants in ICLEI's Cities for Climate Protection Campaign)

Appendix A: Greenhouse Gas Emission Factors

Table A.1. Mapping of Diverted Materials to Emission Factor Source

WDAM Materials	Emissions Factor Used
Mixed paper	ICLEI - Household paper
Cardboard	ICLEI - Cardboard
Chipboard	Not included in modeled strategies
ONP	ICLEI - Newsprint
Phonebooks/magazines	WARM - magazines only
Office Pack	ICLEI -Mixed office paper
Aluminum	ICLEI -Aluminum
Glass	ICLEI - Glass
Ferrous containers	ICLEI - Steel
Other ferrous	ICLEI - Steel
Currently recycled 1&2	ICLEI - Average of PET and HDPE
Other 1&2	ICLEI - Average of PET and HDPE
Film	WARM - LDPE
Other Plastics and Resins	ICLEI - Other plastics
Organics	WARM - Mixed organic composting, ICLEI uses earlier WARM data that did not recognize a benefit from composting organics
C&D	See development in Table A.2
Electronics	WARM - Personal computer
Food (comml, res)	WARM - Food discards
Other non-recy / gbg	Not included in modeled strategies
Other single str / comingled	Not included in modeled strategies

WARM factors used were from the 3rd edition of the EPA's Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks <http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html>.

Neither the ICLEI nor the WARM models directly address the mixed material category of C&D waste. A factor was estimated for this category using preliminary results from a 2006 characterization of waste at the Larimer County landfill, which serves Fort Collins. Materials in that characterization were mapped, as above, to available factors in the ICLEI and WARM models as shown in Table A.2. Unfortunately, a number of materials contributing significantly to the C&D waste stream do not have corresponding factors in either model. Notably, drywall, block/brick/stone, and asphalt roofing are not accounted for. Therefore, the estimated emissions factor for C&D wastes is conservative.

Table A.2. Mapping of C&D Composition to Emission Factor Source

Larimer County C&D Characterization	Emissions Factor Used
OCC/Kraft	ICLEI - Cardboard
Newspaper	ICLEI - Newsprint
Magazines/Glossy	WARM - Magazines
High Grade Paper	ICLEI - Office paper
Mixed (Other Recyclable)	ICLEI - Mixed recyclables
Other Paper (Non Recyclable)	n/a
#1 PET Bottles/Jars	ICLEI - PET
#2 HDPE Bottles/Jars	ICLEI - HDPE
Expanded Polystyrene	ICLEI - Other plastic
Films/Bags	WARM - LDPE
Other Ridged Plastic	ICLEI - Other plastic
Clear Glass	ICLEI - Glass
Green Glass	ICLEI - Glass
Brown Glass	ICLEI - Glass
Other Glass/Broken Glass	ICLEI - Glass
Ferrous Cans	ICLEI - Steel
Other Ferrous Metals	ICLEI - Steel
Aluminum Cans	ICLEI - Aluminum
Other Aluminum	ICLEI - Aluminum
Other Non-Ferrous	No factor available.
Appliances	No factor available.
Food Waste	WARM - Mixed organic composting
Diapers/Sanitary Products	No factor available.
Textiles	No factor available.
Rubber/Leather	No factor available.
Yard Waste -Grass/Leaves	WARM - Mixed organic composting
Land Clearing	WARM - Mixed organic composting
Clean Wood	ICLEI - Wood
Painted/Stained Wood	ICLEI - Wood
Other Wood	ICLEI - Wood
Fines	WARM - Mixed organic composting
Other Organics	WARM - Mixed organic composting
Carpet	WARM - Carpet
Drywall	No factor available.
Block/Brick/Stone	No factor available.
Insulation	No factor available.
Asphalt Roofing	No factor available.
Other C&D Material	WARM - Mixed recyclables
Electronics	WARM – Personal computers
Bulky Items	Assume average of ICLEI - Wood and ICLEI - Steel
Tires	WARM - Tires
Other Inorganic	WARM - Mixed recyclables
Other Hazardous Material	No factor available.