

## Green Parking Lot Case Study: Heifer International, Inc.

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## INTRODUCTION

The Environmental Protection Agency's (EPA) Office of Solid Waste and Emergency Response (OSWER) has initiated a series of pilot projects to test innovative approaches with the potential to realize environmental improvements and public health protection.



The Innovations Pilot Initiative is designed to support a wide range of creative techniques to address environmental issues such as pollution prevention, recycling, and land revitalization.

One OSWER Innovations pilot project centered on the development of an integrated green parking lot and urban wetland. “Green” parking lot is a term increasingly used to describe parking lots that may incorporate a

variety of environmentally preferable features, including a minimized footprint and/or impervious surfaces, use of stormwater best management practices (BMPs), and use of recycled materials. Heifer International, a non-profit sustainable community development organization located in Little Rock, Arkansas, was awarded an OSWER Innovations grant in June of 2003 to design an environmentally-friendly parking plaza to complement the organization's new headquarters, which is a green building located on a former brownfields site. A first of its kind in Arkansas, this project is intended to serve as a model for other organizations and companies considering utilizing green parking lot techniques.

Industrial Economics, Incorporated (IEc) is supporting this effort by developing a detailed case study of the Heifer International green parking lot with the goal of helping to scale-up this innovation by:

- Describing the environmental impacts associated with parking lots and identifying techniques that can be used to mitigate them;
- Quantifying environmental benefits of Heifer International's green parking lot;
- Quantifying the cost elements of Heifer International's green parking lot; and
- Exploring implications for developing policies that encourage the use of green parking lot techniques.

In addition, the case study will provide a foundation for developing a forthcoming EPA resource document on green parking lot construction.

The case study is organized in five sections. The first section describes the environmental and cost impacts associated with conventional parking lots. The second section provides an overview of the benefits of green parking lot development techniques. The third section describes the specific techniques used in the Heifer pilot project and compares the features of the Heifer parking lot to a hypothetical conventional parking lot. In the fourth section we analyze the environmental benefits of the lot including monetizing benefits where possible. The last section presents an analysis of Heifer's costs for building and maintaining the lot.

## IMPACTS OF PARKING LOTS

Parking lots are a ubiquitous feature of the American landscape. Perhaps because they are so commonplace, the significant environmental and cost impacts associated with parking lots are often overlooked. In this section, we provide an overview of the environmental and cost impacts of parking lots.

### ENVIRONMENTAL IMPACTS OF PARKING LOTS

The predominant low-density American development pattern (i.e., urban sprawl) necessitates reliance on automobiles, along with the construction of parking lots to accommodate, and many times overaccommodate, demand for parking. As parking lots have become a dominant feature of urban and suburban landscapes, their environmental impacts have also become increasingly apparent.

Most parking lots are made of pavement - a combination of asphalt concrete, the most widely used paving material in the United States, and aggregates such as sand, gravel, or crushed stone. Pavement is an impervious, heat absorbing material that collects stormwater on its surface, and does not allow it to filter into the soil, inhibiting the natural water cycle. With this in mind, parking lots have traditionally been built with the primary goal of channeling stormwater into receiving water bodies as quickly as possible, via means such as gutters, drains, and pipes. As a result, runoff that is contaminated with many types of petroleum residues, fertilizers, pesticides, and other pollutants from parking surfaces enter receiving waters at an unnaturally high rate and volume, negatively impacting the surrounding ecosystem. Hence, parking lots degrade water quality, strain stormwater management systems, consume large amounts of land and resources, and enable urban sprawl. Also, materials used to construct parking lots have a variety of impacts throughout their life cycle on air, water, and biodiversity. Below we describe some of the major environmental impacts of traditional parking lots.

#### Water Quality Impacts

Parking lot runoff is a major contributor to non-point source pollution of our waterways. Conventional parking lots quickly move stormwater into receiving water bodies. As it flows across pavement, the water picks up pollutants from the surface. This results in large volumes of polluted runoff entering surface water and groundwater resources, negatively affecting water quality.

Contaminants in parking lot runoff can originate from a variety of sources, including the paving materials used to build them. Recently, the USGS has pinpointed parking lot

sealants as a large source of non-point source pollution, specifically polycyclic aromatic hydrocarbons (PAHs), a known carcinogen that can be toxic to fish and wildlife.<sup>1</sup> Automobiles are also a major source of pollutants in parking lot runoff, including antifreeze, oil, hydrocarbons, metals from wearing break linings, rubber particles from tires, nitrous oxide from car exhausts, debris from brake systems, and grease.

#### Water Supply Impacts

Conventional parking lots consist of large areas of impervious surfaces that do not permit the infiltration of water into the soil. Unlike natural conditions where rainwater filters into the ground, impervious surfaces halt this process, inhibiting a watershed's natural hydrological cycle and preventing groundwater recharge. As a result, water tables are lowered, reducing streamflow during dry periods, depleting water supplies, and exacerbating the negative impacts of droughts.

#### Stormwater Management Impacts

According to the USGS, an impervious, man-made surface will generate 2 to 6 times more runoff than a natural surface. In addition to the direct impact of paving, conventional parking lots also typically include pipes, curbing, gutters, and drains to help speed water off of parking surfaces. These systems cause runoff to move even faster downstream, increasing the risk of stream flooding. Sewer systems often become overwhelmed by the rapid runoff of stormwater, causing them to overflow and, in the case of combined sewer and stormwater systems, discharge raw sewage into receiving waterways. In addition to the human health risks related to combined sewer overflows, these discharges can cause algal blooms to form, depleting aquatic oxygen levels and altering a water body's habitat.

#### Air Emission Impacts

Pollutant air emissions occur throughout the lifecycle of a parking lot. Asphalt cement plants emit particulate matter, nitrogen oxides (NO<sub>x</sub>), sulfur oxides (SO<sub>x</sub>), carbon monoxide (CO), volatile organic compound (VOCs), polycyclic aromatic hydrocarbons (PAHs), and carbon dioxide (CO<sub>2</sub>) during the manufacturing process. The activities associated with the construction and maintenance of parking lots also generate emissions, typically in the form of dust, fumes, and equipment and vehicle exhaust. For example, the use of hot mix asphalt, a common process where the asphalt is heated to extremely high temperatures prior to application, can cause health problems for workers including headache, skin rash, fatigue, throat and eye irritation, breathing problems and coughing. Diesel emissions from on-site equipment can also cause similar health effects.<sup>2</sup> In addition, the after effects of parking lot construction, such as fewer trees and less

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<sup>1</sup> Van Metre, P. et al (2006), Parking Lot Sealcoat: A Major Source of Polycyclic Aromatic Hydrocarbons (PAHs) in Urban and Suburban Environments, USGS Fact Sheet 2005-3147, January 2006.

<sup>2</sup> N.Y. State Department of Transportation (DOT), (2003), *Safety Bulletin: Paving with Hot Mix Asphalt*, SB-03-3, accessed at <http://www.dot.state.ny.us/progs/safety/files/pavinghma.pdf#search=%22fumes%20from%20hot%20mix%20asphalt%22>.

vegetation due to clearing, as well as HIE (see below), also lead to higher amounts of CO<sub>2</sub> in the air.

#### Heat Island Effect

Heat island effect (HIE) occurs in urban areas where materials that have heat-absorbing properties, such as asphalt, are prevalent. In urban areas, the combined effect of such surfaces can cause a change in the energy (temperature) balance, leading to hotter air and surface temperatures. Recent research indicates that urban areas are 2 to 8°F hotter in summer due to this increased absorbed heat.<sup>3</sup>

Parking lots contribute significantly to HIE. Asphalt, one of the most common paving materials used in parking lots, is a dark and heat absorbing material.<sup>4</sup> When the asphalt cools at night, all the heat it has absorbed during the day is released into the air, slowing the rate of nighttime cooling. This hot surface also affects surrounding waterbodies when combined with the parking lot's stormwater function. When water is forced to flow quickly off the lot's surface, not enough time is allowed for evaporation to occur, again limiting natural cooling of the air. Lastly, the land clearing needed to create space for parking lots diminishes tree cover and other natural vegetation that can help shade land and moderate temperatures.

The environmental impacts of the HIE are varied. Hotter temperatures can lead to more CO<sub>2</sub> emissions due to increased energy demand to cool neighboring buildings. HIE can also increase smog, and subsequently exacerbate pulmonary and cardiovascular health problems. During rain events, paved surfaces can transfer their higher heat to runoff, increasing the temperature of receiving waters. This warmer water can be detrimental to the natural habitats of fish and other aquatic life.

#### Waste Impacts

The traditional production and application of asphalt relies heavily on the use of virgin stone and aggregate and non-renewable, petroleum-based materials. Use of fresh asphalt in parking lot construction creates a lost opportunity for reusing waste products, such as recycled asphalt, which would reduce the amount of material sent to landfills and increase the amount of virgin materials conserved. The use of recycled asphalt is common in the construction of roads, but has yet to become prevalent in parking lot construction. In addition, alternatives to impervious surfaces such as gravel-pave and grass-pave systems typically utilize recycled materials.

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<sup>3</sup> U.S. EPA, (1992), *Cooling Our Communities*, GPO#055-000-00371-8, January 1992, accessed at [www.epa.gov](http://www.epa.gov), as cited in Pavement Busters Guide (2002), page 10, Victoria Transport Policy Institute.

<sup>4</sup> Gibbons, J. (1999), *Pavements and Surface Materials*, Technical Paper #8, pg. 2, University of Connecticut Nonpoint Education for Municipal Officials (NEMO) program, accessed at [http://nemo.uconn.edu/tools/publications/tech\\_papers/tech\\_paper\\_8.pdf](http://nemo.uconn.edu/tools/publications/tech_papers/tech_paper_8.pdf).

### Disturbance of Habitat and Local Ecology

Traditional parking lots can have a host of negative impacts on adjacent habitat and fauna. The velocity and volume of runoff from parking lots can damage plant, fish and invertebrate habitat. During storm events, runoff can erode stream banks and alter the natural shape of a waterway. Stream edge habitat and stream channel protection removed during the construction of the parking lot increases the potential for erosion. Sediments entering the waterway as a result of erosion can smother habitat and stress aquatic organisms. The turbidity created from the sedimentation can disrupt an aquatic ecosystem by diminishing light transmission, reducing plant growth, altering food supplies, interfering with navigation, decreasing spawning habitat, and reducing shelter.

The contaminants in parking lot runoff also pose a risk to wildlife. Toxic substances from contaminated ground and surface water supplies have the potential to bioaccumulate in the tissue of fish and other organisms in the wildlife food chain. They can also accumulate in sediments, posing risks to bottom feeding organisms and their predators.

The impact of parking lots on water supplies also affects local ecology. Unnaturally low stream flows as a result of decreased infiltration can reduce deep water and swift flowing habitats. The decreased water quality and increase volume and velocity of runoff can lead to habitat loss, stress aquatic species, and have an overall negative effect on biological diversity in abutting areas.

### Decrease In Greenspace

Greenspace is a finite resource that possesses value for a variety of reasons, including conservation, recreation, and agricultural purposes; or simply because of its scenic qualities and contribution to the overall character of a city or town. Proper management of greenspace is essential to achieving and maintaining sustainable communities. With the increased usage of cars, more greenspace is being paved to accommodate demand for parking; it is estimated that 30 to 40 percent of a typical American downtown is used for parking spaces.<sup>5</sup>

Ineffective local government zoning restrictions also result in larger areas of paved surface than necessary to meet the parking demand. Many municipalities require a *minimum* number of parking spaces per development project, often forcing developers to build more spaces than needed to meet actual demand. For instance, commercial parking lots frequently have 60 to 70 percent vacancy rates.<sup>6</sup> Parking stall sizes required by zoning can also be larger than necessary, eliminating opportunities to alter parking lot

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<sup>5</sup> Miramontes, E.M. University of California at Berkeley (1997), *The Bay Area's Love-Hate Relationship With The Motorcar*, San Francisco *Examiner*, October 20, 1997, as cited in Gibbons, J. (1999), *Parking Lots*, Technical Paper #5, page 2, University of Connecticut Nonpoint Education for Municipal Officials (NEMO) program, accessed at [http://nemo.uconn.edu/tools/publications/tech\\_papers/tech\\_paper\\_5.pdf](http://nemo.uconn.edu/tools/publications/tech_papers/tech_paper_5.pdf).

<sup>6</sup> Benfield, F.K. et al (1999) *Once There Were Greenfields: How Urban Sprawl is Undermining America's Environment, Economy, and Social Fabric*, Natural Resources Defense Council (NRDC), as cited in *Paving Our Way to Water Shortages*, NRDC, American Rivers, Smart Growth America, 2002, page 6.

configuration designs to achieve higher car capacity and minimize the area of impervious surface used.

Conventional parking lots are often viewed as unattractive, hostile, and sometimes unsafe areas. In contrast, green parking lots with urban greenscaping provide aesthetic benefits, including privacy and noise reduction, to landowners and to communities. These benefits are lost when an area is conventionally constructed and paved.

#### Urban Sprawl

Urban sprawl and prevailing low-density development patterns characterized by free, plentiful parking reinforce dependence on automobiles for commuting to work, shopping, and social activities. Thus, conventionally designed parking is an enabler of urban sprawl. Conventional parking creates barriers to alternative transportation, including walking and bicycling, and encourages automobile travel, disconnecting communities and decreasing the habitability of cities and towns. The resulting increase in vehicle miles traveled and the associated high levels of mobile source air emissions exacerbate air quality issues, and contribute to global climate change.

#### COSTS OF PARKING LOTS

Beyond their environmental impacts, parking lots have economic and social costs related to their construction – costs that are often much higher than consumers realize. Below we present the four main types of costs related to parking lot construction:

##### On-site Costs

On-site costs include the construction, operation, maintenance, and disposal of materials needed to develop and maintain parking lots including paving materials and infrastructure such as gutters and curb cuts. In addition, on-site costs include the cost of parking lot landscaping that, depending on the shrubs, trees, and turf chosen, vary in their need for mowing, pruning, and irrigation. HIE can add to private costs by decreasing an automobile's value by quickening the deterioration of the vehicle's paint, plastics, and tires while on the lot. HIE can also shorten the life of the pavement, causing it to become brittle and weak; and can increase the energy costs of adjacent buildings due to the hotter air temperatures.

##### Infrastructure Costs

The high volume and velocity of polluted run-off from parking lots can stress stormwater management systems and necessitate repairs, upgrades, and expansions to handle water flow and treat runoff. Flooding caused by runoff can also degrade bridges, roads and other parts of a city's infrastructure. Additionally, groundwater shortages due to disruption of the water cycle can increase the frequency, and thus cost, of pumping groundwater.

#### Opportunity Cost

Parking lots consume large areas of open space that could otherwise be used for alternative, higher value purposes, such as parks, wildlife habitat, recreation, agriculture, housing or other businesses. For local governments, building parking over other development could reduce the property tax base.

#### Distributional Issues

Parking lot access provides a value to consumers who can use them, but results in negative impacts for neighbors and other community members who do not have access to the lots. Such neighbors would be better served by almost any other use, particularly in cases of excessive sizing of paved areas, which can reduce adjacent property values.

#### Community Development Costs

Parking lots and associated sprawl decrease a community's habitability, livability, and sense of identity. The unattractive expanses of pavement placed in the front of buildings create voids and disconnectedness, discouraging pedestrian-friendly communities and alternative methods of transport.

The presence of multiple conventional parking lots can also signal developers that a community accepts urban sprawl development. This signal can create a cyclical effect on a community's future development patterns. Subsequent developments in these areas are far more likely to have a similar pattern of urban sprawl, further disconnecting the link with any older non-sprawl development, and eroding unique characteristics that establish a community's sense of place.

## "GREEN" PARKING LOT TECHNIQUES

Innovative approaches to planning and design can greatly mitigate the negative impacts of parking lots. As a whole, green parking lot technology can reduce the impacts of particular concern, diminished recharge of groundwater, high rates of stormwater runoff, and non-point source pollution, by providing benefits such as decreased impervious surface, protected water quality, reduced stormwater management and maintenance costs, as well as and increased aesthetic value. Some green parking lot techniques include:

### ON-SITE STORMWATER MANAGEMENT

Innovative stormwater management strategies are increasingly being incorporated into parking lot design as part of the overarching concept of Low Impact Development (LID). LID stormwater techniques (also known as Best Management Practices, or BMPs) manage stormwater on-site, reducing negative impacts on receiving waters and municipal stormwater management systems, and decreasing the need for costly infrastructure such as pipes, gutters, and curbs. Done on a small-scale, these controls attempt to mimic the pre-development ecological and hydrological processes of an area, and can reduce stormwater and site development design, construction, and maintenance costs by 25-30% compared to conventional approaches.<sup>7</sup>



Stormwater BMPs include structural controls and bioengineering techniques designed to facilitate natural water cycling processes (i.e. evaporation, transpiration, and groundwater recharge) by capturing, filtering, infiltrating, and/or storing stormwater. Components of these soil- and plant-based systems can carry out one or more of the aforementioned functions, including some that store water for various durations (from 24 hours to permanent storage). Examples of BMPs include:

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<sup>7</sup> Maryland Governor's Office of Smart Growth (2005) *Driving Urban Environments: Smart Growth Parking Best Practices*, page 23, accessed at [www.smartgrowth.state.md.us](http://www.smartgrowth.state.md.us).

- Swales – Open channels or depressions with dense vegetation used to transport, decelerate, and treat runoff. Swales are also designed to help direct water into bioretention areas.
- Filter strips/vegetated buffer strips – Flat pieces of land with low slopes, designed to promote natural sheet flow as opposed to channeled runoff.
- Riparian buffers – Vegetated strips along waterways that trap and filter contaminants, encourage infiltration, and slow stormwater flow. Riparian buffers also help to preserve streambank stability.
- Detention basins – Vegetated basins with controlled outlets, designed to detain runoff (lowering flows and reducing velocity) for a short amount of time (e.g. 24 hours), partially removing pollutants before water is discharged.
- Bioretention areas - Treatment areas consisting of a grass buffer strip, ponding area, organic layer, planting soil, and vegetation. Examples include retention ponds and constructed wetlands designed for longer-term retention of stormwater.

Unlike traditional stormwater management systems designed only for efficiency in stormwater removal, which can lead to negative downstream effects, BMPs represent a shift towards a sustainable approach to stormwater management. Thus, in the context of parking lots, BMPs add value by minimizing environmental impacts of runoff, and often lower site development costs while improving aesthetics.

#### MATERIAL SELECTION

The negative impacts associated with large impervious surface areas in parking lots can be reduced through the use of new permeable materials as substitutes for pavement. A number of paving substitutions have been developed to reduce the range of environmental impacts associated with the use of pavement. Types of permeable and semi-permeable alternative pavers include gravel, cobble, concrete, wood mulch, brick, open jointed pavers filled with turf or aggregate, turf blocks, natural stone, and pervious concrete.

Based on a site's characteristics (i.e. traffic volume, soil type, climate etc.), alternative pavers may not be an option for the entire surface of primary parking areas.<sup>8</sup> However, in many cases the aisles and driveways can be constructed using conventional pavement, while alternative pavers can be used in parking stalls, crosswalks, and overflow lots. Alternative pavers slow the flow of runoff, allowing it to filter into the soil, sustaining an area's natural hydrological cycle, and in some cases, allowing microbes to break down contaminants before entering the soil layer.

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<sup>8</sup> Permeable pavers should not be used for the aisles and main (primary) vehicle travel areas in high traffic lots because they are not strong enough to withstand constant weight and use, however in most cases they would be ideal for use in parking stalls, crosswalks, or overflow (i.e. secondary) parking areas.

RESINPAVE™ and porous pavement are two other notable alternatives to conventional paving options. RESINPAVE™, though not pervious, is manufactured from renewable resources - crushed stone and natural tree resin, contains no petroleum ingredients, and is highly reflective. However, as a new product it is still relatively expensive to install, and faces unresolved questions concerning durability.<sup>9</sup> Porous pavement, although less environmentally preferred than RESINPAVE™ because it uses the same amount of chemicals and energy needed to create conventional pavement, is preferable to asphalt because it provides water infiltration benefits.

#### RECYCLING AND REUSE TECHNIQUES

Opportunities for materials recycling exist in the management and construction of parking lots. For instance, the use of recycled asphalt in parking lot construction is not only environmentally beneficial, but can make economic sense. Other environmentally preferable materials, such as recycled rubberized asphalt, may also be used in parking lot construction. Recycling materials can be more economical for developers than incurring the rising landfill cost in some States for disposal of construction, demolition, and clearing debris.

In addition, the incorporation of recycled materials, such as recycled asphalt and concrete, in parking areas can lessen upstream impacts associated with materials manufacturing and application, and save resources by avoiding the use of virgin materials.<sup>10</sup> For instance, organizations can avoid the energy consumed in mining, manufacturing, and transporting the material. Air emissions can also be reduced, such as those from hot mix asphalt plants, which emit particulate matter and a variety of gaseous pollutants.<sup>11</sup>

Reuse of a natural resources, such as rainwater, can also be a beneficial green parking lot technique. By collecting rainwater and parking lot runoff via cisterns, rainwater can be reused for irrigation and grey water purposes, reducing virgin water demand and costs.

#### SUPPORT AND CONSERVATION OF LOCAL ECOLOGY

Green parking lot techniques work to minimize the amount of land cleared for construction, conserving as much of a site's natural vegetation and open space as possible, and retaining habitat for local wildlife. When designing a parking lot area, landscapers can use native trees and shrubs rather than non-indigenous species, which require less irrigation and are more suitable to local climates. The benefits of increasing the amount of greenscape in and around parking areas include reduction of CO<sub>2</sub> in the air; improved stormwater runoff management including water storage; increases aquifer recharge and flood protection; and increased human comfort through mitigation of HIEs.

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<sup>9</sup> United States Environmental Protection Agency, (2005), EPA Lessons Learned Paper - Heifer International, page 5.

<sup>10</sup> Horvath, A. (2003), *Life-cycle Environmental and Economic Assessment of Using Recycle Materials for Asphalt Pavement*, report funded by the University of California Transportation Center.

<sup>11</sup> EPA (2000), *Hot Mix Asphalt Plants Emission Assessment Report*, page 1, EPA-454/R-00-019.

Wetlands preservation or creation is particularly beneficial, as wetlands can act as natural bioretention basins, providing water quality improvements, flood protection, and erosion control. Wetlands also provide excellent habitat for local avian and fish species, and are invaluable for water storage; one acre of wetlands can store over million gallons of water.<sup>12</sup>

#### PLANNING

Local planners regularly reinforce car dependence through zoning bylaws that, although meant to meet a community's parking needs, can result in an oversupply of parking. To combat this, cities and towns are increasingly trying new approaches to parking management that allow for greater flexibility and adaptability by determining parking space numbers on a project-specific basis, rather than through a one-size-fits-all regulation.

One such technique is to *reduce minimum parking requirements* based on project location or demographics. For example, local government can encourage projects that are located near public transport to reduce the demand for parking spaces. Adaptations of this technique include municipalities allowing a reduction in the minimum parking requirements in return for a developer/employer agreeing to incorporate a transportation demand management program to encourage employees to use alternative modes of transport, through company support or subsidies. Another alternative is for municipalities to institute an optional fee that developers can pay towards an appropriate municipal fund, such as a traffic mitigation fund, in lieu of meeting minimum parking requirements.<sup>13</sup>

Depending on the site, developers may not opt for less parking because it may make a site less marketable. A technique applicable in this case would be to set *parking maximums* and/or *areawide parking restrictions*, which would limit the number of spaces allowed across a larger area, evening the playing field for the marketability of sites in the area.

Beyond reducing the number of parking spaces required, municipalities and developers can also encourage practices that *reduce stall dimensions* by creating more compact car spaces and realistic stall size requirements. Some local zoning laws can require unnecessary large stall dimensions that are bigger than even the largest SUV.<sup>14</sup> In many cases smaller, more realistic, stall sizes would be sufficient while reducing the amount of disturbed land and impervious surface associated with a project.

Improving the aesthetic of the parking lot is also central technique in green parking lots. For instance, placing a parking lot behind a building rather than in front of it creates a more inviting and pedestrian-friendly environment. Reducing the number of curb cuts

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<sup>12</sup> United States Environmental Protection Agency, (2001), *Functions and Values of Wetlands*, EPA 843-F-01-002c, September 2001, accessed at [http://www.epa.gov/owow/wetlands/pdf/fun\\_val.pdf](http://www.epa.gov/owow/wetlands/pdf/fun_val.pdf).

<sup>13</sup> Maryland Governor's Office of Smart Growth (2005) *Driving Urban Environments: Smart Growth Parking Best Practices*, page 4, accessed at [www.smartgrowth.state.md.us](http://www.smartgrowth.state.md.us).

<sup>14</sup> *Ibid*, page 22.

also decreases the frequency of pedestrian/traffic interaction, thus making for a more pedestrian-accessible area. These practices aim to improve the character of the development while maintaining accessibility to the lot. Additionally, parking lots can also be divided into two or more parking areas, again projecting a more visually welcoming appearance.

The impact of locating a parking lot at the front of the building can be mitigated by providing ample space between the lot and the road, and then creating a buffer with landscaping, fencing, or a wall. Landscaping inside the parking lot is also important. Beyond making the parking lot more visually pleasing, vegetation and landscaping (including trees) around and inside the parking lot reduce HIE and help to absorb CO<sub>2</sub> emissions. Curbless islands throughout the lot increase the amount of greenscape and aid in on-site stormwater management.

## THE HEIFER PARKING PLAZA

Heifer's goal in building its parking plaza was to minimize impacts to the environment while handling a large volume of site traffic. This section first presents the environmentally preferable techniques that Heifer incorporated into its parking lot, and then describes a hypothetical conventional parking lot that Heifer would have built had they not incorporated sustainable feature. The hypothetical parking lot serves as the point of comparison for our analysis of environmental benefits.

### PARKING LOT TECHNIQUES

Heifer's parking plaza encompasses numerous green parking lot techniques that minimize impervious surface, reduce runoff, reduce virgin water use, and incorporate recycled materials.

#### Parking Lot Materials

Impervious surface at the Heifer lot is minimized by integrating a gravel pave system and bioswales into the lot design, reducing impervious cover by 30 percent.

The gravel pave system is constructed of 100 percent recycled material (90 percent post-industrial and 10 percent post-consumer). The system consists of a sandy gravel base, covered with filter fabric to contain the sand and restrict any plants from growing through, and topped with a layer of crushed gravel. Maintenance for the gravel pave is minimal, requiring roughly eight hours a month.

The aisles and driveways of the Heifer parking lot are paved with concrete rather than asphalt. The concrete base contains 90 percent recycled cement and its top layer is made of locally produced concrete, reducing materials transport impacts.<sup>15</sup> Because it is a light colored and highly reflective surface, concrete helps minimize the HIE compared to asphalt paving, as well as reduces lighting costs. For instance, at some sites the use of concrete for paving has been shown to result in a 20°F reduction in surface temperatures compared to asphalt.<sup>16</sup> HIE, coupled with the extreme humidity in the Little Rock region, can be stifling in an urban environment. Thus, using concrete in place of asphalt helps decrease heat island impact at the Heifer site.

The remainder of the material and equipment used to construct Heifer's parking lot also enhances the project's environmental benefits. Heifer employees helped recycle brick

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<sup>15</sup> Another option is to also include coal ash in the concrete, which improve its strength and durability while using a recycled material. Heifer explored this, but chose other sustainable options for their lot based on preference and budget.

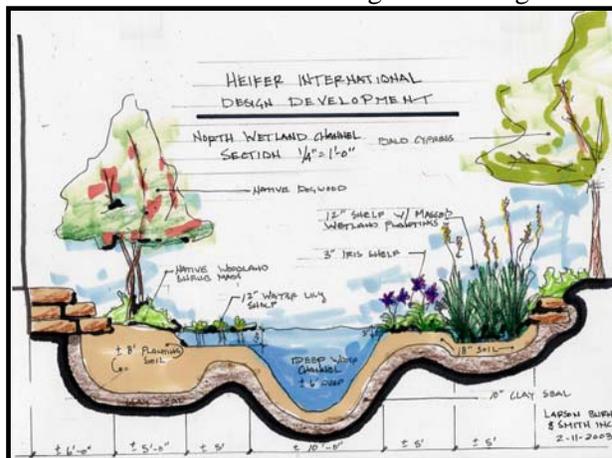
<sup>16</sup> Wade, B. (2000), Putting the freeze on heat islands, American City & County, 115, 2, 30, page 2, Feb 2000.

pavers from buildings that previously occupied the site, which were laid in the circular driveway and sidewalks of the lot. The company also reused on-site seventy-percent of the soil removed for the construction of the parking lot. Additionally, energy efficient lighting is used to illuminate the parking area. This includes 30 percent downlighting/70 percent uplighting with dim footlighting.

All parking lot materials were purchased from local dealers within 500 miles of the site, supporting the local economy and reducing emissions associated with transportation of purchased materials.

#### Innovative Stormwater Management

To minimize runoff and stormwater impacts, Heifer constructed a state-of-the-art stormwater management system. Construction of a conventional parking lot would have channeled runoff into the adjacent Arkansas River. In contrast, the Heifer parking lot is designed to avert runoff via the creation of a closed loop water collection system, which guides stormwater into open space medians and bioswales, and ultimately into constructed wetlands. This system includes five bioswales, encompassing 15,795 ft<sup>2</sup> or 0.36 acres located throughout the parking lot, which slow down and filter runoff. The bioswales are constructed of three-foot deep sand filtration basins and native flora that work to percolate water and filter out pollutants. Within 24 hours, any remaining water in the bioswales that does not infiltrate into the soil slowly drains via a sub-surface drainage system into a retention basin, which can hold up to 3 million gallons (an average of two months of rainwater). The water captured in the retention basin is then circulated to a man-made wetland surrounding the building. These wetlands can store 750,000 gallons



of water and are designed to mimic a natural system by fluctuating the water levels at certain times of the year. Both the retention basin and the wetlands provide irrigation water for landscaping, and the wetlands also help to provide habitat for local species. Wildlife species that utilize the wetlands include birds, watersnakes, dragonflies, butterflies, turtles and frogs.

Innovative landscaping and irrigation surrounding the lot also provide environmental benefits. The grasses, plants, trees, and wildflowers used throughout much of the site are indigenous, and do not require pesticides. They also offer food and shelter to native wildlife, and help create a more visually pleasing aesthetic. Under natural rainfall events, the species planted in the lot should be able to sustain themselves with little or no irrigation. In fact, when the site's vegetation matures, in a normal rainfall year, the landscape will only have to be irrigated once a week. Heifer supported this sustainable

landscaping by amending the soil with compost, which helps increase nutrient retention, decrease irrigation needs, and improve soil and plant health.

Heifer's onsite irrigation system includes a combination of sprinkler and drip irrigation used in the bioswales, and a cistern with a storage capacity of 32,000 gallons of water. This cistern is used mainly to supply bathroom facilities and the HVAC system, however some of the water will flow into the wetlands. When Heifer's stormwater management system is fully operational, all irrigation water will come from the recycled site water system or captured rainwater, requiring no connection to the City of Little Rock's municipal water supply.<sup>17</sup>

#### Reduced Automobile Reliance

Heifer also promotes alternative transport and commuting. The organization has influenced a route change in the local bus system to provide employees with better access to public transport, in addition to the existing city trolley system. To support use of alternative transport options, the company subsidizes the cost of public transit, provides on-site bike racks, and encourages participation in the organization's commuting program. Heifer has also set aside six premium parking spots specifically for carpooling or hybrid vehicles. The city's plan for a new bike trail connecting North Little Rock to Little Rock, which will lead directly to the Heifer site, will add another element to alternative transport options available to Heifer employees and visitors.

#### COMPARING THE HEIFER LOT TO A CONVENTIONAL APPROACH

To analyze the benefits associated with Heifer's green parking lot, we need to compare its benefits to those of a hypothetical conventional parking lot. Envisioning a hypothetical lot requires making some assumptions as to its characteristics, which are explained below. Exhibit 1 summarizes the characteristics of the Heifer parking lot compared to a typical conventional parking that might be constructed at a facility of this size.

*Footprint:* Given the land constrictions of the Heifer site, we assume that the total square footage of the current Heifer parking lot, 130,000 ft.<sup>2</sup>, would be the same as with a conventional lot. However, the space would be allocated differently in a conventional lot, incorporating more parking spaces, no stormwater management BMPs, and less landscaping.

*Paving materials:* Asphalt is the most commonly used parking lot paving material and is often used to pave entire parking lots. Hence, we assume that the entire paved surface area of the baseline parking lot would be constructed of impervious asphalt.

*Landscaping:* We assume that developers of a conventional lot would not exceed the local government's minimum requirements for landscaping. The City of Little Rock's parking ordinances for a lot of Heifer's size requires that the interior landscape area should comprise at least eight percent of the total vehicular use area, or 10,400 ft.<sup>2</sup> in this case. The city parking ordinances also require one tree be planted for every twelve

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<sup>17</sup> Larson Burns Smith (2006) Captured Rainwater Narrative, for credit 2.1 as part of Heifer's on-line LEED application.

parking spaces. Therefore, a minimum of 17 trees would be required for a 199-space lot such as Heifer's. Other than planting trees, landscaping for a conventional lot would typically consist solely of the commonly used sod, rather than the mix of native seeding and sod used by Heifer in its bioswales.

*Stormwater management:* A conventional lot would not integrate an on-site stormwater management system or even individual best management practices. Conventional lots typically use piping, gutters, catch basins, curbs, and man-made channels to speed the flow of water directly into the city's stormwater system.

*Lighting:* A typical conventional lot would incorporate metal halide lighting instead of the energy efficient compact florescent lighting used at the Heifer lots. The standard placement for metal halide lighting is one fixture per 7200 ft.<sup>2</sup>, which would be 18 fixtures for a lot the size of Heifer's.

*Irrigation:* Because sod planted in conventional lot landscaping requires more water than the native planting done by Heifer, a six-zone sprinkler irrigation system would be necessary, rather than the four zones of drip irrigation and two zones of sprinkler irrigation used by Heifer. A conventional lot would not incorporate a closed loop water collection system, and would have to obtain irrigation water from the City of Little Rock's municipal water supply.

*Other characteristics:* We assume that a conventional lot would use the same pavement paint, wheel stops, and handicap signs as used in the Heifer lot. However, bike racks may not be installed in a conventional lot.

EXHIBIT 1: CHARACTERISTICS OF THE HEIFER PARKING LOT COMPARED TO A HYPOTHETICAL CONVENTIONAL LOT

	HEIFER PARKING LOT		CONVENTIONAL PARKING LOT	
	CHARACTERISTIC	ACTUAL QUANTITY	CHARACTERISTIC	ASSUMED QUANTITY
Paving Materials	Concrete	86,000 ft <sup>2</sup>	Asphalt	119,600 ft <sup>2</sup>
	Brick Pavers	2,500 ft <sup>2</sup>	n/a	-
	Gravel Pave System	30,000 ft <sup>2</sup>	n/a	-
Landscaping	Conventional Landscaped Islands (sod)	6,500 ft <sup>2</sup>	Conventional Landscaped Islands (sod)	10,400 ft <sup>2</sup>
	Bioswale Landscaping (native seeding)	11,500 ft <sup>2</sup>	n/a	-
	Trees	80	Trees	17
Irrigation	Sprinkler Irrigation (sod)	2 zones	Sprinkler Irrigation	6 zones
	Drip Irrigation (natives)	4 zones (27,500 ft <sup>2</sup> )	n/a	-
Stormwater Management	Bioswales	11,500 ft <sup>2</sup>	Gutters, Catch Basins, Curbs, and/or pipes	(quantities not known)
	Retention Basin	2,483,450 gallons*		
	Wetlands	741,107 gallons*		
	Sub-surface Drainage System (piping, inlets etc)	n/a		
	Electric Pumps	4		
Lighting	Compact Florescent Lighting	27 fixtures	Metal Halide Lighting	18 fixtures
Other characteristics	Pavement Paint	Same	Pavement Paint	Same
	Wheel Stops (concrete)	Same (199)	Wheel Stops (concrete)	Same
	Handicap Signs	Same	Handicap Signs	Same
	Bicycle Racks (Steel)	1	Bicycle Racks	0
	Fire Hydrants	Same (6)	Fire Hydrants	Same
* At full capacity				

## BENEFITS OF THE HEIFER PARKING LOT

The innovative approaches used in the planning and construction of the Heifer parking lot confer a multitude of environmental benefits. In this chapter, we explore the benefits attributable to the Heifer project, quantifying and monetizing them where possible. In the following section, we explore costs incurred by Heifer in developing the project, and highlight some areas of cost savings. In addition, we discuss how any scale up of green parking lot projects holds potential to reduce burden on Little Rocks' stormwater infrastructure.

### WATER QUALITY BENEFITS

Water quality benefits are often considered to be the most significant environmental benefits conferred by green parking lot design techniques. Non-point source pollution is a major and under-addressed cause of water body impairment, and conventional parking lot design is often cited as a chief source of this type of pollution. As described earlier, one of the key elements of Heifer's parking lot design was to eliminate this type of pollution.

The Heifer site sits directly adjacent to the Arkansas River, which would be the receiving water body for runoff from the site. IEc used the modeling tool L-THIA to estimate the runoff quantity and pounds of pollutants avoided from the Heifer project, compared to a conventional parking lot.<sup>18</sup> IEc made the decision to use L-THIA because site-specific water quality modeling data was not available, and because L-THIA is a straightforward model that has been used by a number of EPA offices. The modeling exercise required choosing an appropriate version of the model and inputting information about the Heifer site and the conventional alternative, including acreage, soil type, and percent of impervious cover. As described in the previous chapter, we assume that the conventional lot would have 92 percent impervious cover, reflecting the city of Little Rock's ordinance that parking lots must dedicate 8 percent of their land area to landscaping. Results from modeling the avoided water quality impacts of the Heifer lot are presented in Exhibit 2.

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<sup>18</sup> Information on the L-THIA model can be found at: <http://www.ecn.purdue.edu/runoff/>

## EXHIBIT 2: WATER QUALITY IMPACTS AVOIDED BY THE HEIFER PARKING LOT

IMPACT	ANNUAL QUANTITY AVOIDED	10 YEAR QUANTITY AVOIDED
Average runoff volume <sup>19</sup>	9.78 acre-feet	97.80 acre-feet
Average runoff depth <sup>20</sup>	39.39 inches	393.9 inches
Nitrogen	18 pounds	180 pounds
Phosphorus	0.266 pounds	2.66 pounds
Suspended Solids	26 pounds	260 pounds
Lead	0.133 pounds	1.33 pounds
Copper	0.266 pounds	2.66 pounds
Zinc	0.159 pounds	1.59 pounds
Cadmium	0.026 pounds	0.26 pounds
Chromium	0.199 pounds	1.99 pounds
BOD	13 pounds	130 pounds
Fecal coliform	24 millions of coliform	240 millions of coliform

As shown in Exhibit 2, the Heifer stormwater system will avoid 180 lbs of nitrogen and 260 lbs of suspended solids over a ten-year period. Typically in economic analysis we would attempt to monetize these benefits by:

1. Using a watershed model (such as EPA's BASINS model) to estimate avoided deterioration of ambient water quality of the receiving water body associated with reduced flows and contaminants.<sup>21</sup>
2. Identifying a value of water quality improvements from economics literature that fits this particular setting, and use benefits transfer to apply that value to the setting.

The Heifer site is very small when considering the magnitude of non-point source impacts on its receiving water body, the Arkansas River. Water quality models are designed to operate at a watershed level, as opposed to addressing one point of impact. They do not have the capacity to accurately estimate changes in ambient water quality resulting from quantities of avoided runoff as small as those associated with the Heifer

<sup>19</sup> An acre-foot is a unit of volume, commonly used to measure quantities of water used or stored, equivalent to the volume of water required to cover 1 acre to a depth of 1 foot and equivalent to 43,560 cubic feet, 325,851 gallons, or 1,233 cubic meters. Source: USGS (2001), Annual Hydrologic Data Report of South Carolina for WY 2001, Definition of Terms, accessed at <http://sc.water.usgs.gov/AAR/wy01/AnnRptDef2001.htm>.

<sup>20</sup> Average runoff depth in inches is the equivalent per year of the amount of inches of water over 1 acre of land. Source: Personal communication with L-THIA contact, Alfred Krause, US EPA Region 5 on October 24, 2006.

<sup>21</sup> EPA's BASINS model is available at: <http://www.epa.gov/waterscience/BASINS/>

project, especially when the receiving water body is as large as the Arkansas River. Moreover, the river segment adjacent to the Heifer site (segment 3C of the Arkansas River) is in pristine condition; ambient water quality is less likely to be affected than if the segment had marginal water quality.<sup>22</sup> Hence, we cannot estimate changes of water quality attributable to the avoided runoff of the Heifer lot.

However, should EPA, Arkansas DEQ, or the City of Little Rock be considering a program to promote the development of green parking facilities across a larger area of the Arkansas River Watershed, the type of analysis described above would become feasible at a certain scale, and could be conducted from either a prospective or retrospective standpoint. For example, when IEc met with Arkansas DEQ, they indicated that their staff promotes stormwater management best practices and low-impact development to land developers when possible, and noted that developers are starting to clear less land to develop parking lots. IEc did identify a value of water quality improvements in the economic literature that is well suited to apply to development projects on the Arkansas River. The literature provides an incremental willingness-to-pay per percent of water quality improvement based on an iterative choice model. The study is particularly useful for this scenario of valuing avoided water quality impacts from development because it corrects for bias common to surveys of this type (i.e., familiarity with a specific water body, which leads to higher valuation). In addition, the study is not tied to an assumption of restoration efforts, which is common among economic literature on the value of water quality, and the study provides values specific to rivers as opposed to lakes; lakes are not valued as highly.<sup>23</sup>

Finally, it should be noted that while the Heifer parking lot project eliminated water runoff with its innovative stormwater management system, it is far more common for green parking lots to incorporate one or two BMPs that significantly reduce but not fully eliminate runoff volume and associated pollutants. Data on the pollutant removal efficiency of different types of BMPs, cross-referenced with different types of land uses (e.g., commercial, residential, industrial) has been compiled by the developers of the L-THIA model, and will be incorporated into the forthcoming green parking lot resource document.<sup>24</sup>

#### **WATER CONSERVATION BENEFITS**

The Heifer project is designed to use recycled water, instead of municipal supplies, for several purposes including irrigation. In addition, the project is designed to minimize the quantity of irrigation water required through use of native plants and drip irrigation. As discussed in the next section, Heifer uses approximately 5,000 gallons of irrigation water

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<sup>22</sup> Arkansas DEQ (2004), 2004 Integrated Water Quality Monitoring Assessment Report, pg. A-119.  
<http://www.adeq.state.ar.us/water/branch%5Fplanning/pdfs/WQ05-07-01.pdf>

<sup>23</sup> Wesley Magat, Joel Huber, Kib Vicusi, and Jason Bell, "An Iterative Choice Approach to Valuing Clean Lakes, Rivers, and Streams," *Journal of Risk and Uncertainty*, 21:1, 2000, pp. 7-43.

<sup>24</sup> Information on the pollutant removal efficiency of various BMPs is available at:  
<http://www.ecn.purdue.edu/runoff/ubmp0/emc2.htm>

per week, or 260,000 gallons annually. According to Heifer's landscape architect, this usage represents a two-thirds reduction from demand for irrigation water under the conventional parking lot scenario with standard landscaping (see next section for details). Hence, by using recycled water, native plants, and water conserving irrigation, Heifer is conserving 520,000 gallons (69,500 cubic feet) of water annually.

Valuation of water conservation can be difficult because the market price of water often does not adequately reflect conditions of water scarcity. This is particularly true for agricultural and industrial uses, where water is typically under-priced. However, commercial customers also sometimes pay less for water than its true value, especially where water is scarce or the future of current water supplies is in question. Under these conditions, it is more appropriate to use a non-market valuation approach to estimate the value of water conservation.<sup>25</sup>

In the case of the Heifer site, non-market valuation does not appear to be necessary. Water utilities serving the Little Rock area draw surface water mainly from Lake Maumelle, a 14 square mile lake in central Arkansas that has served as the area's main water supply for decades.<sup>26</sup> According to the Arkansas Soil and Water Conservation Commission, Lake Maumelle is a protected water source with adequate supplies to meet current and projected future needs.<sup>27</sup> Hence, it is appropriate to use the market price for water paid by Heifer to estimate the value of water conserved through the green parking lot project. The market price paid by Heifer for water is \$0.94 per cubic foot of irrigation water consumption; hence, the value of irrigation water conserved is \$65,343 annually, or \$653,430 over 10 years. Using a seven percent discount rate, the net present value of these savings is \$458,942.<sup>28,29</sup>

#### WETLAND SERVICES

Heifer constructed a wetland as a central component of its stormwater management system for its green parking lot project. The wetland is 32,670 square feet, or 0.75 acres in area, and can hold over 700,000 gallons of water. Wetlands provide a number of valuable ecosystem services, including water purification, regulation of the water cycle, erosion control, nutrient cycling, and provision of habitat.

Although the landscape flora is still maturing, the wetlands environment has already attracted a range of species including watersnakes, dragonflies, butterflies, turtles, ducks, geese and frogs. Some native fish species have also been introduced into the wetlands.

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<sup>25</sup> Robert A. Young, *Determining the Economic Value of Water: Concepts and Methods*, Resources for the Future, 2005.

<sup>26</sup> Basic information on Lake Maumelle is available at: <http://arkansas.com/lakes-rivers/lake/id/49/>.

<sup>27</sup> Personal communication with Todd Fugitt, Arkansas Soil and Water Conservation Commission, September 21, 2006.

<sup>28</sup> OMB recommends the use of a 7% discount rate: OMB Circular A-94, Guidelines And Discount Rates for Benefit-Cost Analysis Of Federal Programs, p. 7-8, <http://www.whitehouse.gov/omb/circulars/a094/a094.pdf>.

<sup>29</sup> The cost structure for Heifer's water use is based on three components: 1. Central Arkansas Water monthly flat fee, 2. Incremental cost based on usage, and 3. A monthly City of Little Rock franchise fee of 6.9% of the total of 1 and 2. The market price of \$0.94 per cubic foot represents the incremental cost of water.

In addition, over 25 bird species have been identified at the site, including red winged black birds, scissor tailed flycatchers, and indigo buntings.

Valuing ecological services provided by wetlands is challenging, as the value of wetlands is highly site-specific. Economic estimates of willingness-to-pay for wetland services vary a great deal, with some studies indicating a willingness-to-pay in the hundreds of dollars per acre for wetland services, while other studies indicate values in the tens of thousands of dollars per acre range.<sup>30</sup>

An alternative approach is to estimate the value of the wetland services using value paid for mitigation banking credits. Wetland mitigation banking systems allow developers to fund the establishment of new wetlands to offset those destroyed or negatively affected during development. The costs associated with mitigation banking can be thought of as a minimum estimate of the value of services provided by wetlands.

The cost of wetland mitigation banking permits for projects within the Little Rock/Arkansas delta area is \$4,000 per acre, so the minimum value of a wetland the size of Heifer's would be \$3,000.<sup>31</sup> This estimate reflects the present value of ecological services provided by the wetland, and cannot be annualized.

#### HEAT ISLAND EFFECT

As discussed previously, Heifer's parking lot incorporates a gravel pave system combined with concrete – a highly reflective surface. This combination of materials eliminates the need for asphalt, a heat absorbing paving material, diminishing the associated heat island effect (HIE). In addition, by increasing the amount of tree cover and other natural vegetation on the site, Heifer has created more shade for the land, which also helps to stabilize temperatures. Although it is not feasible to quantify the site's HIE benefits, it should be noted that reducing the HIE potential helps support the natural nighttime cooling process, reduces the energy demand from neighboring buildings, and provides for a more comfortable outdoor environment at the site during the region's hot summer months.

#### AIR EMISSIONS BENEFITS--ALTERNATIVE TRANSPORTATION FOR COMMUTING

In the development of its site, Heifer took a number of steps to promote alternative transportation among its staff, including designating preferable parking spaces in the lot for carpools and installing bike racks. In addition, Heifer worked with local government officials to ensure adequate bus service to a stop at Heifer's fenceline, providing a safe and convenient public transportation option for many Heifer staff.

From December 2005 through August 2006, Heifer collected data on individual car trips avoided by staff as a result of these policies and services. IEc analyzed these data to

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<sup>30</sup> Ralph E. Heimlich, Keith D. Wiebe, Roger Claassen, Dwight Gadsby, and Robert M. House, Wetlands and Agriculture: Private Interests and Public Benefits, Appendix I: Valuation Studies Summary, Agricultural Economics Report No. (AER765) 104 pp, September 1998, <http://www.ers.usda.gov/publications/aer765/>.

<sup>31</sup> Personal communication with Kenneth Brazil, Arkansas Natural Resource Commission, December 13, 2006.

estimate air emissions benefits. We first derived an average of trips avoided for the nine months of data provided, and then applied that average to the missing months in order to develop an estimate of automobile miles avoided for a full year. We then applied widely used coefficients of mobile source emissions per mile driven to calculate avoided air emissions. Exhibit 3 presents a summary of mobile air emissions benefits; details of the analysis are presented in Appendix 1.

**EXHIBIT 3: MOBILE AIR EMISSIONS BENEFITS FROM HEIFER'S ALTERNATIVE TRANSPORTATION**

AIR EMISSION	ANNUAL QUANTITY AVOIDED (TONS)	10 YEAR QUANTITY AVOIDED (TONS)
Carbon monoxide (CO) <sup>32</sup>	2.4	24
Carbon dioxide (CO <sub>2</sub> ) <sup>33</sup>	39.2	392
Volatile Organic Compounds (VOCs) <sup>34</sup>	0.25	2.5
Nitrous Oxide (NO <sub>x</sub> ) <sup>35</sup>	0.13	1.3

We used available estimates of the economic value of reduced human health and ecological impacts of avoiding these emissions to monetize the benefits of reducing single passenger automobile trips from Heifer's alternative transportation program. Peer reviewed estimates of the value of reducing hydrocarbon emissions, a component of volatile organic compounds (VOCs), range from \$600 - \$2,700 per ton; estimates for reducing nitrous oxide (NO<sub>x</sub>) emissions range from \$730 - \$7,500 per ton. Reliable, accepted estimates of economic value are not available for CO and CO<sub>2</sub> emissions.<sup>36</sup> By applying values to the quantities of emissions avoided shown above, we estimated a range of values associated with the reductions, presented in Exhibit 4. Again, we use a seven percent discount rate to calculate the 10-year net present value of Heifer's mobile emission reductions.

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<sup>32</sup> EPA (2006), Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>.

<sup>33</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg. 2.

<sup>34</sup> EPA (2006, Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>.

<sup>35</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg 2.

<sup>36</sup> U.S. Office of Management and Budget, (2005), Draft 2005 Report to Congress on the Costs and Benefits of Federal Regulations, Appendix B.

EXHIBIT 4: VALUE OF MOBILE AIR EMISSIONS BENEFITS FROM HEIFER'S ALTERNATIVE TRANSPORTATION PROGRAM

AIR EMISSION	ANNUAL		10 YEAR NET PRESENT VALUE	
	LOW	HIGH	LOW	HIGH
VOCs	\$ 150	\$ 675	\$ 1,054	\$4,741
NO <sub>x</sub>	\$ 95	\$ 975	\$ 667	\$6,848

**UPSTREAM BENEFITS**

Upstream benefits were realized through Heifer's use of recycled concrete and other recycled materials, instead of using virgin asphalt, in the construction of its green parking lot. A key upstream benefit is the reduction of air emissions associated with the production of asphalt, as well as the reduced transportation emissions from the procurement of parking lot materials from local sources. Other upstream benefits include reduced energy use and reduced generation of hazardous wastes related to production of virgin materials.

To estimate upstream impacts from the construction of Heifer's lot, IEc utilized the *PaLATE* model, a lifecycle assessment tool created to derive the environmental and economic effects of paved surfaces.<sup>37</sup> To use *PaLATE*, we entered information on the materials used for the Heifer parking plaza (recycled concrete, gravel, and bricks) as well as those used in a typical asphalt parking plaza. To run the model, we had to use recycled concrete as a proxy for gravel pave and recycled bricks, as those materials are not available in *PaLATE*.<sup>38</sup> We also entered information on distance to suppliers; this information was known in most cases and estimated in other cases.

The resulting emissions analysis, presented in Exhibit 5, shows clear overall positive net benefits from the construction of Heifer's lot. However, results for some individual metrics indicate a net increase in emissions or resource use. For instance, Heifer's green parking lot scenario used more water than an asphalt parking lot would have because of the greater water inputs required in the recycling of concrete pavement compared to the production of asphalt pavement. Full results from the *PaLATE* model can be found in Appendix 2.

<sup>37</sup> Information on the PaLATE model can be found at: <http://www.ce.berkeley.edu/~horvath/palate.html>

<sup>38</sup> Given that recycled concrete constitutes most of the Heifer plaza, and the other materials used in constructing Heifer's lot are also recycled, this substitution should not have a significant effect on the model outputs.

EXHIBIT 5: UPSTREAM BENEFITS OF THE HEIFER PARKING LOT<sup>39</sup>

ENERGY (MMBtu)	WATER USE (GALLONS)	TONS				
		CO <sub>2</sub>	NO <sub>x</sub>	PM <sub>10</sub>	SO <sub>2</sub>	HAZARDOUS WASTE GENERATED
668.3	-116	20.9	-0.89	0.72	25.3	20.7

Again, we monetized any upstream benefits by applying estimates of the economic value of reduced human health and ecological impacts from avoiding emissions. Reliable, accepted estimates of economic value are not available for carbon dioxide (CO<sub>2</sub>) emissions. Accepted economic estimates for the value of reducing sulfur dioxide (SO<sub>2</sub>) emissions range widely, from \$1,700 - \$18,000 per ton; and estimates for reducing particulate matter (PM<sub>10</sub>) emissions range from \$10,000 - \$100,000 per ton.<sup>40</sup> By applying these estimates to the quantities of emissions avoided shown above, we estimated a range of monetary values associated with the reductions, presented in Exhibit 6. It should be noted that the values shown here are based on national averages. The high end of this range represents values associated with avoided emissions in areas with severe air quality impairment, and are likely too high to apply to the Little Rock area, which is in attainment with federal PM<sub>10</sub> and SO<sub>2</sub> standards, as well as all other air quality standards.<sup>41</sup>

EXHIBIT 6: VALUE OF UPSTREAM AIR EMISSIONS BENEFITS FROM THE CONSTRUCTION OF HEIFER'S GREEN PARKING LOT

AIR EMISSION	MONETIZED UPSTREAM BENEFIT	
	LOW	HIGH
SO <sub>2</sub>	\$ 43,044	\$ 455,760
PM <sub>10</sub>	\$ 7,170	\$ 71,700

<sup>39</sup> Mercury (Hg) emissions were modeled by PaLATE, but were not mentioned here because the emissions difference was negligible.

<sup>40</sup> U.S. Office of Management and Budget, (2005), Draft 2005 Report to Congress on the Costs and Benefits of Federal Regulations, Appendix B and U.S. Office of Management and Budget, Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, accessed at <http://www.whitehouse.gov/omb/circulars/a094/a094.pdf> on January 10, 2007.

<sup>41</sup> Query of EPA Air Data, January 21, 2006: <http://www.epa.gov/air/data/nonat.html?st-AR-Arkansas>.

### REDUCED INFRASTRUCTURE BURDEN

For municipalities, best management practices (BMPs) such as those incorporated by Heifer can help control growing stormwater management costs by lowering municipal infrastructure and utility maintenance costs.<sup>42,43</sup> By 2030, the population of Pulaski County, where Heifer International is located, is predicted to increase by 18 percent.<sup>44</sup> For Little Rock, the capital of Arkansas and the largest city in Pulaski County, population growth has the potential to lead to stormwater management challenges. For instance, stream channels can swell to two to ten times their normal size to accommodate the increased volume and frequency of runoff associated with urbanization. Such stream enlargements not only impact habitat and water quality, but also can damage bridges, culverts, and sewer infrastructure.<sup>45</sup>

Incorporating BMPs on development projects can be a cost-effective method for offsetting the impacts of predicted growth, but require a cooperative effort between municipalities and developers.<sup>46</sup> Although the avoided run-off quantities from Heifer International's green parking lot alone are not large enough to have a significant impact on the City of Little Rock's stormwater management infrastructure, the cumulative benefit of developing multiple projects that incorporate at least some of the techniques illustrated in the Heifer's lot could relieve burden on the system and delay the need for repairs, upgrades, and expansions.

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<sup>42</sup> Metroplan (2005), Metro 2030 Transportation Plan, page 1, accessed at <http://www.metroplan.org/Metro2030/METRO2030ExSum.pdf>.

<sup>43</sup> U.S. Department of Housing and Urban Development (2003), The Practice of Low Impact Development, pg 14, accessed at [www.huduser.org/publications/pdf/practlowimpctdevel.pdf](http://www.huduser.org/publications/pdf/practlowimpctdevel.pdf).

<sup>44</sup> Metroplan (2005), Metro 2030 Transportation Plan, website accessed at <http://www.metroplan.org/Metro2030/METRO2030ExSum.pdf>.

<sup>45</sup> Minnesota Pollution Control Agency (2006) Minnesota Stormwater Manual, page 17, accessed at [www.pca.state.mn.us/water/stormwater/stormwater-manual.html](http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html)

<sup>46</sup> Stormwater Authority (2006), Infrastructure Planning, pg 1, accessed at [www.stormwaterauthority.org](http://www.stormwaterauthority.org).

## HEIFER'S PARKING LOT COSTS

Heifer International's green parking lot incorporates numerous best management practices (BMPs) and innovative materials that address the full range of environmental impacts of parking. It was designed to maximize environmental benefit without being subject to cost considerations that affect most parking lot projects, and it was designed to provide a real world model of many successful green parking lot design elements that other organizations could learn from. As such, the Heifer project should be considered a demonstration project. As a demonstration project, some of the costs incurred by Heifer are high compared to a "normal" green parking lot. For example, most organizations would incorporate only select BMPs and alternative materials, many of which can be very cost-effective on their own or in conjunction with a small number of other techniques.

This section provides an overview of the costs incurred by Heifer in building and maintaining its parking lot, including costs for paving materials, landscaping, irrigation, and stormwater management. It also provides information on cost savings associated with some of the green parking lot techniques utilized.

### PAVING MATERIALS

Heifer evaluated a variety of paving options when selecting materials for building their lot. A conventional lot most likely would be constructed primarily of asphalt and incorporate excess parking capacity. In contrast, Heifer constructed the minimum number of parking spaces required by the City of Little Rock, and used three types of paving materials that provide environmental benefits over asphalt. Concrete was used for the high traffic aisles and the driveway, a gravel pave system was used for the parking stalls, and recycled brick pavers were used to form a decorative driveway centerpiece. The costs for each of these materials are outlined below:

- *Concrete* - Heifer covered an 86,000 ft<sup>2</sup> area of its parking lot with concrete at a cost of \$5.75 per square foot, totaling \$494,500. Heifer has yet to incur any concrete maintenance cost.
- *Gravel Pave system* - Thirty thousand square feet of Heifer's parking plaza is covered by a gravel pave system. The system consists of a sandy gravel base course, covered with porous geotextile filter fabric, and topped with a layer of crushed gravel. Heifer purchased recycled gravel from a local dealer for this project. At a unit cost of \$4.75 per square foot, the gravel pave portion of the lot cost a total of \$142,500. Maintenance for the gravel pave is minimal, requiring roughly eight hours a month at a cost of \$160 per month.

- *Brick pavers* - Brick pavers cover the smallest part of the lot (2,500 ft<sup>2</sup>) at a total cost of \$34,418. Heifer minimized the cost for the pavers by reusing bricks from buildings that previously occupied the site. Heifer employees even volunteered to help clean the bricks so they could be reused. The cost of the pavers includes additional labor, beyond the volunteer hours, to clean the bricks and construct the brick section of the lot. Heifer has yet to incur any paving maintenance costs.

#### LANDSCAPING

The City of Little Rock's parking ordinances for a lot of Heifer's size requires that the interior landscape area should comprise at least eight-percent of the total vehicular use area, or 10,400 ft.<sup>2</sup>. Heifer exceeds this minimum standard with 18,000 ft<sup>2</sup> of conventionally landscaped islands and bioswales.

- *Bioswales landscaping* – Heifer constructed five bioswales landscaped with a mix of native seeding and sod, covering over 11,500 ft<sup>2</sup> of the parking lot. Landscaping for a conventional lot would typically consist solely of the commonly used sod, rather than the mix of native seeding and sod used by Heifer in its bioswales. The total cost for landscaping the bioswales with native seeding and sod was \$18,000.
- *Conventionally landscaped islands* – Heifer created two islands in its lot using conventional landscaping materials, covering an area of 6,500 ft<sup>2</sup>. The cost for these islands was \$7,800, including 13 pallets of sod, topsoil, and installation.
- *Trees* - City of Little Rock parking ordinances require that one tree be planted for every 12 parking spaces. Typically a minimum of 17 trees would be required for a 199-space lot such as Heifer's. Heifer exceeded this standard, planting 80 trees at an average cost of \$200 per tree, or a total of \$16,000 to plant trees throughout the parking plaza.

Planning and developing the entire parking lot landscaping also included a landscaping design team fee of \$121,000. In addition, the average monthly landscaping maintenance cost for the Heifer parking lot is \$2,215. Landscaping was also incorporated into the designs for the wetlands and retention basin, which are part of the stormwater management system discussed below.

#### IRRIGATION SYSTEM

Because Heifer used a combination of native seeding and sod, the lot required less irrigation than would be needed for a lot using all sod and non-native landscaping. In a typical, non-drought year, Heifer's closed loop stormwater system will provide 100 percent of the water necessary to irrigate the lot, eliminating the cost of using municipal

water for this purpose. Currently Heifer has six zones for irrigation, two that use conventional sprinkler irrigation and four that use drip irrigation.<sup>47</sup>

- *Sprinkler Irrigation* - Heifer currently has two spray-zones for irrigating the sod portions of the lot. These conventional pop-up spray heads produce approximately 25 gallons of water per minute per zone, using a total of approximately 3,000 gallons of water per week. The total cost for the sprinkler irrigation system was \$42,354.
- *Drip Irrigation* - Heifer has four drip-zones for irrigating trees and shrubs on the parking site. Each drip emitter releases 0.9 gallons per hour, using a total of approximately 2,000 gallons of water per week. The total cost for the drip irrigation system was \$78,824.

In addition, Heifer installed an irrigation system controller at a cost of \$20,000, which includes electrical contractor labor and materials. Heifer's irrigation system also includes a submersible pump to draw water from the closed loop stormwater system (see below). According to Heifer's landscape architect, Heifer's use of native plants in combination with the combined sprinkler and drip irrigation system, reduces irrigation water demand and associated costs by two-thirds, compared to conventionally landscaped islands and a conventional sprinkler system. In addition, Heifer saved \$300,000 in initial construction costs by using the native instead of using conventional sod.<sup>48</sup>

#### STORMWATER MANAGEMENT SYSTEM

Conventional parking lots typically use a combination of piping, gutters, catch basins, curbs, and man-made channels to speed the flow of water directly into the municipality's stormwater system. In contrast, Heifer used an innovative closed loop system to catch, retain, and recycle runoff. The system consists of the following four components:

- *Bioswales* - As discussed above, Heifer constructed five bioswales, totaling 11,500 ft<sup>2</sup> of the lot, as part of its stormwater management system. Each bioswale consists of an inlet with an elevation of approximately 12 feet. The inlets are surrounded by a filtration basin with geotextile fabric and weep holes. The estimated cost for constructing the bioswales was \$46,487. This cost does not include irrigation systems or landscaping in the bioswales, which are addressed in separate sections above.
- *Retention Basin* - Heifer constructed a retention basin as part of its stormwater management system. This retention basin covers 2.3 acres and holds 2,483,450 gallons of water at full capacity. The total cost for the basin, including excavation

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<sup>47</sup> A rainfall shutoff system was considered, but other green parking lot techniques were chosen instead based on budget restrictions. The Facilities Manager programs their irrigation system weekly based on weather predictions of rainfall, with a sixty percent accuracy rate.

<sup>48</sup> E-mail correspondence from Martin Smith, Principal at Larson, Burns, Smith, Heifer International's landscape architect, October 11, 2006.

and removal of river clay soil and installation of the drainage system was \$100,000.

- *Wetlands* - The constructed wetlands can hold up to 741,100 gallons of water and includes native shrubs, grasses and aquatic plants. The cost for the wetland construction, including excavation, soil removal, landscaping, and drainage system was \$764,857. Heifer constructed four bridges to span the wetlands for \$204,300. In addition, Heifer holds an annual wetlands maintenance contract for \$19,350.
- *Subsurface drainage system* – Four pumps were installed as parts of Heifer’s closed-loop stormwater management system. These include two large turbine pumps for moving the water from the wetlands and underground storage to the retention pond, at a cost of \$25,000 each. Two smaller pumps, costing \$10,000 each, are also used to raise water levels around the wetland and supply the irrigation system. The total subsurface drainage system including materials (piping, inlets, electric pumps, etc.) and labor was \$213,874.

#### **PARKING LOT LIGHTING**

Heifer installed 27 compact fluorescent lighting fixtures in its lot, at a total cost of \$59,400. Each fixture cost \$2,200, which included the \$1,900 per fixture purchase price and \$300 per fixture for labor and additional materials (i.e. concrete).

#### **OTHER COSTS**

Heifer also incurred costs for standard parking lot materials and accessories including:

- pavement paint for \$50
- 199 concrete wheel stops at a cost of roughly \$21 per wheel stop, totaling \$4,200
- handicap signs for \$800
- one steel bicycle rack for \$1,773
- six fire hydrants for \$37,185

Exhibit 7 summarizes Heifer's costs in building and maintaining their green parking lot.

## EXHIBIT 7: COSTS OF THE HEIFER PARKING LOT

	HEIFER PARKING LOT			
	FEATURE	ACTUAL QUANTITY	TOTAL COST*	COMMENTS
Paving Materials	Concrete	86,000 ft <sup>2</sup>	\$494,500	Includes labor and materials -- at \$5.75/ft <sup>2</sup> (i.e. contractor and subcontractor fees, base, steel, finishing etc.)
	Brick Pavers	2,500 ft <sup>2</sup>	\$34,418	Pavers were free; cost reflects labor to clean and construct decorative driveway feature.
	Gravel Pave System	30,000 ft <sup>2</sup>	\$142,500	Includes base, material, stone, and labor -- at \$4.75/ft <sup>2</sup>
	Maintenance	n/a	\$1,920	Annual Maintenance costs. Eight hours (\$160) per month are incurred to maintain the gravel pave system; no maintenance costs incurred to date for concrete and brick pavers.
Landscaping	Landscape Design	n/a	\$121,000	Design team fee (Lead architect, landscape architect, and civil engineer)
	Bioswale Landscaping	11,500 ft <sup>2</sup>	\$18,000	Includes native seeding and installation.
	Conventional Landscape Islands	6,500 ft <sup>2</sup>	\$7,800	Includes sod, topsoil and installation. Thirteen pallets of sod were needed for the islands.
	Trees	80	\$16,000	Each tree cost an average of \$200.
	Maintenance (annual)	n/a	\$26,580	Average monthly cost for maintenance of landscaping is \$2,215.
Irrigation	Sprinkler Irrigation	2 zones	\$42,354	Conventional pop-up spray heads.
	Drip Irrigation	4 zones (27,500 ft <sup>2</sup> )	\$78,824	Covers 27,500 ft <sup>2</sup> of drip emitters.
	Irrigation System Controller	n/a	\$20,000	Includes electrical contractor labor and materials for irrigation control system.
Stormwater Management	Bioswales	11,500 ft <sup>2</sup>	\$46,487	Labor and materials (i.e. excavation, drainage system), not including irrigation, drip irrigation, irrigation system control, and landscaping which are detailed in other sections.
	Retention Basin	2,483,450 gallons	\$100,000	Includes excavation and removal of river clay soil and installment of the drainage system.
	Wetlands	741,107 gallons	\$764,857	Includes excavation and removal of soil, landscaping, and drainage system.
	Wetlands Maintenance	n/a	\$19,350	Annual maintenance contract for wetlands.
	Entire Sub-surface Drainage System	n/a	\$213,874	Includes materials (i.e. piping) and labor fees.
	Electric Pumps	4	\$70,000	Includes two large turbine pumps at \$25,000 each, and two smaller pumps at \$10,000 each.

	HEIFER PARKING LOT			
	FEATURE	ACTUAL QUANTITY	TOTAL COST*	COMMENTS
Lighting	Compact Florescent Lighting	27 fixtures	\$59,400	Cost was \$2,200 per fixture, which includes \$1,900 per fixture to purchase the fixtures, and \$300 per fixture for labor and additional materials.
Other	Wetland Bridges	4	\$204,300	\$172,457 - Two wood decking bridges \$31,845 - Two limestone bridges
	Pavement Paint	--	\$50	
	Wheel Stops	199	\$4,200	Concrete wheel stops.
	Handicap Signs	4	\$800	
	Bicycle Rack	1	\$1,773	Steel bicycle rack.
	Fire Hydrants	6	\$37,185	
TOTAL INITIAL COST			\$2,478,322	
ANNUAL MAINTENANCE COST			\$47,850	

\* Estimate; allow for  $\pm$  5% variance in costs.

APPENDIX 1:  
ALTERNATIVE COMMUTING BENEFITS ANALYSIS

## Air Emissions Benefits

	CO (lbs) <sup>1</sup>	CO <sub>2</sub> (lbs) <sup>2</sup>	VOC (lbs) <sup>3</sup>	NO <sub>x</sub> (lbs) <sup>4</sup>	
Dec	457.09	7913	47.61	26.47	
Jan	611.76	12126	63.72	40.57	
Feb	417.97	3220	43.54	10.77	
Mar	409.42	3154	42.65	10.55	
Apr	512.76	8877	53.41	29.7	
May	466.89	8906	48.63	29.8	
Jun	199.05	4540	20.73	15.19	
Jul	205.61	3822	21.42	12.79	
Aug	285.82	6255	29.77	20.93	
<i>Total 9 months</i>	<i>3566.37</i>	<i>58813.00</i>	<i>371.48</i>	<i>196.77</i>	
<i>Average</i>	<i>396.26</i>	<i>6534.78</i>	<i>41.28</i>	<i>21.86</i>	
Sept	396.26	6534.78	41.28	21.86	
Oct	396.26	6534.78	41.28	21.86	
Nov	396.26	6534.78	41.28	21.86	
Annual Total	4,755.15	78,417.34	495.32	262.35	lbs
	2.4	39.2	0.3	0.1	tons
Ten Year Total	24	392	2.50	1.3	tons

<sup>1</sup> Source for emissions rates per mile is EPA (2006, Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>.

<sup>2</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg 2.

<sup>3</sup> Source for emissions rates per mile is EPA (2006, Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>.

<sup>4</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg 2.

Air Emissions Benefits of Alternate Transport

Employee	Daily Round Trip Miles	Frequency					Mode	Driving Expense Saved	Total Miles (August)	Carbon Monoxide emissions saved (grams) <sup>1</sup>	Carbon Dioxide emissions saved (lbs) <sup>2</sup>	Volitile Organic Compound emissions saved (grams) <sup>3</sup>	Nitrogen Oxide emissions saved (grams) <sup>4</sup>
		August 1-4	August 7-11	August 14-18	August 21-25	August 28-31							
Sandi (Mya) Aung	56	4	5	5	3	3	CP	\$498.40	1120	22848	1026	2380	1557
Sonia Pedraza	7						Flextime	\$0.00	0	0	0	0	0
Terry Wollen							Moped	\$0.00	0	0	0	0	0

<b>TOTAL</b>	\$3,038.91	6829	129,648	6,255	13,505	9,492
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<b>Conversion to pounds</b>	285.82	6255.00	29.77	20.93
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0.002204623 1 g = lb

<sup>1</sup> Source for emissions rates per mile is EPA (2006, Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>

<sup>2</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg 2.

<sup>3</sup> Source for emissions rates per mile is EPA (2006, Carpool Emissions and Gas Savings Study, accessed at <http://www.epa.gov/rtp/transportation/carpooling/emissions.htm>.

<sup>4</sup> Source for emission rates per mile is EPA (2000), Emission Facts, Office of Transport and Quality, EPA420-F-00-013, pg 2.

APPENDIX 2:  
UPSTREAM BENEFITS ANALYSIS

Upstream Benefits Analysis  
PaLATE Inputs

**Baseline Scenario (Virgin Asphalt Parking Lot)**

<i>Wearing course:</i>	119,600 sq ft asphalt pavement Transport distance: 10 miles <sup>c</sup>	@ 3.5 inches (pavement depth) <sup>1</sup> (0.2917 ft)	= 34,883 cubic ft	= 1,292 cubic yards asphalt pavement
<i>Base course:</i>	119,600 sq ft aggregate Transport distance: 50 miles	@ 8 inches (base course depth) <sup>1</sup>	= 79,733 cubic ft	= 2,953 cubic yards aggregate

**Heifer Scenario (Recycled Concrete, Gravel Pave, and Brick Parking Lot)**

<i>Wearing course:</i>	86,000 sq ft concrete pavement Transport distance: 50 miles	@ 3.5 inches (depth)	= 25,083 cubic feet concrete pavement	= 929 cubic yards concrete pavement
<i>Base course:</i>	86,000 sq ft base course for concrete pavement Transport distance: 50 miles	@ 8 inches (depth) <sup>4</sup>	= 57,333 cubic feet base course	= 2,123 cubic yards base course = 1,911 yd <sup>3</sup> RCP (90%) 212 yd <sup>3</sup> virgin gravel (10%)
	30,000 sq ft gravel pave Transport distance: 0	@ 3 inches (depth) <sup>5</sup>	= 7,500 cubic feet gravel pave	= 278 cubic yards gravel pave = 278 yd <sup>3</sup> RCP from recycling plant to site (as proxy)
	2,500 sq ft recycled brick Transport distance: 0	@ 2.25 inches (height of brick) <sup>3</sup>	= 469 cubic feet recycled brick	= 17 cubic yards recycled brick = 17 yd <sup>3</sup> RCP (as proxy)

**Notes**

1. Asphalt Paving Association, "Asphalt Paving Design Guide"
2. Information from Heifer
3. Dimension of a standard brick from [http://www.mc2-ice.com/support/estref/popular\\_conversion\\_files/masonry/brick.htm](http://www.mc2-ice.com/support/estref/popular_conversion_files/masonry/brick.htm)
4. From BEES Manual p.148
2. Information from Heifer

Upstream Benefits Analysis  
PaLATE Inputs

Baseline Scenario (Virgin Asphalt Parking Lot)

Asphalt Parking Lot Inputs			
<i>Wearing Course</i>			<u>Transport (miles)</u>
1,292 yd <sup>3</sup> HMA =	95% virgin aggregate =	1,227 yd <sup>3</sup>	10*
	5% bitumen =	65 yd <sup>3</sup>	10*
	100% HMA	1,292 yd <sup>3</sup>	10*
<i>Subbase</i>			
2,953 yd <sup>3</sup> aggregate=	100% gravel =	2,953 yd <sup>3</sup>	10*

Total volume:	4245
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Heifer Scenario (Recycled Concrete, Gravel Pave, and Brick Parking Lot)

Green Parking Lot Inputs			
<i>Wearing Course</i>			<u>Transport (miles)</u>
929 yd <sup>3</sup> Concrete =	78% virgin aggregate	724 yd <sup>3</sup>	6.5
	16% cement	149 yd <sup>3</sup>	6
	6% water	56 yd <sup>3</sup>	0
	100%	929 yd <sup>3</sup>	6
<i>Subbase</i>			
2,123 yd <sup>3</sup> subbase =	90% RCP	1911 yd <sup>3</sup>	2
	10% gravel	212 yd <sup>3</sup>	10*
	100% Subbase	2,123 yd <sup>3</sup>	
278 yd <sup>3</sup> gravel pave =	100% RCP =	278 yd <sup>3</sup>	2
17 yd <sup>3</sup> brick =	100% RCP =	17 yd <sup>3</sup>	2

Total RCP in subbase:	2206
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Total volume:	3347
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\*Assumption made on transport distance

Upstream Benefits Analysis  
PaLATE Results

VIRGIN ASPHALT PAVEMENT SCENARIO		Energy [MJ]	Water Consumption [000 gal]	CO <sub>2</sub> [Mg] = GWP	NO <sub>x</sub> [kg]	PM <sub>10</sub> [kg]	SO <sub>2</sub> [kg]	RCRA Hazardous Waste Generated [kg]
Total	Materials Production	2,547,596	613	147	598	1,222	24,197	20,495
	Materials Transportation	99,896	17	7	398	77	24	720
	Processes (Equipment)	14,767	1	1	27	2	2	106
	<i>Total</i>	2,662,259	631	156	1,023	1,301	24,223	21,321

RECYCLED MATERIALS SCENARIO		Energy [MJ]	Water Consumption [000 gal]	CO <sub>2</sub> [Mg] = GWP	NO <sub>x</sub> [kg]	PM <sub>10</sub> [kg]	SO <sub>2</sub> [kg]	RCRA Hazardous Waste Generated [kg]
Total	Materials Production	1,909,086	742	133	1,669	624	1,245	2,281
	Materials Transportation	32,269	3	2	129	25	8	143
	Processes (Equipment)	15,829	2	1	25	2	2	114
	<i>Total</i>	1,957,183	747	137	1,822	651	1,255	2,538

DIFFERENCE		Energy [MJ]	Water Consumption [000 gal]	CO <sub>2</sub> [Mg] = GWP	NO <sub>x</sub> [kg]	PM <sub>10</sub> [kg]	SO <sub>2</sub> [kg]	RCRA Hazardous Waste Generated [kg]
Total	Materials Production	638,511	-129	14	-1,070	598	22,952	18,214
	Materials Transportation	67,628	14	5	269	52	16	577
	Processes (Equipment)	-1,062	0	0	2	0	0	-8
	<i>Total</i>	705,077	-116	19	-800	650	22,968	18,783