RICE UNIVERSITY

In partnership with:

WEST HOUSTON ASSOCIATION

Leadership in Quality Growth

Analyzing Returns on Sustainable Infrastructure Investment

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December 8, 2023

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Executive Summary

Context

The West Houston Association has been dedicated to improving the living and working conditions in Greater West Houston since 1979. They do this by advocating for developments benefiting the community, sustainable infrastructure, and thoughtful long-term planning.

As the area expands, the West Houston Association noticed that developers favor non-sustainable projects, generally due to higher returns on investment compared to its sustainable alternative. The West Houston association has worked in partnership with multiple projects that focus on sustainable infrastructure, but oftentimes have faced challenges in convincing developers to pursue these projects over conventional ones. Therefore, the West Houston Association would like to identify specific sustainable infrastructure projects that have a higher Return On Investment (ROI) than their conventional equivalents. Additionally, they would like recommendations on specific sustainable infrastructure projects for developers to pursue.

Approach

Our approach aimed to pitch sustainable development projects to developers by contrasting their returns on investment to non-sustainably developed projects. We accomplished this through a three-phase approach. In the first phase, we identified and engaged with field experts for interviews. We developed a comprehensive interview questionnaire to guide the discussions and then proceeded to conduct the interviews to gather valuable insights and perspectives from these experts. In the second phase, researched sustainable infrastructure projects that had high return on investment (ROI). We then conducted case studies that showcase the success of such projects, emphasizing the substantial cost savings and increased revenues associated with sustainable development. Using our insights gained from the research in this phase, we were able to determine the focus of our project. Finally, in the third phase, we identified potential parcels of land for sale. We calculated the financial structure of the projects by analyzing their costs and revenues. Finally, we calculated the Return on Investment (ROI) to assess the project's profitability. This analysis provides a clear financial perspective on the project's viability and can guide decision-making processes for stakeholders.

Results and Conclusion

Our recommendation for the West Houston Association is to influence developers toward sustainable projects by emphasizing flood-resistant infrastructure. In particular, we suggest demonstrating to developers the benefits of flood-resistant techniques such as Low Impact Development (LID). Integrating these methods will not only decrease land development and maintenance costs but also aesthetically enhance visual appeal through green spaces and water

features, thereby increasing property value. These elements increase the Return on Investment (ROI). We have designed two sustainable infrastructure housing projects for WHA to pitch to developers, both utilizing LID: Project Airtex and Project Briarworth.

Project Airtex is a single-family, master-planned community near George Bush Intercontinental Airport. Maintaining 25% of the property as greenspace and ensuring it is flood-proof would increase property value. With lower land development costs and higher revenues, the project is projected to yield a 14.31% return on investment in present value when developed with LID, compared to a 1.16% return when developed conventionally.

Project Briarworth is a multi-family development project near the Energy Corridor. Developing the land with low-impact development methods yields an extra 3% of land for building, eliminating the need for a water basin as required in the conventional approach. This increases the number of units that can be built on the same land, thereby increasing revenue. The project, when developed with low-impact development, yields a return on investment of 14.18%, compared to a 0.46% when developed conventionally.

Introduction and Background

Introduction

The West Houston Association (WHA) is a nonprofit organization dedicated to improving the quality of life in Greater West Houston. They achieve this by promoting high-quality development, long-term planning, and public policy.

Sustainable infrastructure development is also a key focus of WHA's mission. They have actively worked on and incentivized multiple sustainable infrastructure projects in the area. However, WHA still faces challenges in convincing developers to undertake these projects for multiple reasons. Often, the Returns on Investment (ROI) for sustainable projects are lower compared to conventional ones. Additionally, developers are frequently skeptical about these sustainable projects, tending to favor conventional methods they are more familiar with.

Problem Statement

Given how difficult it is to convince developers to pursue sustainable infrastructure projects, The West Houston Association would like to identify broad types of sustainable infrastructure projects that offer higher returns on investment (ROI) compared to conventional ones. Additionally, they would like for us to issue specific sustainable projects that offer better ROI than conventional ones, encouraging developers to pursue these alternatives. Through this initiative, the association hopes to increase the number of developers undertaking sustainable projects in the area.

Key Terms Used Throughout the Report

In this report, we frequently use certain terms that we will define in this section to facilitate the reader's understanding.

Sustainable Infrastructure

Sustainable infrastructure refers to the planning, design, construction, and maintenance of physical structures and systems that prioritize environmental responsibility, social equity, and economic viability over the long term. This approach seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable infrastructure integrates practices that minimize environmental impact, enhance resilience to climate change, promote resource efficiency, and contribute to social well-being.

Bioswales:

A landscaped channel designed to manage stormwater runoff in urban areas. It utilizes vegetation, soil, and engineered materials to slow, filter, and infiltrate rainwater, reducing

flooding and improving water quality. Bioswales promote sustainable water management by allowing runoff to be absorbed by the soil and vegetation, preventing erosion, and removing pollutants.

Low Impact Development (LID)

A sustainable approach to urban planning and land development, LID aims to manage stormwater runoff and mitigate flooding by utilizing practices that mimic natural hydrological processes. Key features of LID include the use of permeable surfaces, green infrastructure (such as bioswales and rain gardens), and other techniques to reduce impervious cover. By minimizing disturbance to natural landscapes and promoting on-site stormwater management, LID seeks to preserve ecosystems, improve water quality, and enhance overall environmental sustainability in urban and suburban areas.

Return on Investment (ROI)

A financial metric used to evaluate the profitability or efficiency of an investment. ROI is expressed as a percentage and is calculated by dividing the net gain or benefit from an investment by the initial cost or outlay of that investment. The ROI formula is

$$\text{ROI} = \left(\frac{Net\ Gain\ or\ Benefit}{Cost\ of\ Investment}\right) \times 100$$

- Net Gain or Benefit refers to the profit or return generated by the investment.
- Cost of Investment is the initial amount of money invested in a particular project or asset.
- Note: We assume an annual discount rate of 7.5% in all financial calculations, based on the risk of developing residential and commercial real estate (Damodaran, n.d.).

Net Present Value (NPV)

The present value of the cash flows at the required rate of return of your project compared to your initial investment. It is based on the concept of the time value of money, which states that a sum of money today is worth more than the same sum in the future.

The formula for calculating Net Present Value is as follows:

$$\text{NPV} = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} - C_0$$

- NPV is the net present value
- T is the number of periods (usually years).
- CFt is the net cash flow during the period t.
- r is the discount rate, which represents the rate of return required by an investor.
- C0 is the initial investment cost.

Project Phases

In Phase 1, our initial focus was on comprehensive Stakeholder Engagement. We prepared interview questionnaires tailored for the client, developers, and engineers, ensuring a thorough understanding of their perspectives and requirements. Through a series of interviews, both with local and non-local developers who had undertaken sustainable infrastructure projects, as well as with city planners or government representatives involved in such initiatives, we aimed to gain a comprehensive understanding of the challenges associated with sustainable infrastructure

Moving into Phase 2, our emphasis shifted toward Literature Review & Data Collection. Now that we had a solid base understanding of sustainable infrastructure key concepts and ideas, we strategically developed a list of key research topics about sustainable infrastructure, reading academic papers and information on other sources to learn what constitutes successful infrastructure projects. We defined “successful” projects as those that generated a high ROI. However, it was difficult to find specific financial data on these projects on the web. Therefore, we used sources provided by some of our expert interviews, and conducted multiple case studies based on this data.

In Phase 3, the project concluded with the preparation of potential projects and recommendations. After conducting both case studies and identifying successful projects, we created two project recommendations for the West Houston Association to pursue. Each project was assigned a potential location within the West Houston area. Using assumptions driven by the data collection that was conducted in Phase 2, we computed ROIs, creating breakdowns of potential costs and revenue streams. Additionally, we compared these potential costs and revenues to that of a similar project built non-sustainably, because to convince developers to take on sustainable projects, they need to see that they would be worse off doing a particular project non-sustainably as opposed to sustainably.

Research and Analysis

Phase 1: Stakeholder Interviews

This phase consisted of multiple interviews with experts in the field. Our purpose was to deepen our knowledge of what incentives drive sustainable development, which practices are generally successful, and how other experts in the field have convinced developers to pursue sustainable infrastructure projects.

Interview with Ian Garrett

Ian Garret's background is rooted in his academic journey at Rice University, where he majored in architecture and later transitioned into theater and arts administration at the Centre for Sustainable Practice in the Arts. He has been extensively involved in sustainable infrastructure projects, with a focus on city-owned spaces and cultural facilities, including partnerships with private developers to incentivize sustainable practices. Notably, he mentioned the successful example of Hillside, a music festival in Guelph, which achieved carbon neutrality through a range of environmental initiatives, including reducing audience transportation emissions. Sustainability is a core part of his organization's mission, and they emphasize the value of environmentally responsible management, with a keen focus on long-term benefits and corporate mission alignment. He also discussed the primary drivers for pursuing sustainable infrastructure, including regulatory mandates and the financial benefits of life cycle analysis and cost-effectiveness. Ian Garret envisions the future of sustainable infrastructure as a rapidly evolving field, with emerging technologies and integrated solutions. He anticipates that technologies such as advanced solar panels and smart grids will gain prominence. He sees collaboration and partnerships between public and private entities as essential in overcoming sustainable infrastructure challenges.

Interview with Samantha Breaux

Samantha currently serves as a Consultant at Environmental Resources Management (ERM), where she deploys her expertise in climate initiatives, solar energy, and sustainable infrastructure to conduct due diligence for clients looking to invest in sustainable projects. Our interview with Samantha provided us with valuable insights into what drives investors to invest in sustainable projects. Samantha said that growing awareness of climate change and government acts that incentivize developers to pursue sustainable projects are the two main driving factors behind interest in sustainable projects. For instance, the Inflation Reduction Act (IRA), passed in 2022, created significant tax breaks for wind and solar development. Additionally, the Energy Infrastructure Reinvestment offers favorable loans to projects in Texas where developers buy land and redevelop it sustainably. Given how cheap land is in Texas relative to other states, it

makes sense for developers to invest in land and redevelop it sustainably so they can benefit from the incentives.

Interview with Mihir Desu

Mihir's background is deeply connected to sustainable infrastructure, which is why he was a key stakeholder to interview. He is the founder of Celeion, a company that supports other firms in sustainable infrastructure development, focusing on the financial aspects, including investing and leveraging tax credits.

Our conversation with him was particularly helpful, as it covered many aspects of sustainable infrastructure. Mihir started covering his experience leveraging tax credits and discounts for sustainability initiatives, and emphasizing that there is financial support available in the area for firms pursuing these types of projects. He then moved on to discuss which were, in his opinion, projects that yield high returns, and he mentioned geothermal energy as being one of these. He also mentioned he has seen shorter return times on these sustainable projects, especially when accounting for the impact of sustainability commitment on public companies' stock prices and public goodwill. However, he did emphasize that there are numerous challenges in sustainable development, and it is crucial to find collaboration, particularly with public companies. We ended our conversation with an emphasis on how he thinks sustainable infrastructure has a promising future, as it will gain popularity when new technological advancements decrease the time it takes for it to generate returns.

Interview with Wenqi Ni

Wenqi has a role as a Project Manager in the Division of Special Needs Housing at the NYC Department of Housing Preservation & Development. Her focus is on sustainable infrastructure development, particularly in affordable housing, which involves addressing the needs of special housing developments and ensuring they align with sustainable practices and local regulations. Wenqi's experience, particularly in a city like New York, gave us valuable insights into the practical aspects of implementing sustainable infrastructure in urban environments.

Our conversation with her helped us understand the impact that regulations can have in the pursuit of sustainable infrastructure projects. Wenqi discussed her current experience in New York, where local laws require new buildings to use electric power over gas, which influences sustainable development in the region. She also pointed out that these regulations do not exist in Texas, which makes it more challenging to pursue sustainable infrastructure. She also covered how, based on her experience, a major driver for sustainable development is energy savings, especially in housing remodels.

Interview with Jordan Smith

Dr. Smith currently serves as the Planning Manager for the Harris County Community Services Department (CSD). In this role, he oversees the National Environmental Policy Act (NEPA) environmental review records conducted by various sections within the CSD. As the primary liaison between Planning and other CSD sections, Dr. Smith is responsible for developing policies, and standard operating procedures, and providing guidance and training to ensure compliance with Housing and Urban Development's environmental regulations. He has successfully applied ecosystem services in project development, such as building neighborhoods around wetlands. Dr. Smith highlights the effective use of regulatory incentives to encourage developers to invest in sustainable infrastructure and the profit potential of marketing sustainable development. To quantify savings, Dr. Smith suggested comparing various costs, including the cost of flooding, construction, and maintenance of green and grey infrastructure. He also acknowledges the challenge of quantifying future benefits, particularly when they extend over a long period. While he did not explicitly discuss the evaluation of long-term financial viability, he foresees technology playing a prominent role in the future of sustainable infrastructure. Collaborative efforts between public and private entities are crucial to overcoming sustainable infrastructure challenges.

Expert call with David Batts

David Batts currently serves as Vice President of Construction EcoServices and has expertise in stormwater system solutions, low-impact development, underground detention and retention, and stormwater quality maintenance. With every project David takes on, he strives to use environmental elements to drive up infrastructure value. Given his excellent track record of leading highly profitable sustainable projects and his knowledge of LID, we wanted to meet with him so we could learn more about LID and how it can help drive a lucrative sustainable project for WHA.

Initially, David explained how developers' sole focus on profitability and the high upfront costs of sustainable infrastructure make sustainable infrastructure projects relatively unattractive to developers. However, if developers can look past the initial costs, there are many incentives for developers to pursue sustainable projects, specifically those that focus on implementing LID. David told us that a major benefit of creating LID infrastructure is that this infrastructure can be very aesthetically pleasing. Furthermore, the implementation of detention basins, bioswales, and other LID structures can enhance the beauty of a property while improving water filtration processes and reducing runoff, thus driving up property value. An example he mentioned of LID leading to increased property value is The Woodlands.

David also showed us a side-by-side analysis of the financial data from a sustainable project titled Birnamwood Drive, a roadway redevelopment project, and its non-sustainable alternative.

This data was a crucial moment in our Stakeholder Engagement phase because it was the first time we had gained access to financial data of sustainable projects. Also, the financial data was well-detailed, showing where exactly LID leads to lower costs. We were able to identify LID factors, such as optimized drainage, that drove building costs down, as we prepared to research project ideas and eventually create our project proposals.

Expert call with Philip Bedient

Dr. Bedient is the Herman Brown Professor of Engineering at Rice University, specializing in hydrology, disaster management, and flood prediction. He had an important role in developing the sustainable and flood-resistant infrastructure of The Woodlands, a model community in Texas. He also founded the SSPEED Center at Rice, focusing on storm prediction and disaster response. We went to him because, after our conversation with David, we were curious to learn more about The Woodlands and how it was developed.

His deep knowledge and experience helped us understand that flood prevention, particularly in Houston, can deeply increase land value. He started by explaining how The Woodlands is an extremely desirable place to live because it has beautiful green space, amenities like a golf course and a lake, and it is completely flood proof. He also explained that The Woodlands is 25% greenspace and 75% homes. He said this was partially achieved by only cutting the trees necessary to build roads, and leaving the rest of the trees there. Based on his knowledge, these are the key elements that drive the property's value upward.

He also described how The Woodlands is completely flood-proof: it is designed with Low Impact Development (LID). He explained that LID, depending on the particularities of the project, tends to be cheaper to put in place than other detention methods, and it is more effective. He also mentioned that aesthetically integrating LID into a landscape, can increase the property value, and he exemplified The Woodlands' lake, which is not only beautiful but also serves as a detention basin in flood control. He also covered the same concept on the community's golf course.

Finally, our conversation ended with him explaining that the careful planning and marketing of The Woodlands as a premium, flood-resistant area significantly increased its value, yielding a higher return for developers.

Phase 2: Background Research

This phase consisted of both doing a literature review and data collection. The literature review was mainly reading different articles and papers describing successful sustainable infrastructure practices, particularly those yielding a high ROI. Some of these articles and papers were sent to us by the stakeholders we interviewed, and some we found online. With this search, we narrowed down the focus of our project to Low Impact Development, as we discovered its low upfront

costs and potential to increase property value. Based on the literature review, we did the data collection, where we found case studies with published data on their financials and analyzed them.

Flood Prevention through Low Impact Development (LID)

Places that do not implement LID typically try to mitigate rainwater flooding by funneling the water through gutters so that it could travel through a series of pipes and end up in a large body of water, such as a bay or a lake (Doubleday, 2013, p. 1445). However, while a short-term solution, this flood mitigation strategy eventually causes areas downstream to flood due to an overflow of water being transported to these locations.

In contrast, LID aims to reduce the risk of flooding the moment rainwater hits the ground. LID aims to mimic the predevelopment hydrologic regime, which is defined as the most basic form of the hydrologic cycle that occurs on land that is devoid of human-built infrastructure (Doubleday, 2013, p. 1445). Low Impact Development accomplishes this goal by incorporating natural structures that are fundamental to the hydrologic cycle into the infrastructure. An example of a natural structure that is commonly used in LID is a detention basin. Detention basins do an excellent job of absorbing and temporarily storing rainwater. While the water from detention basins is eventually released, it is done so at an extremely slow rate, mitigating flood risk. Other natural structures that are commonly used in LID to reduce flooding are rain gardens, vegetated swales, and permeable pavement.

Case Study 1: Using LID to Decrease Costs in Birnamwood Drive

Our first case study focused on the cost comparison between conventional road construction and road construction incorporating LID practices. We wanted to understand how LID can affect overall costs, with a particular emphasis on specific construction elements such as drainage, landscaping, and stormwater management.

The study provides a detailed breakdown of costs in several categories, contrasting conventional methods with those employing LID (Construction ECO Services & Batts, n.d.). Our analysis determined that although LID incurs higher costs in areas like site preparation, it ultimately reduces overall expenses compared to conventional methods. This is largely due to LID's elimination of detention basins, a major component in traditional stormwater management, resulting in $350,000 in savings. The total cost for conventional road construction was $2,812,945, versus $2,620,873 for LID, leading to a net saving of $192,072 with LID. Despite higher costs for elements like landscaping and biofiltration systems, LID's positive financial impact stems from savings in drainage and stormwater systems. This case study highlights LID's effectiveness in both reducing environmental impact and ensuring cost-efficiency in road construction.

Case Study 2: The Woodlands vs. Spring

Our investigation focused on comparing two neighboring communities in Harris County—The Woodlands, a master-planned community, and Spring, an unincorporated area. The key areas of analysis included the management of flooding, urbanization levels, and the overall attractiveness to potential buyers.

The Woodlands, being a master-planned community, has implemented detention basins effectively to manage flooding. In contrast, Spring, characterized by a high degree of urbanization and significant concrete infrastructure, experiences more frequent flooding incidents. Our earlier research indicated that there is an estimated 10% to 25% markup on LID apartment prices compared to conventional prices due to the aesthetically integrated greenspace (American Home Shield, n.d.). This indicates that The Woodlands' appeal to buyers is its well-developed amenities. The community boasts an abundance of hike and bike trails, expansive green spaces, and a golf course integrated into the flood control system, making it a desirable living environment.

To quantify the economic differences between the two areas, we conducted a comparative analysis by compiling a list of 8-10 lots for sale in each community and calculating the average price per acre. The results revealed a substantial contrast: the average price per acre in Spring was found to be $279,873, significantly lower than The Woodlands' average of $2,065,602. This significant variance in average price per acre underscores the perceived value and desirability of The Woodlands over Spring. While flood management contributes to the appeal of The Woodlands, the presence of attractive amenities, green spaces, and recreational facilities further enhances its market value. In contrast, the higher flood risk and comparatively lower amenities in Spring contribute to its lower average price per acre.

This investigation sheds light on the diverse factors influencing property values and buyer preferences in neighboring communities within Harris County. The findings suggest that not only flood management but also the overall quality of life and community features play a crucial role in shaping the real estate market dynamics in these areas.

Case Study 3: Bridgeland, another Successful Master-Planned Community

Bridgeland, Texas, an 11,401-acre master-planned community near Houston, was developed by The Howard Hughes Corporation to house 20,000 homes and about 65,000 residents. Inspired by The Woodlands, Bridgeland has won awards, including the 2009 Community of the Year by the National Association of Home Builders.

The community's diverse landscape includes lakes and trails, with 3,000 acres dedicated to open spaces and recreation, including the Lakeland Activity Center. Annual events like Nature Fest enhance community engagement.

Bridgeland's environmental plan includes innovative strategies like the "purple pipes" system for sustainable irrigation using recycled water. Rain gardens in Parkland Square filter rainwater, reflecting the community's commitment to Low Impact Development and environmental consciousness. Bridgeland sets a model for sustainable development in Texas and West Houston.

Based on a few assumptions, as well as information found online, we estimate that the total revenue that Bridgeland could bring in to be a value of $8,323,300,000 (($517,000 per home /(1.075^3)) * 20,000 homes) at time 0 (when the project began). We estimate that the total cost of development to be $7,327,700,000 (($420,000 per home/1.075^2) * 20,000 homes) at time 0. This yields an ROI of 13.6%.

Case Study 4: Utilizing Infill Development based on Lowry Air Force

Infill development, building on unused or underutilized urban lands, is key to sustainable urban growth. It supports population growth while being environmentally and socially sustainable. A prime example is the transformation of Denver's Lowry Air Force Base into a sustainable neighborhood.

Covering 900 acres, the Lowry redevelopment turned into a mixed-use area, showcasing infill development's ability to reshape cities. It features tree-lined boulevards, residential areas, offices, and commercial spaces, forming a vibrant community.

A major benefit at Lowry was using existing infrastructure, like electricity, water, and roads. This approach reduces environmental impacts and maximizes resource use. It also combats urban sprawl, using existing city space efficiently and preserving green areas. Now home to 20,000 people, Lowry exemplifies infill development's effectiveness in creating sustainable, appealing urban spaces.

Conclusion

Recommendations

Based on our research phases, we can conclude with two main recommendations for the West Houston Association to effectively persuade developers to pursue sustainable infrastructure.

The first recommendation is to focus projects on Low Impact Development (LID). LID techniques, such as bioswales, permeable concrete, and the use of local plants, significantly reduce land development costs. Furthermore, when integrated aesthetically, LID not only increases property value, thereby enhancing Return on Investment (ROI) but also incurs lower long-term maintenance costs.

The second recommendation is to emphasize marketing for anti-flooding living. Given that Houston is highly prone to flooding, people are generally willing to pay more to live in areas that are less likely to flood. Therefore, if the West Houston Association demonstrates to developers that they can market their properties with this advantage, it could increase revenues and higher ROIs. By promoting green living—highlighting anti-flooding features, green spaces, and sustainability—more people may be inclined to pay a premium for these benefits.

Therefore, we have developed two distinct housing projects incorporating Low Impact Development (LID) techniques and have calculated the Return on Investment (ROI) for each, in comparison to similar projects where LID is not utilized.

Project Airtex

Our first recommendation is to develop a Master-Planned community using LID.

Rationale

Project Airtex is a Master Planned Community that would be located on 70.75 acres of land at 1115 Airtex Dr., Houston, TX, 77073. It is near businesses and restaurants like Chandra's Braids & Hair Design, Family Dollar, Domino's Pizza, Sam's Club, Saltgrass Steak House, China Bear Buffet, Carmax, Tom Peacock Cadillac and Nissan. It is near several educational institutions, including Universal Technical Institute, Francois Academy Early Education, Brightwood College in Houston, Richard Milburn Academy, Grantham Academy, Riri's Daycare, and Richey Academy. We believe that building a neighborhood profitable to developers in an under-developed area (formerly a truck depot) will also serve as an economic stimulus to the surrounding neighborhood, which will in turn benefit local schools, businesses, and communities.

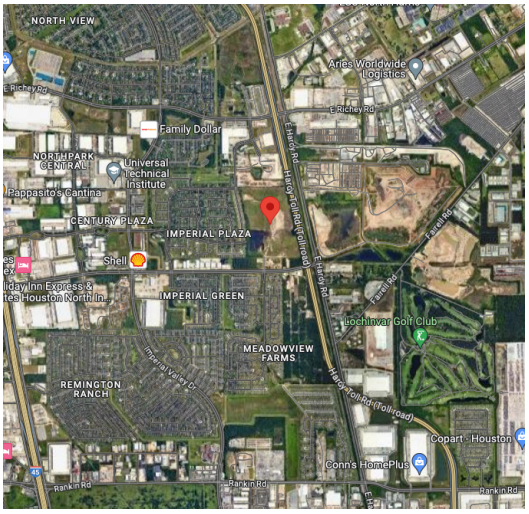

Figure 1 and 2: Aerial and map view of 1115 Airtex Dr., Houston, TX, 77073

LID Implementation

We plan to preserve 17.75 acres (25.1%) of the lot for greenspace, including a lake[1] to be used as detention. We chose to do this due to the successful implementation of similar ratios in The Woodlands and Bridgeland, where approximately the same percentage of the land is reserved for green space. This leaves 53.00 acres for development, where we plan to build 200 homes, each on approximately 0.265 acres (11,543 square feet).

Figure 3: A mockup of what LID designed Project Airtex could look like

[1] Detailed calculations in appendix 5

On the costs side[2], 1115 Airtex itself is listed for $11,000,000 (year 0). We estimate we would incur a total development cost of $16,850,465 over years 1 and 2, which is equivalent to a year 0 cost of $15,285,646, to implement the LID and other sustainable features. The largest cost we estimated was the cost to construct the homes, which we estimated at a year 3 cost of $325,000 per home ($150 per square foot * 2,167 square feet per home), which brings the total home construction cost to $65,000,000 (20,000 homes) in year 3, equivalent to $52,322,437 in y This brings us a total year 0 cost of **$78,608,083.**

On the revenue side, we estimate based on the selling price of homes in The Woodlands and Bridgeland, the proximity to the airport and other business hubs, and the prices of the surrounding neighborhoods, that each home could be sold for $600,000 in year 4. This brings a year 4 revenue of $120,000,000, which is equivalent to a year 0 revenue of **$89,856,000.**

ROI: ($89,856,000-$78,608,083)/$78,608,083 **= 14.31%**

Conventional Implementation

With a conventional implementation, a mandated 15% of a development's lot (in our case 10.75) acres is required for detention storage. This leaves 60.00 acres available for building houses and lots. Given that this is a conventional development, there is no space dedicated to greenery or lakes. We plan to fit 225 lots on this land, at an average of 0.267 acres per lot.

On the costs side[3], we pay the same $11,000,000 in year 0 for the land. We estimate that we will incur a development cost of $22,363,854 over two years, which is equivalent to a year 0 cost of $20,077,112. With the same estimation of $325,000 per home to build, we have a year 3 build cost of $73,125,000, which is equivalent to a year 0 cost of $58,862,742. This brings our total cost to **$89,939,854.**

On the revenue side, we assume we will be able to sell each home at $540,000, down from the $600,000 in the LID implementation due to the lack of greenspace, lake, and an improved view. This estimation of dropoff is conservative compared to the industry standards. Thus, we estimate a total revenue of $121,500,000 in year 4, which is equivalent to **$90,979,264** in year 0.

ROI: ($90,979,264 - $89,939,854) / $89,939,854 = **1.16%**

As we can see, the ROI for conventional development is not viable for consideration, while the ROI for LID development is.

[2] Detailed calculations in appendix 3
[3]Detailed calculations and information in appendix 4 and 6

Project Briarworth

Our second recommendation is to develop a multi-family development, using greenspace and aesthetic integration of LID.

Rationale:

Project Briarworth is a multi-family development project of 2.33 acres located at 13900 Briarworth Dr, Houston, TX 77077. It is near multiple offices and restaurants, such as BB's Tex-Orleans, Hungry's, and Urban American Kitchen. The location is ideal for people working in the area, as it would offer a short commute. It also has close proximity to schools like Westside High School, West Briar Middle School, and Ray Daily Elementary School, which can be a significant advantage for families. The area scores well in terms of transit, with some public transportation options available. It is also close to major highways, enhancing its appeal to residents who commute. The property is located in the Briar Village subdivision within the Houston region, known for its quality of life and community amenities. Being part of a well-regarded community can be a strong selling point for potential residents. We believe this is the ideal location for a multi-family development, catering to young people seeking a short commute to work. It is also perfect for young couples working nearby, possibly with one or even two children.

Furthermore, the lot is sizable enough to support a multi-family development. The possibility of subdividing the acres further enhances its potential, allowing for development that can meet specific market needs or preferences.

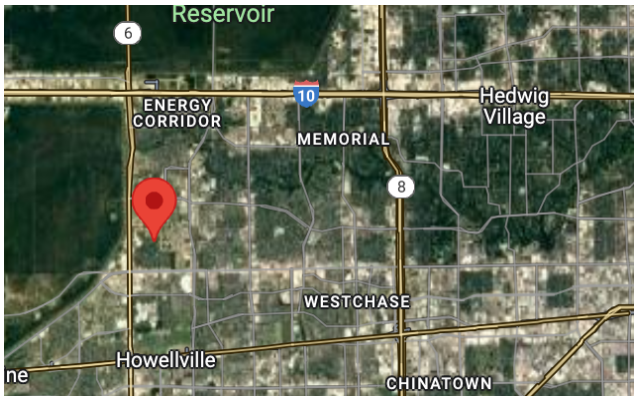

Figure 4 and 5: Map and aerial view of 13900 Briarworth Dr, Houston, TX 77077

LID Implementation

Only 12% of the area has to be dedicated to the detention area for LID, where we will integrate it with greenspace to create an aesthetically pleasing greenspace view from the apartments (Houston-Galveston Area Council, n.d, page 38-39). This leaves 2.05 acres for development,

where we plan to build 96 apartment units: 59 one-bedroom and 37 two-bedroom units[4], integrated in a four-story apartment complex with a wrap-around garage.

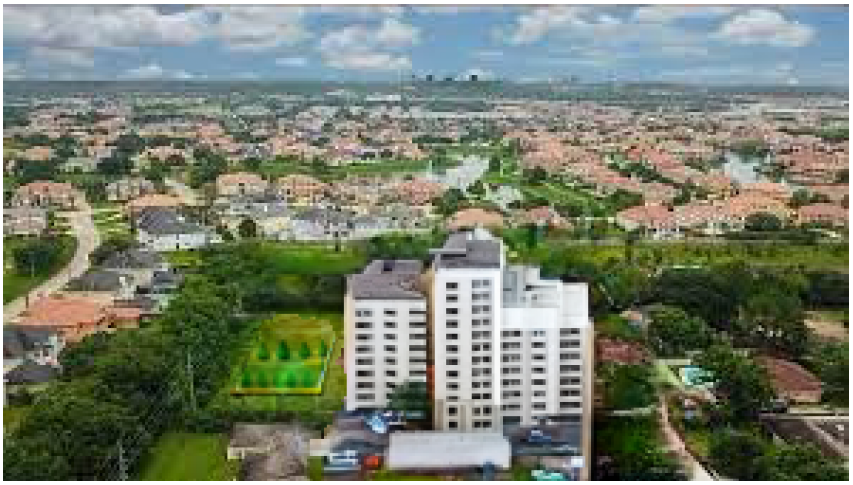

Figure 6: A mockup of what a LID designed Project Briarworth could look like

Regarding the costs, the property is listed for $895,000. For land development, we estimate a $635,250.67 cost[5], which is already discounted to time zero. We estimate we would incur a total building cost of $9,860,000.00, which includes the apartment building and parking spaces[6]. This would be distributed across the 12 months that it takes to build[7], so $986,000 would be incurred per each of those months.

On the revenue side, we expect the project to yield a total revenue of $17,460,800.00 for sales[8] of all apartments, forecasted to happen in year 3. We estimated a 12% markup on LID apartment prices compared to conventional prices due to the aesthetically integrated greenspace (American Home Shield, n.d.).

Discounting our costs and revenues according to the project timeline[9], we get a total discounted revenue at the present value of $14,055,255.51, and a total discounted cost at the present value of $12,309,360. This yields an ROI of 14.18%. This ROI is a robust estimate and therefore is a very appealing number for developers.

[4] Detailed calculations as to the number of units can be found in appendix 10
[5] Detailed cost breakdown found in appendix 9
[6] Detailed cost breakdown found in appendix 11
[7] Detailed timeline found in appendix 14
[8] Detailed revenue breakdown found in appendix 13
[9] Detailed timeline found in appendix 14

Conventional Implementation

For the conventional approach, 15% of the area has to be dedicated to the rainwater detention area. This leaves 1.98 acres for development, where we can fit 50 one-bedroom units and 32 two-bedroom units as a four-story apartment complex with a wrap-around garage.

Regarding the costs, the same list price of $895,000 applies. For land development, we estimated a cost of $1,327,465.45[10], which is already discounted to time zero. We estimate we would incur a total building cost of $9,200,000.00, which includes the apartment building and parking spaces. This would be distributed across the 10 months that it takes to build, so $920,000 would be incurred per each of those months. We estimate the conventional project will take less time to build due to having fewer apartment units.

On the revenue side, we expect the project to yield a total revenue of $13,360,000.00 for sales of all apartments, forecasted to happen in year 3.

Discounting our costs and revenues according to the project timeline, we get a total discounted revenue at the present value of $10,754,273.21 and a total discounted cost at the present value of $10,704,858. This yields an ROI of 0.46%. This low ROI is extremely unappealing and therefore it is very unlikely for a developer to even consider taking on this project.

Risks & Mitigation

Land Suitability and Feasibility

We do not possess the capabilities or expertise required to assess the land and ensure its suitability for the project. Consequently, there is a risk that the proposed drainage plan may not be compatible with the plot of land initially suggested for the project. To mitigate this risk, we suggested alternative plots of land for each project[11].

Unsold Inventory Risk

As the economy can be volatile, we cannot be fully certain that there will be demand for the project once it has been finished building. Factors such as market fluctuations, economic uncertainties, or unforeseen external events may impact our ability to sell all houses and apartments within the expected timeframe. However, to mitigate this risk WHA can perform a forecasted market analysis at the point of the sale.

[10] Detailed cost breakdown found in appendix 9
[11] Appendix 8 for Project Airtex, appendix 16 for Project Briarworth

Regulations Can Demotivate Developers

We are aware that regulations can demotivate developers in pursuing sustainable infrastructure development. Something WHA can do to mitigate this is to engage early in the process with local regulatory authorities to facilitate this process for developers.

Costs of Hiring Architects and Designers

We have omitted the costs of hiring architects and designers, as it is outside the scope of this project, but we acknowledge that hiring a LID-expert architectural team has the potential to cost more than a conventional team.

Next Steps

We recommend that WHA takes the following next steps:

1. **Investigate whether projects are feasible in given lots of land:** To assess the suitability of each lot, WHA can use a combination of geographic information system (GIS) mapping, environmental impact studies, and thorough reviews of local zoning laws. The goal of this approach is to understand each plot's topography, accessibility, and potential legal or environmental constraints. Collaboration with environmental consultants, surveyors, and legal experts can help uncover any challenges such as underground utilities or historical preservation requirements. Finally, if the plot of land suggested for either project is unsuitable, investigate for alternative lots of land[12].

2. **Perform a market analysis at the point of sale to gauge demand:** This can involve a mix of surveys, focus groups, and an analysis of local and regional demographic trends. Additionally, we suggest conducting a competitive landscape analysis, studying sales data, marketing strategies, and customer feedback from similar developments in the area. The goal of doing this is to identify market gaps and opportunities, ensuring the project's alignment with current and future market needs.

3. **Engage with authorities to facilitate LID projects for developers:** We suggest that WHA engage with local authorities to facilitate LID projects. This includes discussions around policy collaboration and negotiations for zoning variances or government incentives. This step ensures that the LID projects not only align with municipal sustainability goals but also gain the necessary support and approvals from the authorities, becoming more accessible for developers.

4. **Estimate price to hire a team of architects and designers for LID vs. Conventional:** We suggest WHA does a cost-benefit analysis to compare the costs associated with hiring architects and designers experienced in designing LID versus conventional development methods.

[12] Appendix 8 for Project Airtex, appendix 16 for Project Briarworth

5. **Deepen Estimates to Enhance Accuracy:** As an important next step, the WHA will focus on refining and deepening its estimates to enhance the accuracy and reliability of the project's financial and operational forecasts. This involves conducting more granular analyses of costs, revenues, and market dynamics.

6. **Pitch projects to developers:** We suggest that the WHA prepares materials to show developers including project earnings, cost estimates, expected returns, and sustainability credentials.

7. **Monitor and evaluate project performance post-completion:** Post-completion, the WHA will implement a system to monitor and evaluate the performance of the projects.

Appendix

Appendix 1: How Low Impact Development Technologies Generate Financial Returns: Data for Birnamwood Drive case study (Batts, 2022)

	Conventional	LID	Difference
Site Prep & Earthwork	391,634.00	449,060.00	57,426.00
Drainage	400,000.00	288,432.00	-111,568.00
SWPPP	69,600.00	87,000.00	17,400.00
Landscape Planting	30,000.00	66,140.00	36,140.00
Landscape warranty/Maint	0.00	34,630.00	34,630.00
Extra Work Items	15,650.00	36,650.00	21,000.00
Biofiltration System	0.00	132,900.00	132,900.00
SWQ System	30,000.00	0.00	-30,000.00
Detention Basin	350,000.00	0.00	-350,000.00
Total	**2,812,945.00**	**2,620,873.00**	**-192,072.00**

The table shows a 7% Savings per mile on the same project using LID in contrast to conventional.

Appendix 2: Bridgeland, — a ROI analysis

11,400-acre master-planned community with 65,000 residents.

	Revenue (Present value, assuming 7.5% yearly interest rate)	**Costs** (Present value, 7.5% IR)	
Homes	($517,000/(1.075^3)* 20,000 homes **$8,323,300,000**	($420,000/1.075^2) * 20,000 homes **$(7,268,800,000)**	
Infrastructure	**$0**	**$60,000,000/(1.075^2) = $(51,920,000)**	
Total	**$8,323,300,000**	**$(7,327,700,000)**	**Profit: $995,600,000**

ROI = 100*(Total Revenue - Total Construction Cost) / Revenue

ROI = (995,600,000)/(7,327,700,000) = 13.6%

Appendix 3: Cost Breakdown on landscape for Project Airtex (Conventional vs. LID)

	Conventional	LID	Difference	%
Concrete Sidewalk	$343,716	$542,538	$198,822	57.84%
Concrete Driveway	$2,383,263	$960,462	-$1,422,801	-59.70%
Curbs & Gutters	$350,661	$377,544	$26,883	7.67%
Street	$3,247,209	$3,019,904	$1,380,072	42.50%
Parking Lot	$948,171	$0	-$948,171	-100.00%
Conventional Stormwater Storage	$2,962,575	$1,794,324	-$1,168,251	-39.43%
Standard Roof	$7,032,771	$5,966,286	-$1,066,485	-15.16%
Permeable Pavement- Pavers	$0	$163,719	$163,719	
Turf	$4,717,770	$969,195	-$3,748,575	-79.46%
Native Plants	$0	$2,128,455	$2,128,455	
Rain Garden	$0	$591,408	$591,408	
Trees	$377,718	$319,608	-$58,110	-15.38%

Downspout Disconnection	$0	$303	$303	
Rain Barrels	$0	$16,719	$16,719	
Total	$22,363,854	$16,850,465	-$3,906,012	-17.47%

Based on the project information and estimates on Designing for Impact: Guide for Governments (Houston-Galveston Area Council, n.d, page 40-41).

Appendix 4: ROI Analysis Project Airtex (Conventional vs. LID)

Conventional Development Plan:

Total Area: 70.75 Acres.

Residential Lot Area: 60.00 Acres (85%) → (0.27 acres/home)

Detention area: 10.75Acres (15%).

Cost Analysis:

Total cost: $106,488,000

Lot cost: $11,000,000

Traditional Development Cost: $22,363,000 (Life Cycle cost)

Building homes cost: 225 homes * $325,000 = $73,125,000

Revenue Analysis:

Total Revenue:

225 homes * $540,000 = $121,500,000 (Assuming 10% decrease in home value due to loss of greenspace, view, LID techniques, etc)

ROI: (121,500,000 - 106,488,000)/(121,500,000) = 12.3% Pre TVM

LID Development Plan:

Total Area: 70.75 Acres.

Residential Lot Area: 53.00 Acres (75%) → (0.265 acres/home)

Lake and Green Area (Includes detention area): 17.75Acres (25%).

Cost Analysis:

Total cost: $89,856,064

Lot cost: $11,000,000

LID Development Cost: $16,850,000 (Life Cycle cost)

Building homes cost: 200 homes * $325,000 = $65,000,000

Revenue Analysis:

Total Revenue:

200 homes * $600,000 = $120,000,000

ROI: (120,000,000 - 92,850,000)/(120,000,000) = 22.6% Pre TVM

Appendix 5: Lake-Specific Financials for Project Airtex

Size of the Lake: Assuming that one-fourth of the 70.75-acre lot is allocated for the lake and trees, the lake would occupy a significant portion of this area. Let's assume the lake covers about 15 acres.

General Cost Estimate: Median figure of $5,500 per acre for this estimate.

Wetlands and native plants:

Design and Engineering: $11,500 per acre (median of $8,000 to $15,000)

Retrofit Grading and Construction: $10,000 per acre (median of $5,000 to $15,000)

Installing Vegetation: $15,000 per acre (median of $10,000 to $20,000)

Outlet Structure Construction: $12,500 (flat rate per project)

Assuming 20% of the lake area is dedicated to wetlands, that would be 12×0.20=2.4 acres.

Total Cost for Design and Engineering: 2.4 acres×$11,500/acre=$27,600

Total Cost for Retrofit Grading and Construction: 2.4 acres×$10,000/acre=$24,000

Total Cost for Installing Vegetation: 2.4 acres×$15,000/acre=$36,000

Total Cost for Outlet Structure Construction: $12,500

Overall Wetlands Cost = $27,600+$24,000+$36,000+$12,500=$100,100

Calculating Lake Construction Costs:

Estimated Lake Construction Cost: 15 acres * $5,500 per acre = $82,500.

Total cost to build lake with wetlands= $182,600

Appendix 6: Timeline Calculations & Assumptions for Project Airtex

To forecast over how many years the Return on Investment (ROI) will be achieved for the gated community project at 1115 E Airtex Dr, Houston, TX, we need to consider the timeline of various stages such as land acquisition, development, construction, and the sales process.

Project Timeline Phases:

1. Land Acquisition: Immediate, as the land purchase is a one-time cost.
2. Development and Construction:
    a. Development (Infrastructure and Lake Construction): Typically, such development can take 1-2 years, depending on the scale and complexity.
    b. Construction of Individual Lots/Homes: Assuming the developers sell lots to builders or individuals who then construct homes, the construction timeline can vary. If the community plans to build the houses themselves, additional time can be added for this phase.
3. Sales Process:
    a. Pre-Sales Phase: This can start during the later stages of development. The duration depends on market conditions and the attractiveness of the community. Let's assume a 2-3 year period for selling a significant portion of the lots.

Estimating the ROI Achievement Timeline:

1. Development and Construction Period: 1-3 years.
2. Sales Period: 3-4 years (can overlap with development to some extent).
3. Total Estimated Timeline for ROI Achievement: 3-5 years.

Assumptions for ROI Forecast:

- Revenue Recognition: The revenue from lot sales would likely be recognized progressively as sales are made. For simplicity, we'll assume an even distribution of sales over the sales period.
- Cost Recovery: Initial investment costs (land purchase and development) are considered upfront expenses.
- Cash Flow Positive: The project is considered to achieve its ROI once the total revenue from sales exceeds the total investment costs.

Appendix 7: Time Value of Money calculations for Project Airtex

Revenues	Conventional	LID
Value year 4	$121,500,000	$120,000,000
Total revenue value today	$90,979,264	$89,856,064
Costs	Conventional	LID
Value time 0	$11,000,000	$11,000,000
Value year 1	$11,181,500	$8,425,000
Value year 2	$11,181,500	$8,607,600
Value year 3	$73,125,000	$65,000,000
Discounted year 1	$10,401,395	$7,837,209
Discounted year 2	$9,675,717	$7,448,437
Discounted year 3	$58,862,742	$52,322,437
Discounted sum	$78,939,854	$67,608,083
Total cost value today	$89,939,854	$78,608,083
Discounted ROI	1.16%	14.31%

Discounted at a rate of 7.5%, based on the risk of developing residential and commercial real estate (Damodaran, n.d.).

Appendix 8: Alternative Lots for Project Airtex

- 14802 Duke Rd, Splendora, TX 77372 (From Zillow.com)
- 43306 Highway 290 Bus, Waller, TX 77484 (From Zillow.com)
- N Fairway Oaks, Houston, TX 77336 (From Realtor.com)
    - Price: $11,652,500
    - Lot Size: 298.07 acres.
- 840 Huntington Rd, Rosenberg, TX 77471 (From Zillow.com)
- 44291 Old Houston Hwy, Prairie View, TX 77446 (From Realtor.com)
    - Price: $5,492,369
    - Lot Size: 93.09 acres.
- 43306 Highway 290 Business, Prairie View, TX 77484 (From Realtor.com)
    - Price: $16,000,000
    - Lot Size: 101.24 acres.
- Fm 1098 Wyatt Chapel Rd, Prairie View, TX 77445 (From Realtor.com)
    - Price: $8,754,471
    - Lot Size: 160.79 acres.

Appendix 9: Project Briarworth Cost Breakdown for landscape development and stormwater management (LID vs. Conventional)

	Life Cycle Cost ($ NPV) Net Present Value		
Item	**Conventional**	**LID**	**Difference**
Concrete Sidewalk	$59,936.04	$21,966.56	-$37,969.49

Curbs & Gutters	$1,131.23	$1,178.04	$46.81
Street	$6,151.31	$6,416.91	$265.60
Parking Lot	$783,777.16	$157,418.65	-$626,358.51
Conventional Stormwater Storage	$121,819.88	$49,522.76	-$72,297.12
Standard Roof	$224,446.87	$225,087.94	$641.07
Green Roof	$0.00	$12,972.01	$12,972.01
Turf	$113,640.51	$34,633.21	-$79,007.31
Native Plants	$0.00	$76,058.15	$76,058.15
Rain Garden	$0.00	$14,442.37	$14,442.37
Trees in Parking Lot	$16,562.45	$26,547.46	$9,985.01
Swales	$0.00	$7,292.90	$7,292.90
Downspout Disconnection	$0.00	$10.79	$10.79
Cisterns	$0.00	$1,702.93	$1,702.93
Total for development	$1,327,465.45	$635,250.67	-$692,214.78

Appendix 10: Calculations on number of units in Project Briarworth (LID vs. Conventional)

How many more units (LID vs Conventional) (Houston-Galveston Area Council, n.d., page 38-39): In 21.8 acres:

- LID 486 units with 12% detention area
    - 22.9 units per acre

- Conventional 416 units with 15% detention area
    - 19.08 units per acre

In 2.33 acres (based on two story buildings):

- LID: 22.29*2.33 = 51.94 units
- Conventional 19.08*2.33 = 44.46

4 story building with a 5 story garage wrap around:

- LID 51.94*2 = 103.88 units
- Conventional 44.46*2 = 88.92 units

Average Unit Size (in handbook) 800 sq ft

- LID: 800*103 = 82,400 total sq ft
- Conventional: 800*88 = 70,400 sq ft

Unit division:

- LID: 82,400 sq ft / 2 = 41,200 sq ft
    - One bedroom units: 41,200 sq ft /700 sq ft per unit = 59 units
    - Two bedroom units: 41,200 sq ft / 1100 sq ft per unit = 37 units
- Conventional: 70,400 sq ft / 2 = 35,200 sq ft
    - One bedroom units: 35,200 sq ft /700 sq ft per unit = 50 units
    - Two bedroom units: 35,200 sq ft / 1100 sq ft per unit = 32 units

Parking:

- LID: 1.5 spaces per unit * 96 = 144 parking spaces
- Conventional: 2 spaces per unit * 82 = 164 parking spaces

Appendix 11: Building Cost Breakdown Project Briarworth (Conventional vs. LID)

Building cost breakdown	**Conventional**	**LID**
Living Space Construction (sq ft)	70400	82400
Cost per sq ft	100	100
Total for apartments	7040000	8240000
parking area (sq ft)	48,000	36,000
cost per sq ft	45	45
Total for parking	2160000	1620000

Total	$9,200,000.00	$9,860,000.00

Appendix 12: Total Cost Project Briarworth (Conventional vs. LID)

	Conventional	LID
Land Cost	$895,000	$895,000
Total for development	$1,327,465.45	$635,250.67
Total for building	$9,200,000.00	$9,860,000.00
Total costs	$11,422,465	$11,390,251

Appendix 13: Total Revenue on Project Briarworth (Conventional vs. LID)

	Conventional	LID
Number of one bedrooms	50	59
Number of two bedrooms	32	37
Price one bedroom	$120,000.00	$134,400.00
Price two bedroom	$230,000.00	$257,600.00
1 bedroom	$6,000,000.00	$7,929,600.00
2 bedroom	$7,360,000.00	$9,531,200.00
Total for sales	$13,360,000.00	$17,460,800.00

Appendix 14: Timeline Calculations & Assumptions for Project Briarworth (Conventional vs. LID)

Conventional Development Timeline:

1. Land Acquisition: 1 month
2. Site Planning and Design: 2 months
3. Permitting and Approvals: 3 months
4. Site Preparation and Infrastructure Development: 2 months
5. Construction of Apartment Complex: 10 months
6. Final Inspections and Approvals: 1 month
7. Marketing and Leasing: 2 months
8. Total Time for Conventional Project: 21 months

Low Impact Development (LID) Timeline:

1. Land Acquisition: 1 month

2. Site Planning and Design: 3 months
3. Permitting and Approvals: 3 months
4. Site Preparation and Infrastructure Development: 2 months
5. Construction of Apartment Complex: 12 months
6. Final Inspections and Approvals: 1 month
7. Marketing and Leasing: 2 months
8. Total Time for LID Project: 24 months

Appendix 15: Calculations of Incorporating Time Value of Money into Project Briarworth (Conventional vs. LID)

Costs	**Conventional**	**LID**
Land	$895,000	$895,000
Landscape	$1,327,465	635,250.67
Building Construction (per month)	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
	$920,000	$986,000
		$986,000
		$986,000
Total discounted cost	$10,704,858	$12,309,360

Discounted revenue	Conventional	LID
Condo sales (discounted)	$10,754,273.21	$14,055,255.51
Discounted ROI	0.46%	14.18%

Everything is discounted at a rate of 7.5%, based on the risk of developing residential and commercial real estate (Damodaran, n.d.).

Appendix 16: Alternative lots for Project Briarworth

- Park Row Rd, Katy, TX 77449 (From Realtor.com)
    - Price: $595,000
    - Lot Size: 1.09 acres.
- 2738 Deborah St, Stafford, TX 77477 (From Realtor.com)
    - Price: $975,000
    - Lot Size: 5.96 acres.

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