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Geodesign: Applications towards Smarter Planning and Urban Design Solutions

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Abstract

As world population becomes increasingly urban (World Health Organization, 2017), the need for smart city planning becomes crucial. Cities continue to increase in size and density, and with the accompanying infrastructure of buildings, roads, transportation tunnels and subways, the amount of permeable surface that is able to absorb storm water decreases (Hunt & Watkiss, 2011). As urban densification combines with increases in storm frequency and intensity, municipalities need to find new ways of managing storm water. Solutions require collaboration across planning disciplines and input from an informed public. Geodesign approaches and technologies can assist in making wiser design decisions. Geodesign refers to geographic design or using geographic data to aid design. This design approach supports the rapid iteration and application of new planning strategies and urban design ideas by integrating the site's data with computer software such as a GIS (Geographic Information System). The formalization of geodesign was developed and fostered by Jack Dangermond, founder and president of the Environmental Systems Research Institute (ESRI). ESRI is a leading global provider of GIS software technology, offering new geode sign technologies to help achieve better planning outcomes. This paper defines the concept of geode sign and demonstrates its application for achieving sustainable landscapes and cities. The paper focuses on two key projects that serve to show planners and urban designers how to make wiser design decisions based on geo-data. It reviews the project goals, methods and results to achieve data-driven design solutions using a geodesign process and technology.

Keywords; geodesign, GIS, data-driven design; landscape architecture

Cities are under great threat from the impacts of climate change. Major urban centres have been struggling to deal with flooding and increased storm water management. The need to intelligently design, model and evaluate planning solutions for sustainable and resilient cities is a must. These design strategies need to take into account geographic data, both for achieving a thorough knowledge of the landscape and for designing its systems. The notion of 'geodesign' is not necessarily a new concept; rather a newkind of framework for planners and urban designers to achieve evidence-based planning solutions. Geodesign utilizes geo-based (landscape-based) information together with advances in GIS technology.

The word 'geodesign' refers to geographic design or using geography to assist with design. The application of geodesign has been brought to the forefront by Jack Dangermond, the founder and president of the Environmental Systems Research Institute (ESRI), the global provider of Geographic Information Systems (GIS) software technology. Jack Dangermond is a landscape architect by training and studied at Harvard's Graduate School of Design under the teachings of Carl Stenitz. ESRI was founded in 1969 by Jack and Laura Dangermond. ESRI states "Geodesign combines geography with design by providing designers with robust tools that support rapid evaluation of design alternatives against the impacts of those designs. Dangermond held the first Geodesign Summit on January 6–8, 2010, at Esri's Headquarters in Redlands, California. He introduced the benefits of geospatial technologies to help make design decisions and rapid design porotypes in a rapidly changing environment.

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Planners, urban designers, landscape architects and city officials, including mayors have showcased the benefits of geodesign application each year at the Summit. Though not limited to ESRI products, ESRI advocates for their suite of software products such as ArcGIS Online, Geoplanner, ArcGIS Pro and CityEngine, as the technical tools for effective geodesign solutions. (Figure 1) These GIS tools help planners and urban designers analyze, design, manage and visualize rapidly changing planning solutions.

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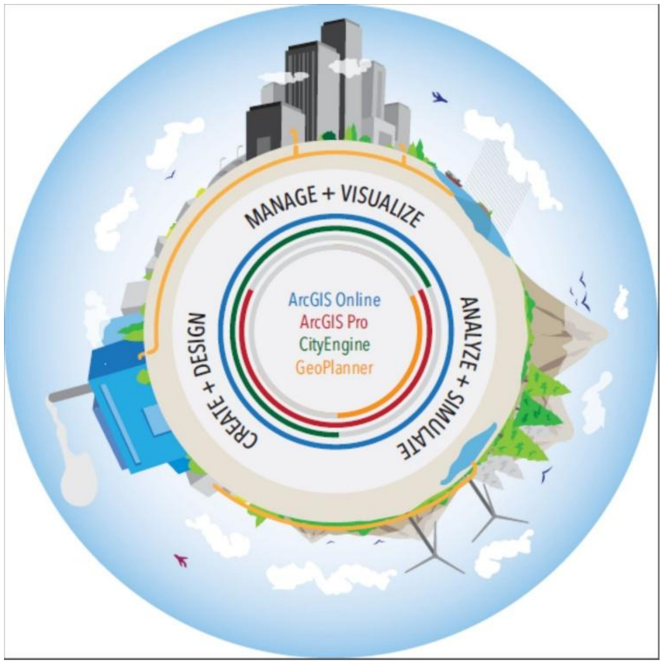

Figure 1 Tools for Geodesign Solution

Planners and urban designers are challenged by rapidly changing environments, from climate change to storm- water management to expanding urbanization. CityEngine is a type of parametric tool that applies rules and procedures to help guide the designer. The urban designers can craft digital models within CityEngine, and evaluate it against various parameters, such as zoning by-laws, street widths, boulevard and bike lanes dimension, storm water runoff, and other attributes critical for the quality design of public realm spaces. Landscape architects and designers of the built environment are seeking these kinds of applications to assist them in making wiser planning decisions through the utilization of geo-data. Planning and landscape architecture firms such as HousealLavigne (USA), Turenscape (China) and O2 Planning + Design (Canada) are just a few prominent firms utilizing geodesign as a way to advance planning outcomes through advanced spatial analysis.

This paper presents two practical projects using geodesign technology and approaches by O2 Planning + Design. O2's project, the Emerald Crescent, is situated in the Decoteau area of the southeast portion of the City of Edmonton, Canada. It is currently dominated by agricultural land use but has long been recognized as an important area for new residential development. The second project by HousealLavigne Associatesis located in Battle Creek, Michigan.

Emerald Crescent Case Study

Early collaborative efforts between the City and development community stakeholders produced an illustrative concept of a well-connected open space network for the area, the Emerald Crescent. Since that time, an Area Structure Plan (ASP) was approved by council in 2015, identifying five neighbourhoods for further development; (CoE 2015), and the first Neighbourhood Structure Plan (NSP) for the North Decoteau neighbourhood was approved at the end of 2018. With four remaining NSPS still to be developed (the Northwest, Southwest, Central and Southeast neighbourhoods), there is a pressing need to ensure that subsequent Neighbourhood Structure Plans (NSPs) align with the framework outlined in the City's recently approved BREATHE: Green Network Strategy (CoE 2017) for open space management. BREATHE brings a new multi-functional network focus to the management of the City's open spaces, requiring equitable access to diverse open spaces which support the 'Ecology, Celebration and Wellness' functional themes established by the City.

This study provided the City of Edmonton with an innovative opportunity to bring together landowners, developer groups, and city planners during an earlier stage of the planning process than is typically afforded, thus allowing for a broad, objective based planning process supported by well-defined spatial metrics of success. The timing of this process provides more leverage to both city planners and developers over the potential land use of the area, ensuring more effective buy-in to the recommendations, minimizing opportunity costs, and allowing for more transparent decisions at an early stage. The recommendations arising out of this effort will help reduce overall costs of planning and land acquisition, removing roadblocks to more innovative integration of well-connected open space systems into greenfield development. A holistic and inclusive planning process helps to bring greater diversity and multi-functionality to parkland development.

Goals

To arrive at a solution that met the needs of all stakeholders, O2 adopted a geodesign framework, in which modelling and evaluation of alternatives were coupled with planning and design in a collaborative environment (McHarg 1969; Flaxman 2010; Steinitz 1995, 2012). Under this framework, a collaborative series of three workshops explored the development of alternative land use concepts. The goal is to create a recommended concept that balances ecological, recreational and development considerations. The concept ensures economically feasible residential and commercial development while preserving key natural areas linked together by a well-connected and easily accessible network of parkland and other public open space. This non-statutory concept is intended to highlight benefits and challenges facing the development of the Decoteau area, provide reference material to draw upon during the subsequent Neighborhood Structure Plans for the area, and act as a representative case study for the geodesign process.

This study adopts an ecological urbanism approach where the underlying ecological function of the landscape provides the primary organizing structure of the urban system. It recognizes that the protection of existing natural systems and purposeful design of new functional open spaces can give rise to new models of urban form. The goal is to ensure the creation of a multifunctional open space network which stewards natural processes, creates inviting community spaces, and encourages active outdoor recreation, while supporting economic development and a sense of place. The geodesign approach brings together practical development constraints, ecological valuation and functional open-space assessment to produce a recommended land use concept that maximizes the value of the study area.

Methods

Potential land use concepts were tested against specific measurable criteria to ensure transparency and rationality of the decision-making process. This transparent process encouraged workshop participants to clearly identify measurable indicators of success with which to assess alternative land use concepts. This solution-oriented approach is respectful of diverse stakeholder interests while providing a robust and transparent decision-making process. The collaborative workshop environment, supported by spatially explicit analytic tools, helped identify areas of consensus and highlight key areas of conflicting value. This project moved through three primary phases, each focused around an in-person workshop where stakeholders had the opportunity to review information, establish measurable criteria of success, and guide the development of land use concepts for the area.

The first workshop focused on the identification of values of concern and general analytic approaches to assessing the functional performance of potential land use designs. The second workshop saw the implementation of these analyses using a draft land use concept, based on initial stakeholder input and the constraints identified in the ASP. This draft concept provided a chance to review the analytic approach, as well as serving as a focal point to encourage discussion and criticism and produce explicit direction for concept refinement. The final workshop reviewed the land use concept that arose out of this stakeholder direction, providing the chance to highlight any outstanding concerns, as well as describe the practical challenges that must be overcome to bring the concept into being. The final workshop saw the general approval of the recommended concept by the participating stakeholders.

Results

The recommended Emerald Crescent concept (Figure 2) contains 72% of all areas which qualify as Environmental Reserve. Large wetland complexes and natural areas were preferentially retained, with small isolated wetlands ceded to development, where necessary to align with the approved road network or constraints identified in the ASP. The Emerald Crescent is intended to be highly accessible to the surrounding neighbourhoods.

In total, 79,613 people, or 91% of the total estimated population, would be located within a 5-minute walk from the Emerald Crescent (Figure 3). This is a marked improvement compared to the Decoteau ASP, which was estimated to have only 75% of population within 500m of any parkland area.

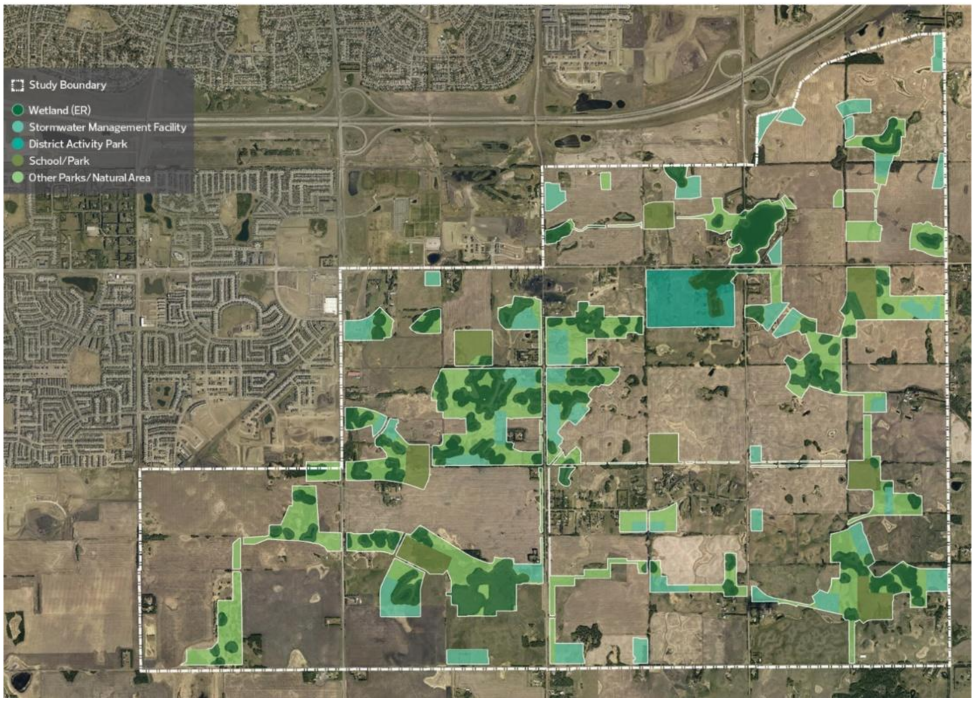

Figure 2 Wetlands, school sites, stormwater management infrastructure, and other parkland are connected to form the Emerald Crescent.

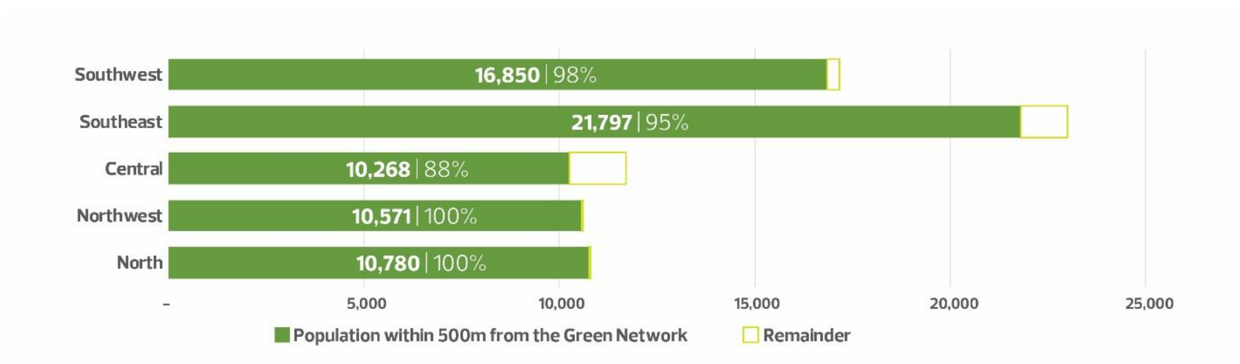

Figure 3 Estimated Number and Percent of Population within 500m from the Emerald Crescent at the Neighbourhood Level

The Emerald Crescent concept provides 828.6 hectares of Net Residential Area, 96.1% of that provided in the ASP (Figure 4). This reduction occurs because of the increased parkland area, required to provide the necessary required connections throughout the area. The original Decoteau ASP simply identified the residential area zones, and generally described the relative fraction of housing types that fell within this footprint. This study developed a more spatially explicit design that indicated conceptual street and lot layout in order to properly assess the connectivity and accessibility of open space provided by the Emerald Crescent. Following the ASP classification, residential areas have been allocated into the following housing types:

- Single-Detached housing
- Townhouses
- Low-Rise Apartment Buildings (4 story)
- High-Rise Apartment Buildings (12 story)

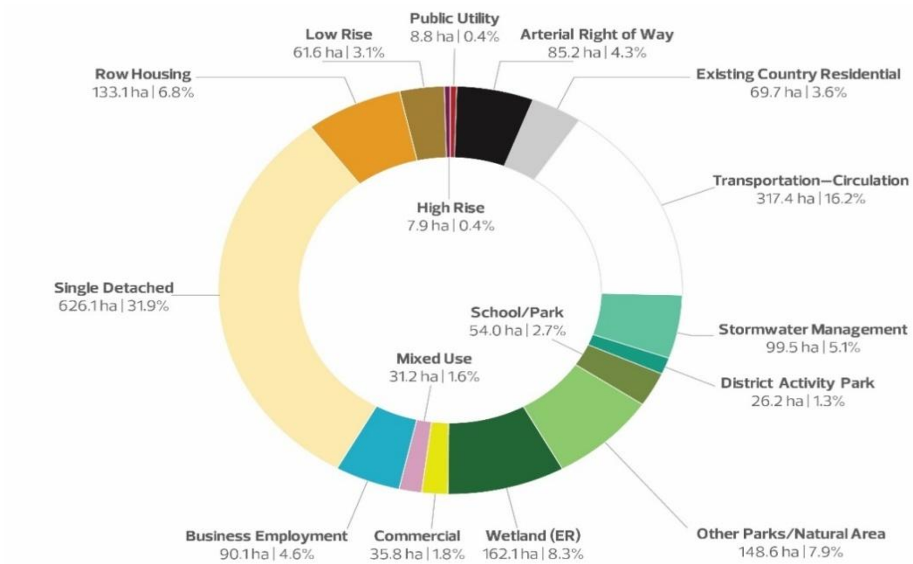

Figure 4 Area and Percent of Each Land Use Type for the Decoteau area

Townhouses were preferentially placed along collector roads, near town centre areas, and not directly adjacent to open space. Low-Rise Apartments are placed near to transit nodes, mixed-use commercial areas, and other "town centres". High-Rise apartments were similarly placed, with the stipulation that they occur on the northern side of an adjacent open space, to prevent shading effects and other impacts to the ecological and aesthetic functions of the Emerald Crescent network (Figure 5).

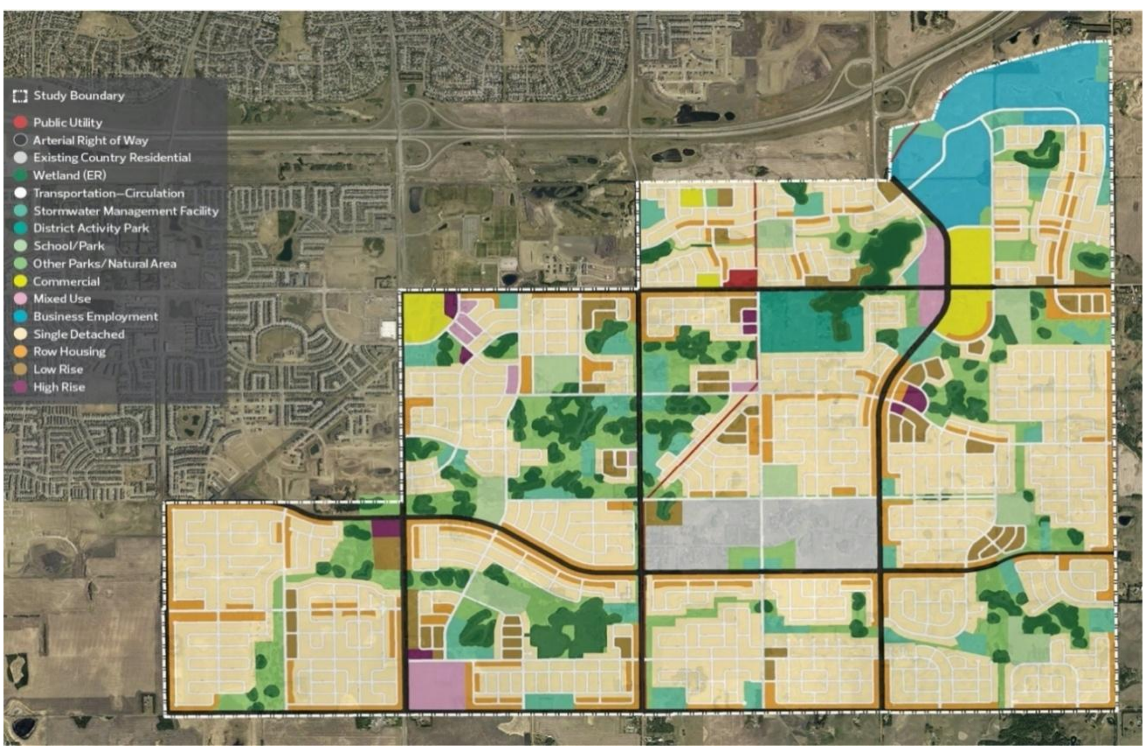

Figure 5 The Emerald Crescent Land Use Concept

The City requires an average housing density for the Decoteau area of 35 units per net residential hectare. To achieve the connected Emerald Crescent concept, some neighbourhoods require more total open space than originally allocated in the Decoteau ASP. To ensure that each neighbourhood meets its residential density target, a reduced amount of single-detached units are allocatedin favour of an increased number of townhouses and low-rise apartment buildings (Figure 6).

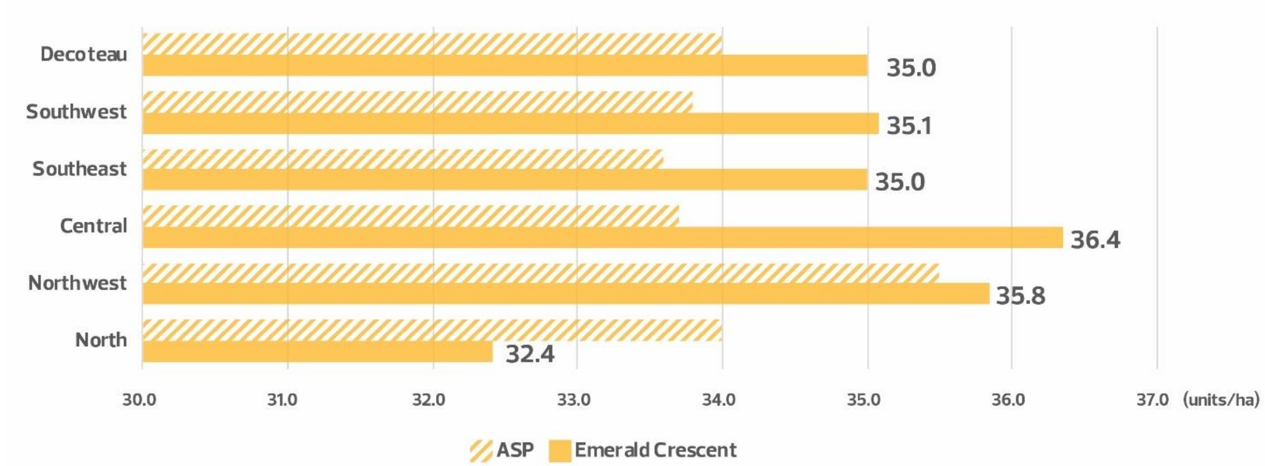

Figure 6 Number of Dwelling Units per Net Residential Hectare in the Emerald Crescent Land Use Concept vs the ASP at the Neighbourhood Level

The resulting land use concept was brought into CityEngine, where parcel subdivision rules partitioned the residential zoning. Residential and commercial buildings were placed using similar rulesets. Complete streets were modelled according to the City's transportation guidelines, including boulevard widths, shared and separated bike lanes, and street trees and lights. Structural changes to the existing terrain ensured that 3D structures were realistically placed in development areas. Following development of the 3D structure, a virtual model was built in the Unreal Studio visualization environment, allowing greater detail and flexibility in the textures and lighting than is possible in the CityEngine environment (Figure 7). Procedural ecosystem modelling was used to recreate retained natural forested and wetland areas, and ensure the realistic representation of constructed open spaces, wetlands and stormwater management features (Figures 8 – 11).

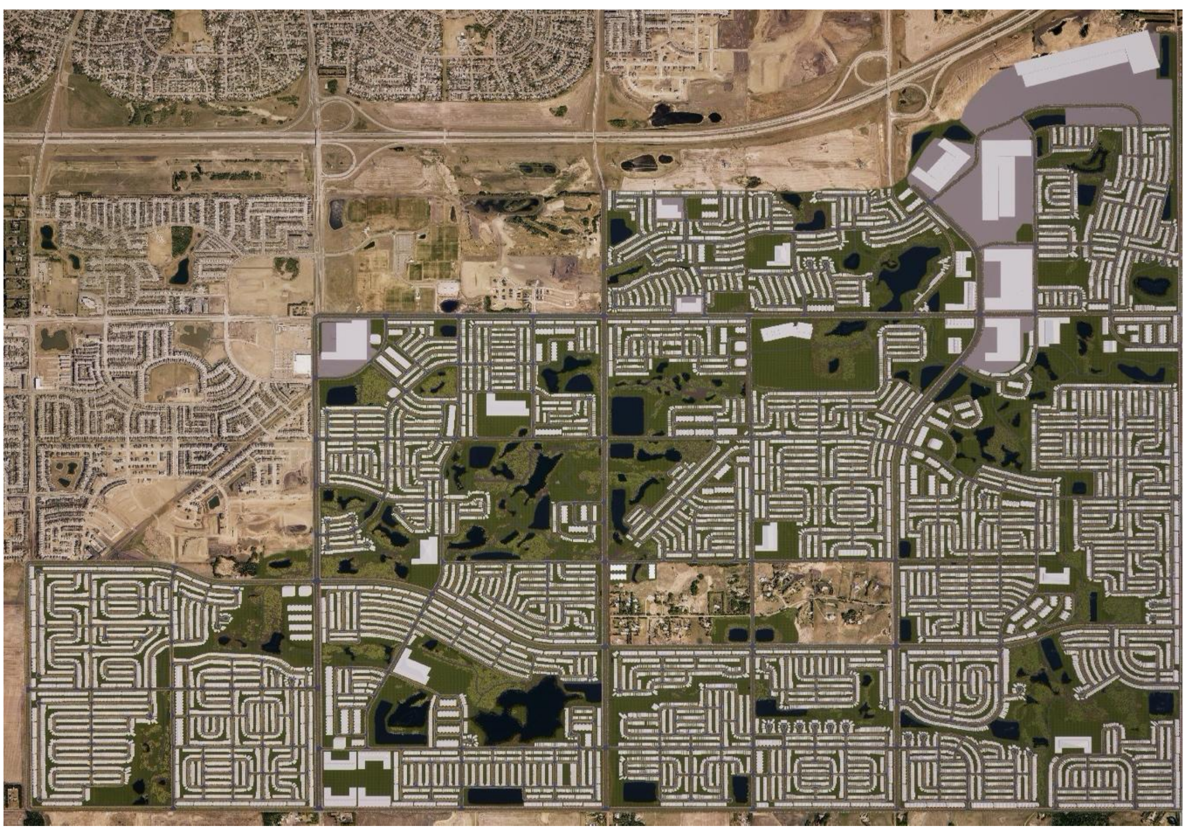

Figure 7 The Emerald Crescent concept rendered using the Unreal virtual engine.

Figure 8 The Emerald Crescent rendered using the Unreal virtual engine.

Figure 9 The Emerald Crescent rendered using the Unreal virtual engine.

Figure 10 The Emerald Crescent rendered using the Unreal virtual engine.

Figure 11 The Emerald Crescent rendered using the Unreal virtual engine.

The project highlights the efficiencies which may be realized by collaborative, multi-objective land use planning, ensuring economically viable development decisions are made with full awareness of the natural context. The collaborative process drew attention to key roadblocks and lynchpin areas to focus on during the refinement and approval of subsequent Neighbourhood Structure Plans. Implementation of this recommended land use concept will require a shift in approach within the City's Urban Form, Infrastructure Services, and Financial Services departments. A collaborative, long-term planning process is necessary to maximize the potential functionality of the land, bring the greatest benefit to future residents, and ensure that development feasibility is not compromised.

Case Study- Battle Creek, Michigan

Often referred to as the Cereal City because it hosts Kellogg's global headquarters, Battle Creek is a regional economic center in Western Michigan that was looking for some direction in planning for future development and investment. Recently, the city partnered with HousealLavigne Associates to update its master plan, incorporating spatial data to help guide the areas evolution.

Goals

The Battle Creek Master Plan is a framework to guide decision-making, city policy, and collective community action within Battle Creek. It is supported by twelve goals which provide clear direction on key issues and opportunities the City will face in the coming five to ten years. The goals are founded in a comprehensive understanding of the community based on extensive public engagement and research. Further, each goal includes detailed objectives which outline more specific actions that should be undertaken to advance toward that overall goal. The goals include promoting investment in the city core while limiting unnecessary and premature outward growth; repositioning land use to reflect the anticipated needs of the community; promoting reinvestment in Battle Creek's established neighborhoods; revitalizing commercial corridors as vibrant, successful business districts; elevatingthe downtown as an energetic community focal point and center of government and commerce; activating the Kalamazoo and Battle Creek Riverfronts; improving the overall appearance of the community and inspire pride in Battle Creek; fostering an educated, diverse, and well-trained workforce; ensuring an efficient and well-maintained local transportation network; expanding the pedestrian and bicycle network to promote active transportation; ~~to~~ offering residents a full range of accessible parks, trails, and recreation opportunities; and continuing to provide adequate infrastructure and high-quality City services. Each goal is supported by a series of objectives to provide specific actions for follow through.

Battle Creek's Master Plan is the product of a planning process that actively sought input from a variety of stakeholders, including residents, neighborhood groups, business owners, developers, service providers, elected and appointed officials, and City staff. A variety of outreach efforts were used to gather the concerns, ideas, and aspirations of residents. This feedback wascritical in identifying the key issues and opportunities that served as the foundation for the new Master Plan and informed the plan's development and recommendations.

Methods

Outreach conducted in support of the Master Plan included both in-person meetings and workshops as well as online tools and applications. These efforts helped to complement each other, providing members of the community a variety of methods by which to get involved. After completing a series of projects workshops and key stakeholder interviews, HousealLavigne Associates used ArcGIS Business Analyst to assess the City's demographic trends and market potential. The company then turned to ArcGIS Pro to spatially analyze existing conditions and create the master plan's attractive maps and graphics.

Next, HousealLavigne Associates created more detailed blueprints for specific areas of Battle Creek. For Columbia Avenue, an aging auto-oriented corridor in Battle Creek, the company made a detailed corridor plan that recommends specific actions to take to improve the area. It also employed CityEngine to generate a detailed redevelopment concept for the lakefront area near key intersection in the community.

Results

Battle Creek's new master plan, which places a strong emphasis on land use and development in a post-recession era, is a prime example of geodesign in practice, underlining how important map-based analysis and comprehensive graphics are to the future of planning. Using geospatial data more prominently than it ever has before, Battle Creek can now more easily identify its most pressing issues and determine the best solutions. Shortly after Battle Creek adopted the new master plan, the City re-engaged HousealLavigne Associates to develop an interactive model that would allow City officials to visualize various ways the redevelopment plan could work based on the master plan's recommendations. Using CityEngine again, HousealLavigne Associates created a Web Scene that detailed the land use "place types" outlined in the master plan, which gives the city a comprehensive idea of how it could change in the future. (Figure 12)

Figure 12 Concept Development of Battle Creek, Michigan

The entire project, underlaid with GIS and spatial analytics, is fostering a holistic approach to planning and redevelopment in Battle Creek. The master plan takes into account the unique appearance and built character of distinct areas and examines how planning will affect different districts within the community. Also, the Web Scene is being put to good use. Currently, the City's economic development agency, Battle Creek Unlimited, is employing it to promote the area's full potential and market available properties to prospective buyers and business owners.

Conclusion: The Value of Geodesign

The geodesign process with accompanying technologies was used in the above case studies to ensure data-driven, along with value-driven, solutions could deliver optimal planning outcomes. Geodesign technologies such as CityEngine were selected as the main design tool for these projects. CityEngine was used to build out parcels and roads in 3D consistent with land use recommendations and typical buildouts. ArcGIS performed a number of geospatial queries and analysis to inform future land use suitability. Geodesign technologies have been used in these projects as support for the implementation of a complete approach to sustainable urban development. CityEngine allows for three-dimensional visualization and analysis. Throughout the analytical phase of design, information is communicated directly to the designer as changes are made; data and visuals are integrated so that a change in one is automatically reflected in the other. This constant feedback aids in informed decision making, creating a sustainable approach towards urban development using geography as its source of guidance. The geodesign approach provided validation on many of the planning decisions including reclaiming public rights-of-way, reconstructing poorly maintained or inconsistent sidewalk segments, allocating appropriate buffers, landscaping elements, screening, and other on-site improvements between commercial corridors and adjacent residential neighborhoods. The geodesign approach and technology helped deliver and justify a more ecological and sustainable plan in both cases.

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