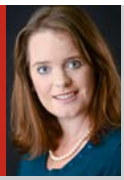
How sustainable urban design can reduce infrastructure costs



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Wetlands are a natural and aesthetic strategy towards improving water quality

Developers often associate environmental requirements with additional costs and extended project time frames, in many instances seeing environmental services as a grudge purchase. But what if the opposite was possible? What if building environmental considerations into each phase of infrastructure development could decrease the overall cost of the project?

In this article, we describe how this can be accomplished. We look at the various phases of infrastructure development and explore how the use of environmental considerations and innovations can avoid delays and potentially even reduce the cost of infrastructure development. Indeed, while this article focuses on infrastructure development, the approach proposed may be adapted to any type of development.

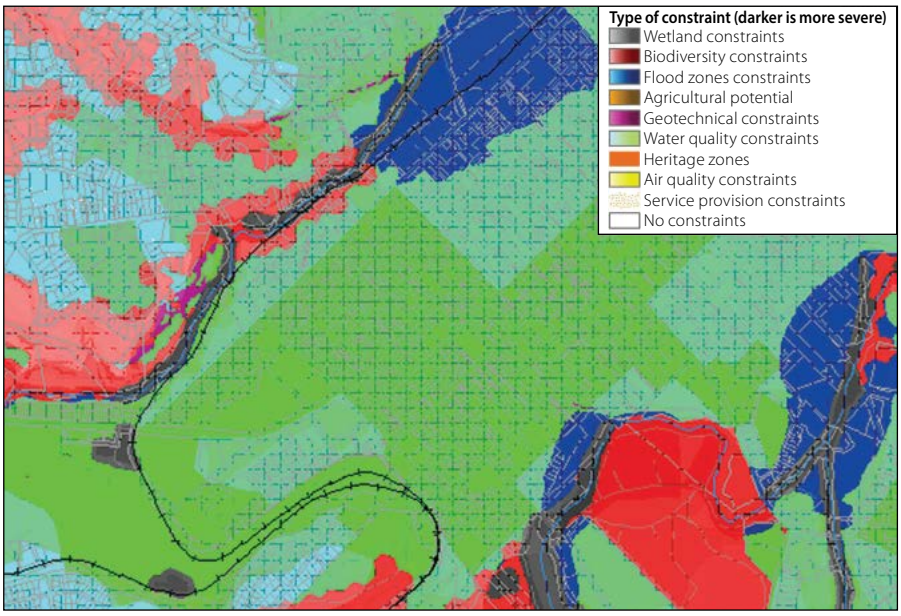
PHASE 1: SITE IDENTIFICATION

Generally, infrastructure development projects are undertaken in response to the need for services in an area. In some instances, site conditions are ideal for development, especially in more rural settings where developers have the luxury of sufficient space to suit their needs. However, suitable land for development in close proximity to city centres and built-up urban areas is usually limited. Various environmental factors impact on land suitability and constructability, which could range from geotechnical stability to areas set aside for conservation purposes.

It is therefore important to understand an area earmarked for development or infrastructure establishment, in the context of the environmental challenges and opportunities that exist in the area. By going through a process of elimination, suitable sites can be identified and assessed further. This can be achieved by spatially mapping the environmental opportunities and constraints of an area earmarked for development. Environmental opportunities can range from suitable soils to areas with a low environmental conservation significance. Environmental constraints, on the other hand, can include environmentally protected or regulated areas such as watercourses, municipal conservation areas, steep slopes and unsuitable soils – which are generally difficult to develop. The mapping which provides a spatial snapshot of potentially developable areas and no-go areas is called negative mapping.

This negative mapping exercise is commonly undertaken during the site selection process, but relies on the amount and quality of the mapping data available. A useful resource for these purposes is a comprehensive and up-to-date geospatial database of environmental constraints, which makes it possible to easily map less suitable areas and use them to plan proposed infrastructure layouts or linear alignments.

To build on existing information, the use of GIS, mobile-mapping and data visualisation facilitates the collection



An example of a screening map used to inform site and route selection, based on suitability from an environmental perspective

of spatial data. It allows the live upload of information gathered in the field for real-time access by the entire project team. This significantly reduces the time between the collection of the data and its use in informing project planning – also reducing the costs of data collection.

Without such hi-tech tools, it may only be discovered during the detailed design stage that an area is totally unsuitable for development due to environmental constraints. Changing designs at that point is likely to result in substantial additional costs and delays.

PHASE 2: PLANNING

Another valuable intervention is a review of legislated environmental requirements at the outset of a project, as this can often identify alternatives in the design that will avoid the need for environmental authorisation, permits or licences. South Africa's environmental legislation is largely dictated by thresholds and proximity to sensitive environmental features. Being aware of these sensitive features allows a project to find ways to avoid them and thus also avoid triggering the need for an Environmental Impact Assessment (EIA). A good starting point is to understand these thresholds so that they can be considered in the design. A screening of enviro-legal requirements by a qualified and experienced environmental scientist or practitioner is therefore crucial during the planning phase.

Obtaining environmental authorisation by undertaking an EIA can take anything from six to twelve months, with another four months for a final decision to be reached by the authorities. Careful planning can inform project designs and thresholds to the extent that an EIA process may not be required, which could lead to significant time and cost savings.

Even if an EIA is unavoidable, the screening of impacts allows developers to understand the environmental implications before committing substantially to a project. Screening allows many risk factors – such as fatal flaws, costly mitigation measures and no-go areas – to be identified during the concept or prefeasibility stage. The cost of required management measures can then be included in feasibility assessments. It also allows the EIA process to run in parallel with project planning so that it does not delay the project.

PHASE 3: DESIGN

In South Africa's National Development Plan 2030 (NDP), Sustainable Development Goals are used to inform national development policy and projects up to 2030. By implementing policies aimed at increasing sustainability, the development goals aim to eliminate poverty and reduce inequality (NDP 2030, p 1), thereby bringing about real change in the lives of all people living in South Africa.

The NDP also aligns with the United Nations Sustainable Development Goals and the global effort to make infrastructure, water and sanitation, urbanisation and cities more sustainable.

In keeping with these Sustainable Development Goals, the South African Water Research Commission (WRC) has produced the *South African Guidelines for Sustainable Drainage Systems* (SuDS). SuDS use ecosystem goods and services to replace traditional engineering at reduced cost. The guidelines set out the methods which can be used to create sustainable stormwater drainage design that is both functional and healthier for the environment. These approaches have practical limitations, such as requiring additional space. In some instances they may also have a higher initial cost, but in general cost less in the long term if measured by a life-cycle cost analysis; such an analysis would incorporate the cost or value added of the natural goods and services provided, as well as the long-term maintenance costs.

By leveraging the use of natural goods and services, the SuDS approach works to reduce costs, improve efficiencies and provide a more sustainable and holistic solution. Under the right conditions, it uses the natural abilities of plants and organisms within the soils and aquatic systems to dissipate energy, reduce erosion and clean water downstream – so that the costs to carry out these services are reduced or even removed completely.

A typical example of using SuDS to inform stormwater design is the creation of a constructed (engineered) wetland – an alternative approach to dealing with pre-development and post-development attenuation of storm flows, as well as a natural, aesthetic solution to water quality improvement. A constructed wetland can be incorporated into typical stormwater management plans as an attenuation facility to accommodate the obligatory 50-year design storm volumes.

Providing SuDS-based solutions typically requires an interdisciplinary approach, which facilitates the additional potential benefit of innovation on the boundary of disciplines, drawing on professionals such as civil engineers, environmental scientists, engineering geologists and geohydrologists – depending on the complexity of the project. An integrated approach that closely aligns the contribution of each specialist will typically yield an outcome that adds more value than just the sum of its parts. Such designs will tend to be the most reliable, cost-effective and sustainable.

Flora and fauna of rehabilitated grassland, offering a number of traditional infrastructure services such as stormwater attenuation and erosion control

PHASE 4: IMPLEMENTATION

Construction managers frequently experience cost overruns and delays as a result of misalignment between the design specification and actual construction. Similarly, non-compliance with environmental requirements – which results in delays and costly rehabilitation – results largely from contractors being unaware of these requirements or misunderstanding them. This is a real risk, given that environmental requirements are governed by multiple pieces of legislation, and requirements are specified by more than one authority. The requirements are therefore not always aligned, and in some instances seem to be contradictory.

For instance, a pipeline project may require environmental authorisation – in terms of the EIA Regulations GN R326 (2017) promulgated under the National Environmental Management Act (NEMA) of 1998 – and a water use licence in terms of the National Water Act of 1998. The former would have been granted by the Department of Environmental Affairs or their provincial equivalent, and the latter by the Department of Water and Sanitation. Either of these two sets of requirements may refer to further requirements, as detailed in a separate specialist report. It is easy to see how misunderstandings can arise.

To address this risk and improve compliance, an Environmental Implementation Plan (EIP) can be used as a site-specific implementation plan for project managers and contractors. The EIP – which differs from an environmental authorisation or Environmental Management Plan – breaks up the requirements into specific areas (particularly relevant for linear infrastructure) or specific activities. In this way, the EIP takes various requirements and integrates these with the project schedule.

The EIP allows a focus on just one part of a development, by presenting all the environmental requirements for just that part. During this process, inconsistencies and conflicts can be resolved through consultation with the various authorities and specialists. This would be done prior to construction, in order to avoid delays. The EIPs also aim to represent as much information as possible in maps, such as sensitive areas, which also makes it easier for a contractor to understand what is required. Design specifications can be integrated into the EIPs to further reduce the need to review multiple documents. A contractor can then review the requirements for a particular day at a glance, instead of needing to refer back to a number of lengthy documents.

As per the example above, it is possible for developers to consolidate the most applicable and important requirements of the environmental authorisation, the water use licence, any additional specialist requirements and the design specification for a specific section or activity in a larger project. Construction managers would then clearly understand their obligations for the following day's work, because they would be able to focus only on the requirements for that specific part of the project and not the entire project.

At a practical level, the EIP would outline on a map that the work for the following day includes the excavation of a wetland area – and would highlight specifically where the wetland boundaries and buffers occur, as well as the special measures required while excavating a wetland. These measures may include that the wetland must be dug by hand and the excavated soil must be stockpiled separately. It would also include the design drawings for the installation of a pipeline trench through the wetland – which would be different from the rest of the pipeline. The map would even identify a suitable

Natural water purification provided by wetlands

A manufactured wetland as part of a housing development, assisting the sewage treatment plant with water purification and providing stormwater attenuation from the houses and other hard surfaces

location for the stockpiling of the soil. A construction manager would then know that additional equipment for hand excavation is required – and even the design specification that 300 mm of concrete, for instance, would be required to encase the pipeline for 30 m.

It is our experience that when the requirements are laid out simply, are represented spatially and are better understood, compliance increases dramatically, rehabilitation costs reduce substantially and delays are minimised considerably.

CONCLUSION

The natural environment is an impressive self-cleaning and regulating system. By integrating the natural environment in all phases of infrastructure development, the natural environment can provide a basis for urban design strategies that can reduce infrastructure costs and project delays when systematically implemented.

Gertrude Stein (American writer/poet 1874–1946) once said the following: "Everybody gets so much information all day long that they lose their common sense." The approaches proposed in this article are just that – common sense. While there are a number of challenges in any infrastructure development project, by timeously incorporating environmental considerations at every stage of an infrastructure project, and by communicating the requirements in a clear and simple way, project performance can be improved and money can be saved.

This approach highlights the rules and provides a map of the playing field before requiring action from the players – offering a way to cut through the noise and to let common sense be heard. □