

Overcoming Design Waste with Clear Visualization of Green Infrastructure Design

Une meilleure efficacité du processus de conception par l'intermédiaire d'une meilleure visualisation pour les projets de techniques alternatives

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RÉSUMÉ

Cette présentation a pour but d'explorer les lacunes dans le processus de conception de techniques alternatives et comment les problématiques liées au dimensionnement de ces structures peuvent être compensées en utilisant des outils de visualisation clairs et complets sur l'ensemble des phases projets. Une étude de cas réalisée sur la ville de Houston (Texas, US) permettra d'illustrer l'utilisation de chaînes de traitement (assemblage de plusieurs techniques alternatives) et la comparaison de deux phases d'un projet de développement. Les débits, les volumes et les flux de polluants entre les phases avant et après développement seront utilisés pour illustrer cette approche. Cette étude de cas démontre une amélioration du processus de conception par l'intermédiaire de l'interconnexion entre les chaînes de traitements. Avec une meilleure visualisation du projet, il est donc possible d'augmenter l'atténuation des ruissellements urbains et l'abattage des polluants.

ABSTRACT

This presentation will explore gaps in the conventional Green Infrastructure design process and how these problems can be solved by utilizing clear visualization workflows and tools throughout the design process. A case study from the Houston Texas area will exhibit how this design scheme allows us to compare the pre-development site with post-development flows, volumes and pollution removal in order to demonstrate, in a quantifiable way, an effective treatment train approach to flow and pollution control. Further, it will show an immediate reduction in design waste by demonstrating the realistic connectivity of these treatment trains and how these can influence site planning and design. As a result of this clear visualization scheme, we are able to mitigate urban runoff and protect the water quality of the receiving waters in a way that is affordable now and in the future.

KEYWORDS

Green Infrastructure, Low Impact Development, stormwater, treatment train, water quality

1 GREEN INFRASTRUCTURE DESIGN

The array of benefits which come from implementing Green Stormwater Infrastructure (GSI) and Low Impact Design (LID) have been proven in practice over the past two decades and are largely understood by the greater water resources community (WEF, 2014). This approach to stormwater design is referred to in a number of different ways around the world. In France, "techniques alternatives en assainissement pluvial" is what is often described in the UK as Sustainable Drainage Systems (SuDS), in Australia as Water Sensitive Urban Design (WSUD) and in the United States and other countries referred to as Low Impact Development (LID). Essentially these all demonstrate a change to the way we value rainwater and a desire to use it to improve our urban environment.

Conventional GSI design techniques have generally focussed only on volume rather than the truly multiple-benefit approach that should also include water quality, amenity, biodiversity and other aspects. Many regions have standardized the design and quantification of GSI and LID, with the conventional approach borrowing heavily from early stormwater design procedures. The design requirements of these systems hinge principally on retention volume estimates and infiltration capacities i.e. First Flush or Water Quality runoff volume (New York State Stormwater Management Design Manual, 2014) which can be calculated by hand or with a spreadsheet based tool.

This approach assumes that the most concentrated pollutants will be captured in the small volume of water that makes up the initial runoff and focuses on sizing individual unconnected stormwater controls to retain the water quality volume. It does not always track pollutant concentrations and assumes that higher average recurrence interval (ARI) events will bypass these structures and be contained by 'traditional' stormwater drainage infrastructure.

2 GAPS IN CONVENTIONAL PRACTICES

When looking at the design-build-maintain lifecycle in its entirety, shortcomings or gaps in this conventional design approach can be seen to hold back the potential success of GSI designs. Simplified catchment delineation, overland flow path definition and independently designed and isolated stormwater controls are the by-product of this conventional design approach in part due to the lack of suitable tools available. When using spreadsheets and hand calculations it is often impractical if not impossible to include the effects of multiple connected systems. Therefore an assumption is made that the facilities are not-interconnected or simply put, water levels in one facility will not affect others. However, in practice, stormwater controls are rarely isolated within their systems. Real world GSI scenarios typically demand integrated, distributed GSI systems with holistic surface runoff management plans, which cannot be appropriately designed or implemented with conventional approaches.

Conventional spreadsheets and tools too often make it difficult to see what the end design will look like so it can be too easy for designed facilities to 'not fit' spatially in a proposed site plan due to the fact that CAD, GIS and Surface Data are not included. They may also not fit vertically such as not having enough drop to gravity drain to the stormwater system or have incorrectly set overflow levels. Being able to visually check the connectivity of pipes, channels and stormwater controls as well as outlet levels reducing the risk of construction issues arising and unnecessary design iterations.

3 SOLUTIONS BY FOCUSING ON CLEAR VISUALISATION OF DESIGN

The ability to visualize the integrated and holistic approach could provide easily-created, easy-to-understand and cost-effective designs which would benefit the designer and the designed system. All of the before mentioned solutions can be summed up by adhering to the following design tenets.

- Always work 'live' on project data (CAD, GIS, Surface) and be able to push any work to CAD or GIS
- Show not only where sustainable drainage system is located but why it works – by showing where the natural surface flows are, how much space it takes up on plan, that the levels of connected systems work in series (treatment train profiles, areas of flooding concern, result comparisons)
- Do not ignore connectivity and complexity – also include the detail of complex/cascading treatment systems. Excluding it can make it more difficult to get LID accepted, if it can't be visualized then going for the 'traditional' solution feels safe

Ultimately this will reduce the amount of treatment you need, number of design iterations and save site area which results directly in saving money.

4 CASE STUDY

The Montgomery County development is an approximately 967-acre master planned community in west central Montgomery County, TX. This case study analyzes Phase 1 of the masterplan which is 157 Acres. Phases 2 and 3 will also be developed along-side existing golf courses.

4.1 Case Study Aims

The aims of the case study were to develop and improve a residential site with no adverse hydrological impact in accordance with the criteria below:

- Mitigate developed condition runoff rates to pre-developed levels for 25 and 100 year ARI events
- Reduce pollutant runoff through use of distributed Green Stormwater Infrastructure
- Due to distributed infrastructure, reduce size of detention facility
- Assess viability of incorporation of Green Stormwater Infrastructure in comparison to traditional end-of-line detention

4.2 Case Study Methodology

A number of stages were undertaken as part of the case study.

4.2.1 Preliminary flow assessment

To identify the natural flow paths and ponding areas an initial quick assessment was undertaken. This allowed us to work with the natural channels that existed on site and avoid excessive earthworks as shown on Figure 1(Left).

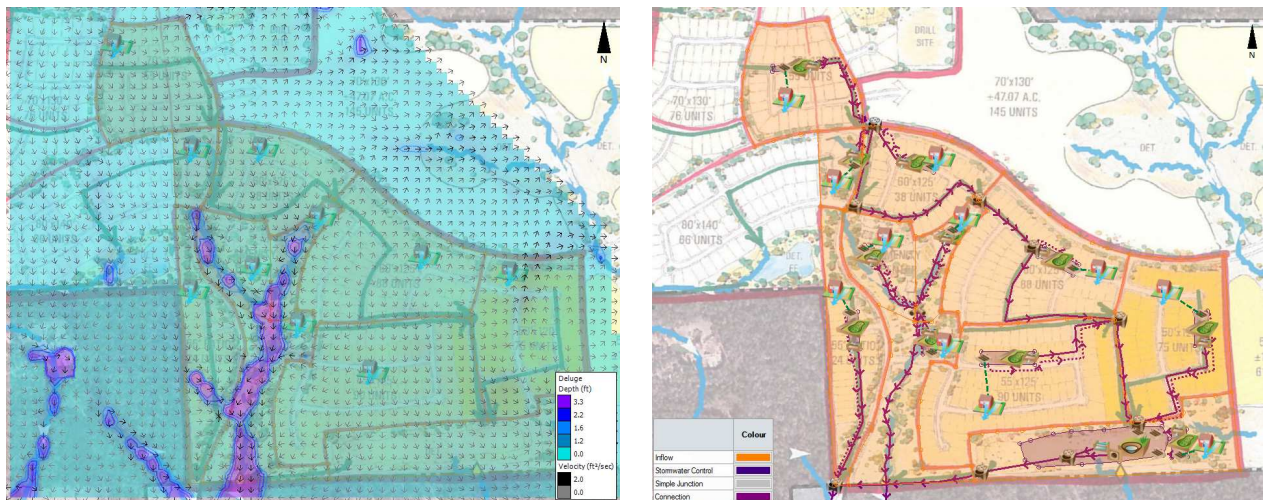


Figure 1 Left Initial "Deluge" Assessment showing flowpaths and ponding areas, Right, Initial Pipe Sizing Assessment showing Western "Valley" in purple and Eastern "Trunk" in grey

4.2.2 Rational Method and Pipe Sizing Assessment

The next initial phase calculation was to compare a pipe sizing assessment between developed and 'effective Green' scenarios. C values (lumped catchment runoff coefficient) were decreased and Tc (Time of Concentration) values were increased between scenarios in order to account for the preliminary impact of Green Stormwater Infrastructure over a traditional drainage on each catchment. This assessment was based on Rational flows and Mannings Eq. and demonstrated a reduction in the required pipe sizes shown for the 'effective Green' scenario which was justification for further investigation into mitigation efforts. The catchments and two main paths are shown in Figure 1 (Right).

4.2.3 Existing Runoff Plan

The existing runoff was calculated using SCS (Soil Conservation Society) runoff method based on 'park' landuses. This resulting in the following flows:

Table 1. Existing (pre-development) Site Runoff

Rainfall Event	Maximum Outflow
Water Quality event (WQe) - typically 3 month ARI	48.7 cfs (cubic feet per second)
25 year ARI	120.9 cfs
100 year ARI	156.0 cfs

4.2.4 Developed scenario – Typical Drainage Plan

In the typical drainage plan scenario the Eastern 'Trunk' system is to be attenuated by a basin with the Western 'Valley' to leave the site untreated due to site constraints. Extra treatment of other site areas will be required to compensate. This resulted in a pond of 6.7 acres, two outfall pipes and a high flow weir from the pond to meet the existing site runoff requirements.

4.2.5 Developed Scenario – LID Plan

In the LID based plan a distributed Green Stormwater Infrastructure approach was taken with a Raingarden for each neighborhood catchment. Due to the high intensity nature of rainfall events in the Houston area, bypass was required for the higher ARI events to avoid wash out occurring. By including raingardens the final basin was 1.2 acres smaller than the typical drainage plan scenario. It was also possible to direct all flows to a single outfall pipe. Further pollutant analysis is possible but was beyond the scope of this exercise and will be analysed at a later date. A comparison of flows is shown below:

Table 2. Comparison of flows for Existing, Developed (Typical Drainage Plan) and LID Scenarios

WQe - typically 3 month ARI	Max Outflow
Existing	48.7 cfs
Developed	35.1 cfs
LID	5.7 cfs
100 year ARI	
Existing	156.0 cfs
Developed	136.9 cfs
LID	113.8 cfs

4.3 Case Study Conclusions

This type of analysis may have typically required may separate tools that were linked together however in utilizing the XPDRAINAGE tool it was possible to go from initial site analysis, through concept design to detailed design in one process. The drag and drop placement of elements and easy incorporation of GIS, Surface, and CAD reference data made it easy to visualize and communicate the project quickly and effectively. The end result was a plan that demonstrated that taking an LID approach can reduce the overall runoff rates and the size of storage required.

LIST OF REFERENCES

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