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CSOs and Landscape as Infrastructure in Troy, NY

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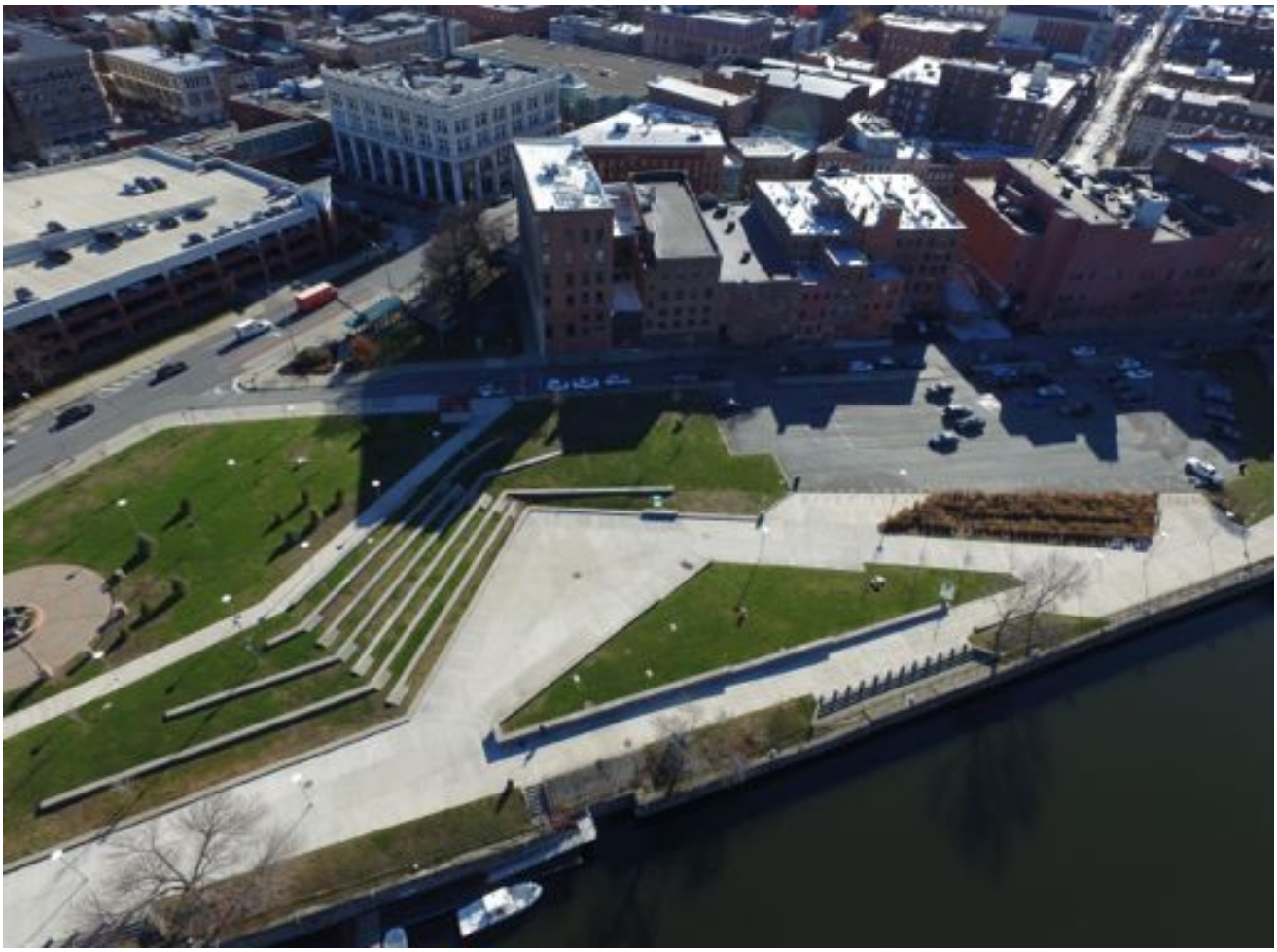

Riverfront Park in downtown Troy; three separate CSO outfalls surface here at the edge of the park and dump into the Hudson.

Abstract

This report describes the combined sewer overflow (CSO) infrastructure of Troy, NY as a landscape at four different scales. It is intended to allow for a more integrated understanding of the problem of combined sewer overflows in the Capital Region generally, and Troy specifically, as identified in the Long Term Control Plan (LTCP) of the NYS DEC. In

particular, it includes the role of public space, hydrography, soil type, tidal change, topography, and forest cover alongside the plumbing of the city. By collecting, producing and analyzing spatial data we draw conclusions about the relations between water quality, land use, and public space.

The study concludes that the waterfront and historic area ("River City") should not a primary strategic zone for green infrastructures that focus on stormwater detention, but should instead focus on social cohesion and identity, flood prevention, and access to the river. The role of the steep "Forest City" running north-south on the steep topographic areas could be protected as habitat and recreation space to preserve current infiltration and detention performance. The suburban and rural areas on the "High City" should in most cases be the areas targeted for detention and retention of stormwater because of their infiltration potential.

Four Summary Points of Interest

· The CSO problem of municipalities along the Hudson operates on four spatial scales: estuary, city, sub-sewershed, site

· Detaining stormwater is not always the most important form of green infrastructure to combat combined sewer overflows; flood prevention and environmental literacy related to the CSO problem through access to and use of the river itself may be prioritized in some situations, such as near the waterfront.

· New *types* of green infrastructure need to be developed in order to address this (most contemporary forms of green infrastructure are some type of detention structure or basin).

· The suburban zones of the city of Troy, located above the bluff, are one of three main landscapes in the city (the others being the river city, and the forest belt on the steep bluff itself). The suburban zones hold high infiltration potential and may be prime places for integrating stormwater detention green infrastructures.

Keywords
Combined sewer overflows, green infrastructure, spatial mapping, landscape infrastructure, urban morphology

Introduction

This research proposes that space is the final frontier in green infrastructure. Understanding how the spatial distribution of green infrastructures affects performance across scales of the landscape is critical for effective implementation.

Combined Sewer Outfall (CSO) overflows can happen for many reasons including a blockage or lack of maintenance in the municipal interceptor pipe. Complex jurisdictional overlays in Troy, NY– where interceptor pipes are controlled by the county, collector pipes by the municipality, and regulator structures are split between entities– lead to some dry-weather overflows. The maintenance and repair of these structures has been subject of an ongoing effort of the municipality in Troy. Because of this effort, CSO overflow occurrences that are described in the Albany Pool Region Long Term CSO Control Plan are well accounted for by amount and duration of rain events in the sewer-watershed[1] which has implications for climate change planning and adaptation[2].

Efforts to reduce CSO overflows are underway in the Capital Area with a focus on Green Infrastructure strategies such as surface detention, alongside traditional grey infrastructure strategies including upgrades to pumping stations and maintenance of control structures. A primary complication to widespread effective implementation of these and other strategies is related to space and scale. The interrelationships between sewer system performance, rain events, and water quality of the Hudson River are poorly understood. This is because they exist at and operate on different, discrete scales.

[1] A. Mailhot et al. Relationships between Rainfall and Combined Sewer Overflow (CSO) Occurrences. *Journal of Hydrology 523* (2015) 602-609

[2] C. Fortier and A. Mailhot, Climate Change Impact on Combined Sewer Overflows, *Journal of Water Resources Planning and Management 141(5)*, (2015), 04014073.

Results & Discussion

The Estuary

Water quality is a primary concern on the Hudson River Estuary, and the Capital Region has some of the worst conditions due to a concentration of CSO inputs together with limited tidal flushing as compared to downstream situations, despite the massive elevation changes of the river due to tidal action. In addition, access to the river in the Capital Region is nearly non-existent, and so the problem tends to stay removed from the concerns of the daily life of citizens.

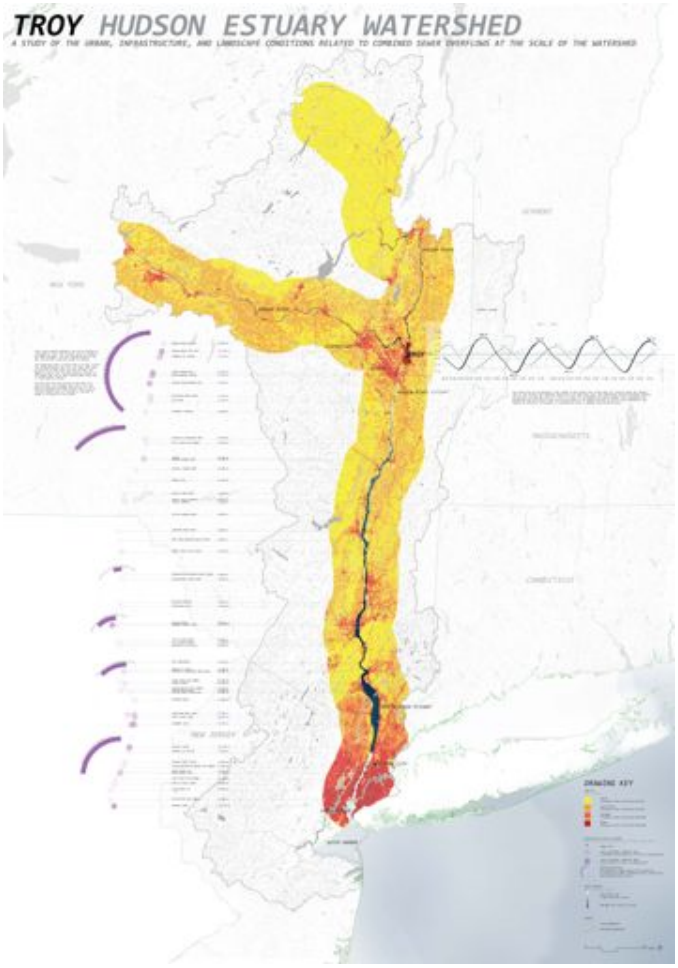

Figure 1 (see appendix for enlarged version)

The City

The City of Troy manages its sewer system together with surrounding municipalities through the Rensselaer County Sewer District No. 1 Facilities. As part of the Long Term Control Plan, upgrades have either been

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planned or implemented to interceptor pumping stations and the wastewater treatment facility. Green infrastructures are seen by the state-level Department of Environmental Conservation as a way to further augment this system and improve the water quality of the Hudson[3]. However, to date, it is still unclear where the most effective use of green infrastructure would be, what form it should take, and what its specific role would be in the context of the Capital Region.

This map demonstrates that in addition to detaining surface water in order to minimize combined sewer volume during storm events, two critical dynamics have a direct relation to the problem– flood zones and public access to the river. The problem of flood zones can become an acute public health issue when water quality is a problem and people live or work in these areas. This is because flooding is often accompanied by combined sewer overflows, which usually contain organic and inorganic contaminants harmful to human health[4].

This map (Figure 2) shows that there are several areas within the city that are prone to flooding despite the large sea wall along most of the river's edge. Second, the current configuration of the sea wall itself, together with the now-abandoned industrial uses at that same edge mean that public access to the river is dramatically cut off. This largely eliminates the river as a community recreational resource and place of gathering, and route of pedestrian, boat, and bicycle circulation for the city of Troy, and destroys the typical gradient between land and water needed to have riparian ecotones. Green Infrastructure projects may have the unique capacity to take on a different form in these zones and become less about stormwater detention and more about community access, creating resilient habitats, and providing flood protection for the community.

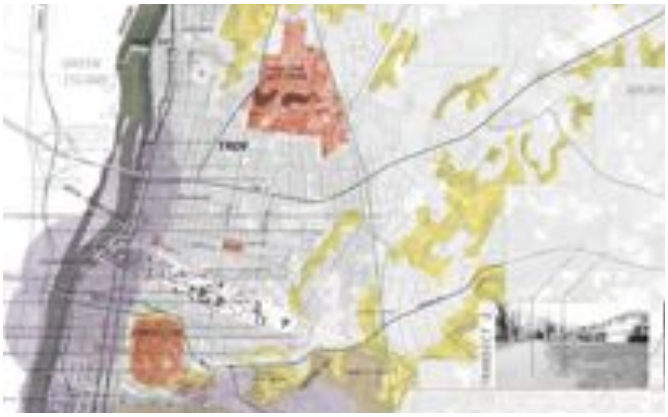

Figure 2 (enlargement; see Appendix for full map at enlarged scale)

The Sub-Sewershed

Through an analysis of the spatial information and CSO performance data at the city scale three different sub-sewersheds and their respective outfalls were chosen as broadly representative of the range of conditions related to CSO performance and urban morphology in Troy. This scale of analysis enables a better understanding of the relationship between urban form, landscape structure, and sewer infrastructure performance (especially overflow events).

In the suburban zones, Transect One (see Figure 3), for instance, shows much broader streets, less forest and more specimen trees, and more drain inlets going directly to the CSO system than Transects Two (see Figure 4) and Three (see appendix). Transect one also has a much higher severity of outfall events (number, duration, and volume divided by sub-sewershed area). The infiltration potential analysis demonstrates that the suburban zones are also primary areas for infiltrating stormwater, due to slope, soil type, and land cover. This scale of mapping suggests that public and private lands in the suburban periphery are primary areas for green infrastructure projects for the purposes of detention.

[3] NYSDEC, Green Infrastructure Planning in the Hudson Valley, http://www.dec.ny.gov/lands/70657.html, accessed June 1, 2016.

[4] J. Gasperi et al, Priority pollutants in wastewater and combined sewer overflow. *Science of the Total Environment 407* (2008) 263-272.

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The infiltration potential and overall landscape structure of the three main zones of the city is better understood, but it is still unclear where green infrastructure would be most effective because the storage capacity of the sewer network itself (mainly, the underground pipes), and the spatial distribution of that capacity, is poorly understood. We have tried to map this network using urban design visualization tools to visualize the pipes at the same scale as landscape structure and urban form (see Figure 5). However, a great deal more data would be needed in order to be confident that the representation is accurate. While these correlations are not conclusive, they allow for informed analysis and offer directions for future work, such as focusing detention green infrastructures in the suburbs, and green infrastructures that provide social access to the Hudson and its tributaries in the city.

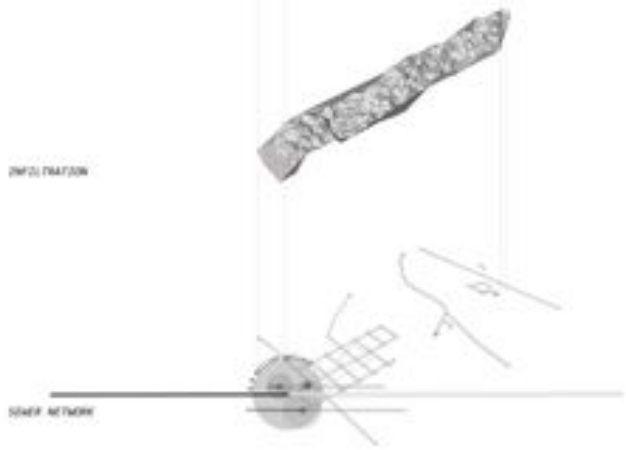

Figure 3. Transect 1 (See appendix for enlargement)

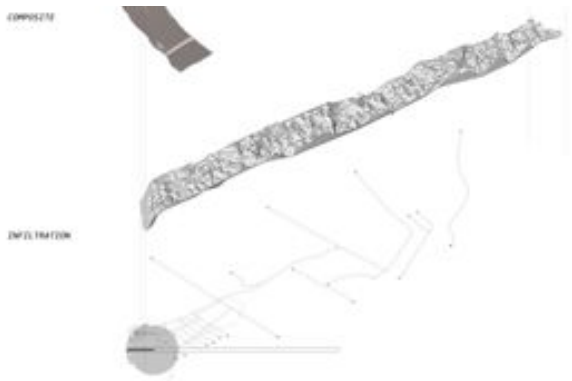

Figure 4. Transect 2 (See appendix for enlargement)

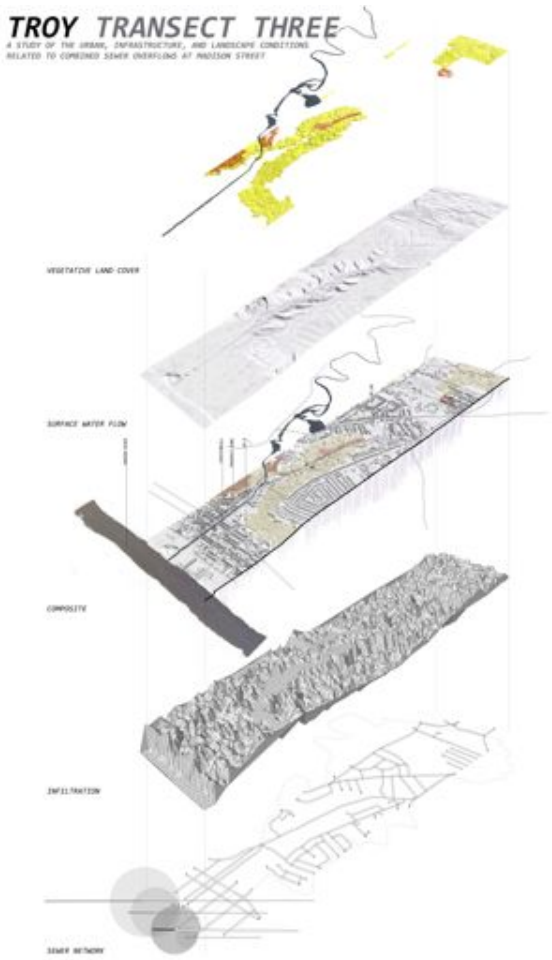

Figure 5. Transect 3 (see appendix for enlargement)

The Sites

The question of community access and cultural significance is an important consideration for green infrastructure strategies and the larger goals of combating the CSO problem in the Capital Region because of the need for ongoing maintenance, awareness, and acceptance. Because of this it is important to understand the places where these projects might land, or might be most visible, as *sites*, rather than as simply nodes or objects in a larger system. The investments needed to construct these projects as sites can be costly, but can also return tremendous value when strategically chosen for visibility, social significance, and potential impact on ecological health and infrastructure performance. The set of site maps combines aerial photos of the dry and (when possible) wet outfall locations (see Figure 8),

together with the surrounding urban situation. When combined with the larger scale maps, this level of analysis enables consideration of existing site conditions and surrounding context, accounting for topography, vegetation, existing structures, the patterns of use and preferences of local residents and visitors.

The selection of the three representative outfall locations from the transects focuses on the waterfront. Generally these sites have the potential for providing river access (see Figure 7), they have the potential to become riparian zones (where aquatic and terrestrial ecosystems intermingle), and they are most directly affected by overflow events. In addition, through the design of *new green infrastructure types* they may be able to actually ameliorate the effects of overflow events themselves. The analysis of these sites makes clear that Troy's waterfront is ripe for a long-term redesign projects, conceptualized along the lines of green-and-blue infrastructure.

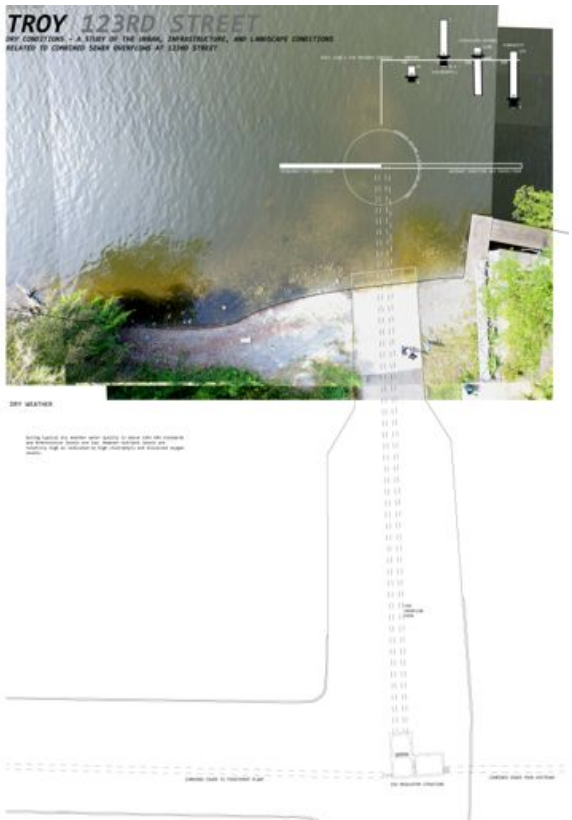

Figure 6. 123rd Street during dry conditions

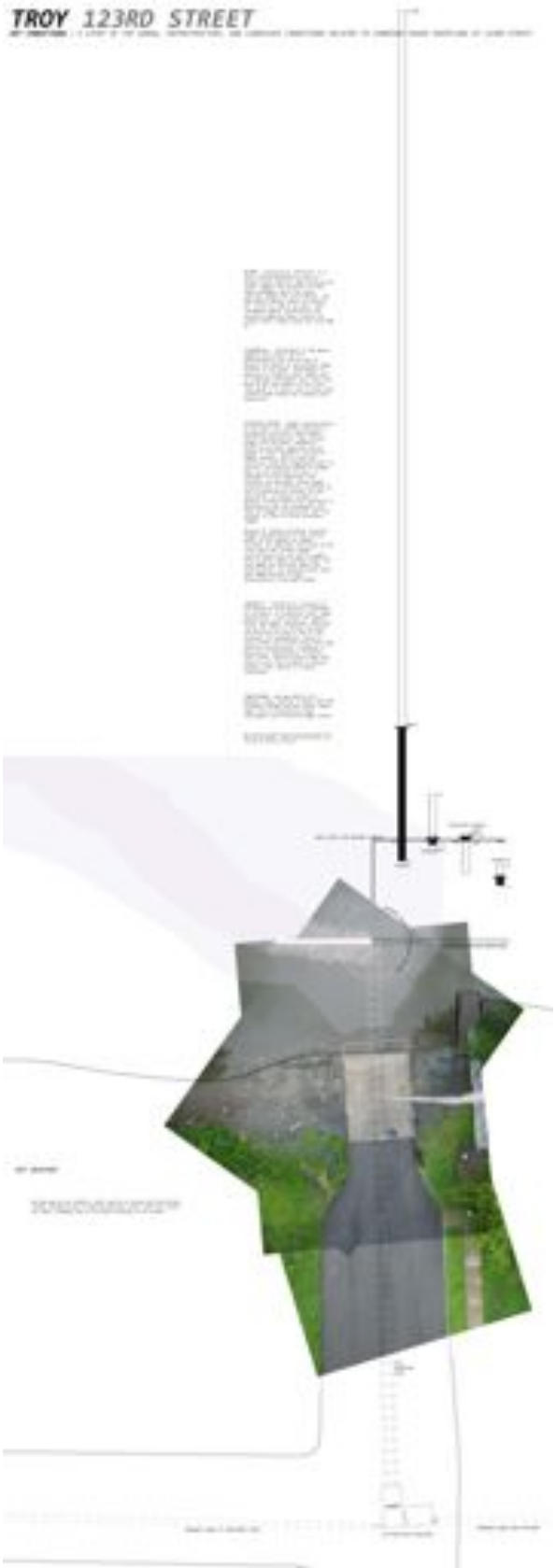

Figure 7. 123rd Street during wet conditions.

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Policy and Practical Implications

This research suggests one major policy implication: green infrastructures need to be designed in conjunction with the overall landscape structure and urban morphology. Currently, most green infrastructures (bioswales, detention and retention basins, rain gardens, rain barrels, treatment wetlands, etc) relate to the detention of stormwater and the treatment of contaminated stormwater and effluent. These are often pushed as a general strategy. However, they are most effective and socially appropriate only in certain areas, such as where soils and land cover and slope allow for high infiltration potential.

One conclusion is that new types of green infrastructure need to be developed. Most green infrastructure is related to low-impact development guidelines developed in the 1970s and is focused on stormwater, typically taking the form of creating basins. The retention pond in the suburban development from Transect One is a prime example of this. One new strategy might be to create new types of landscapes that focus on producing articulated surfaces that can guide the flow of water while producing habitat gradients. Another possibility is that a new type of waterfront could be designed and implemented over a long time scale. Troy's waterfront was remade during the 19th century for industrial shipping and flood control. Reshaping this edge to create habitat and allow for recreational access in key areas might be a way to create an infrastructure that serves as a membrane between overflow effluent and the Hudson, while reknitting the city to its river.

Lastly, design quality– specifically non-quantifiable, value-oriented design choices that provide a framework for situating and choosing among various alternatives within performance parameters– may be a necessary and little-discussed method for integration into existing and future communities that will help build the political will and social capital necessary to maintain and adapt these infrastructures over time.

Methods

The methods employed in this study focused on spatial mapping using a landscape approach. First, a boundary was described that attempted to encompass the entire landscape pertaining to the combined sewer system of Rensselaer County Sewer District No. 1. Next, all of the objects and their relations (including macro dynamics) that are a part of this network were mapped together. This necessitated working at four different scales, and pulling data sets from many sources that are traditionally separated from one another. As part of this mapping a three-dimensional landscape model was created (see the transects, in the appendix) where the different layers of landscape structure and performance could be visualized and analyzed given to establish performance parameters such as infiltration potential. While neither completely comprehensive nor conclusive, the maps allow for new types of conclusions to be inferred, connections between seemingly unrelated phenomena to be made (such as urban form and sewer performance), and provide a robust foundation that can be combined with other types of analysis (such as chemical water quality data, or demographic information, or user preferences) to make specific decisions related to the problems of combined sewer overflows and green infrastructure in Troy.

Outreach Comments

Outreach efforts for this project have included:

Dan Shapley, Hudson Riverkeeper, Water Quality Program Manager
Martin Daley, Capital District Regional Planning Commission, Environmental Planner
Barbara Nelson and Chico Christopher, Troy Architecture Project, Director and Project Manager
John Johanson, Troy Urban Trails Project
Emily Vail, NYS DEC
Chris Wheland, City of Troy, Sewer Authority

Communication with this group will continue in the third and final year of this stage of the project. One of

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the goals will be to organize a project group that can prepare funding applications to continue the work and begin to search for ways to implement a key pilot project in the future by working with local officials and community members and groups.

Student Training

Three graduate students were trained in fieldwork, mapping, computation, data visualization, and landscape analysis through this work.

Additional final reports related to water resource infrastructure research are available at http://wri.cals.cornell.edu/research-reports

References

See footnotes

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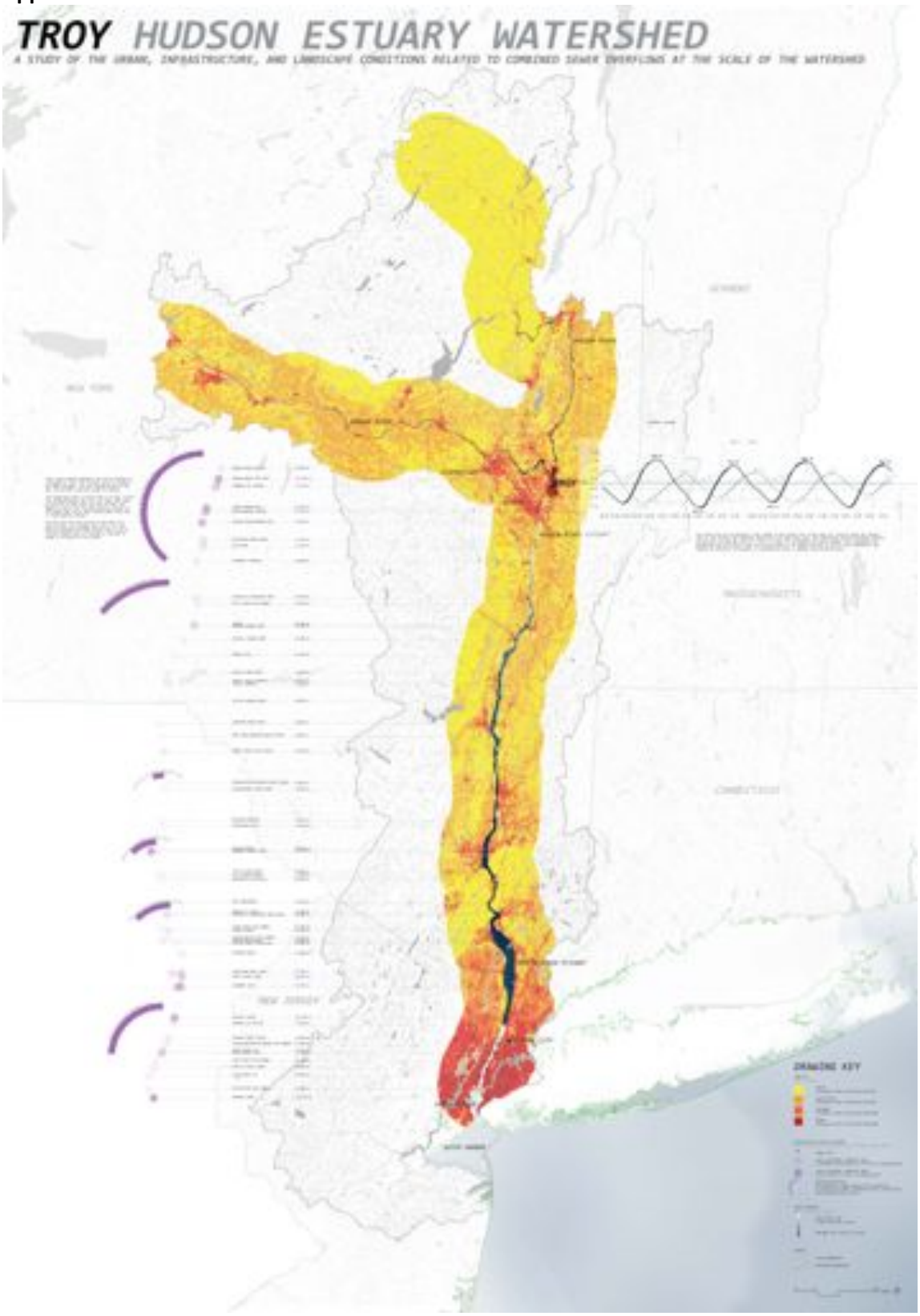
Appendix



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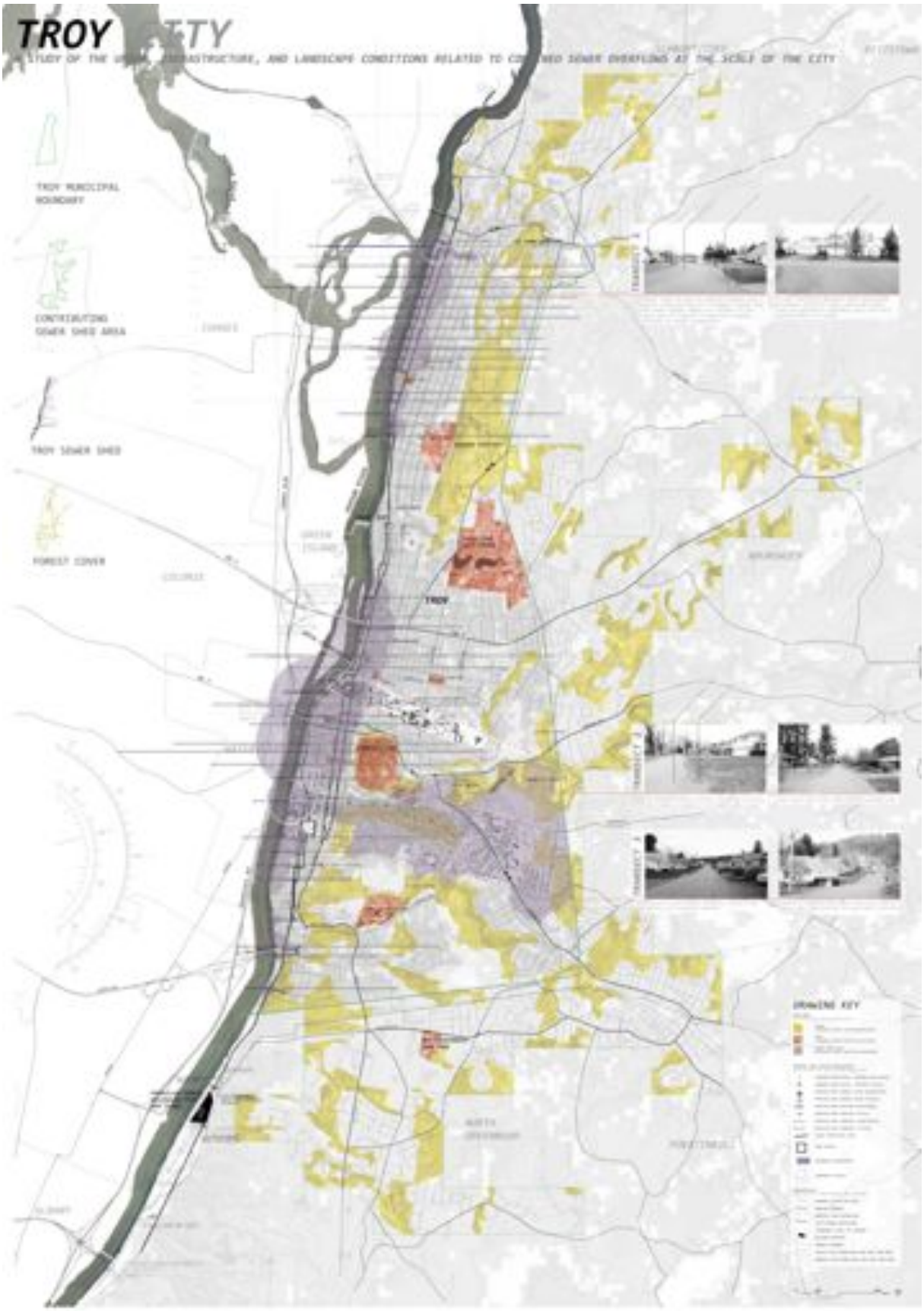

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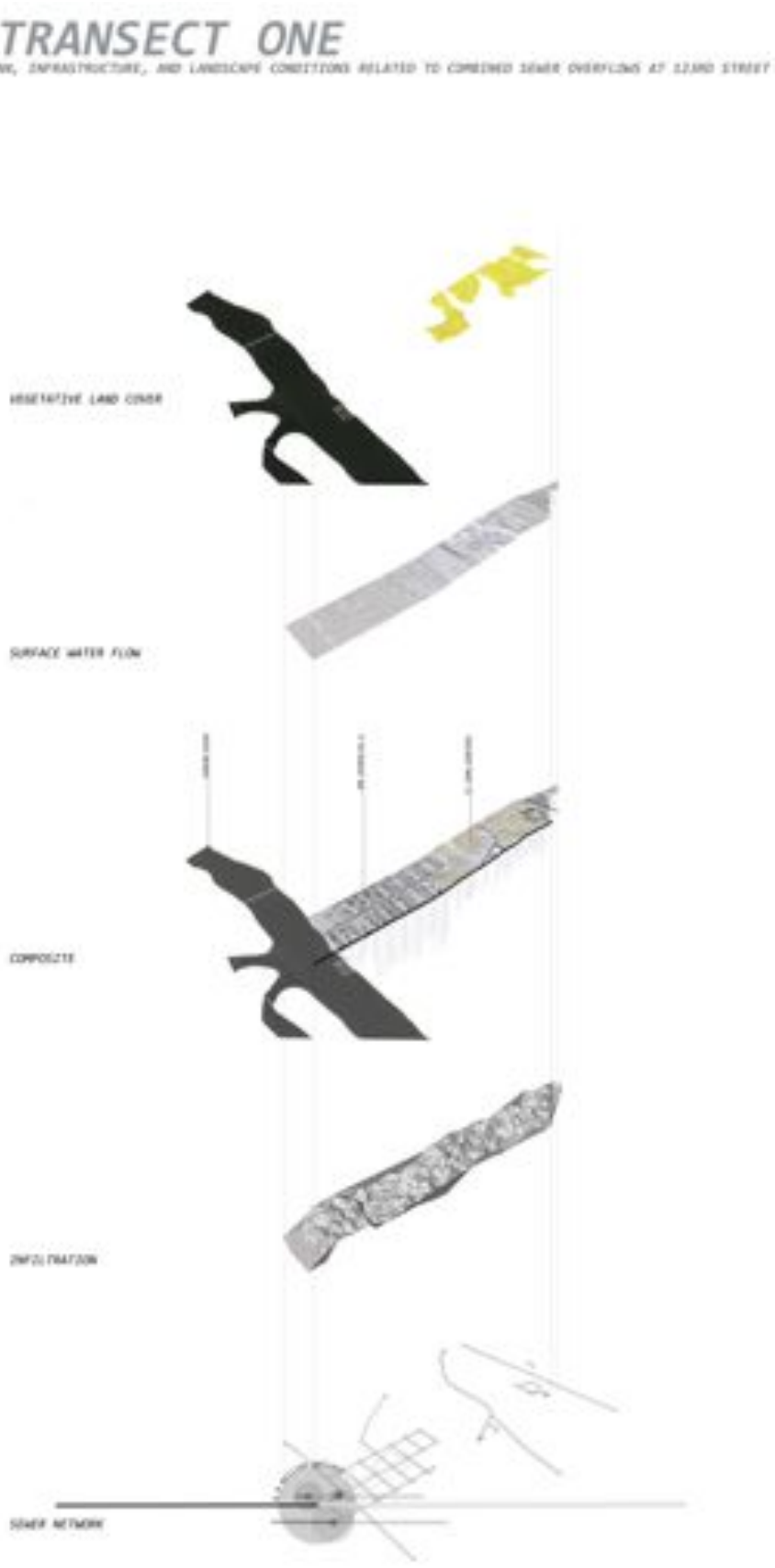

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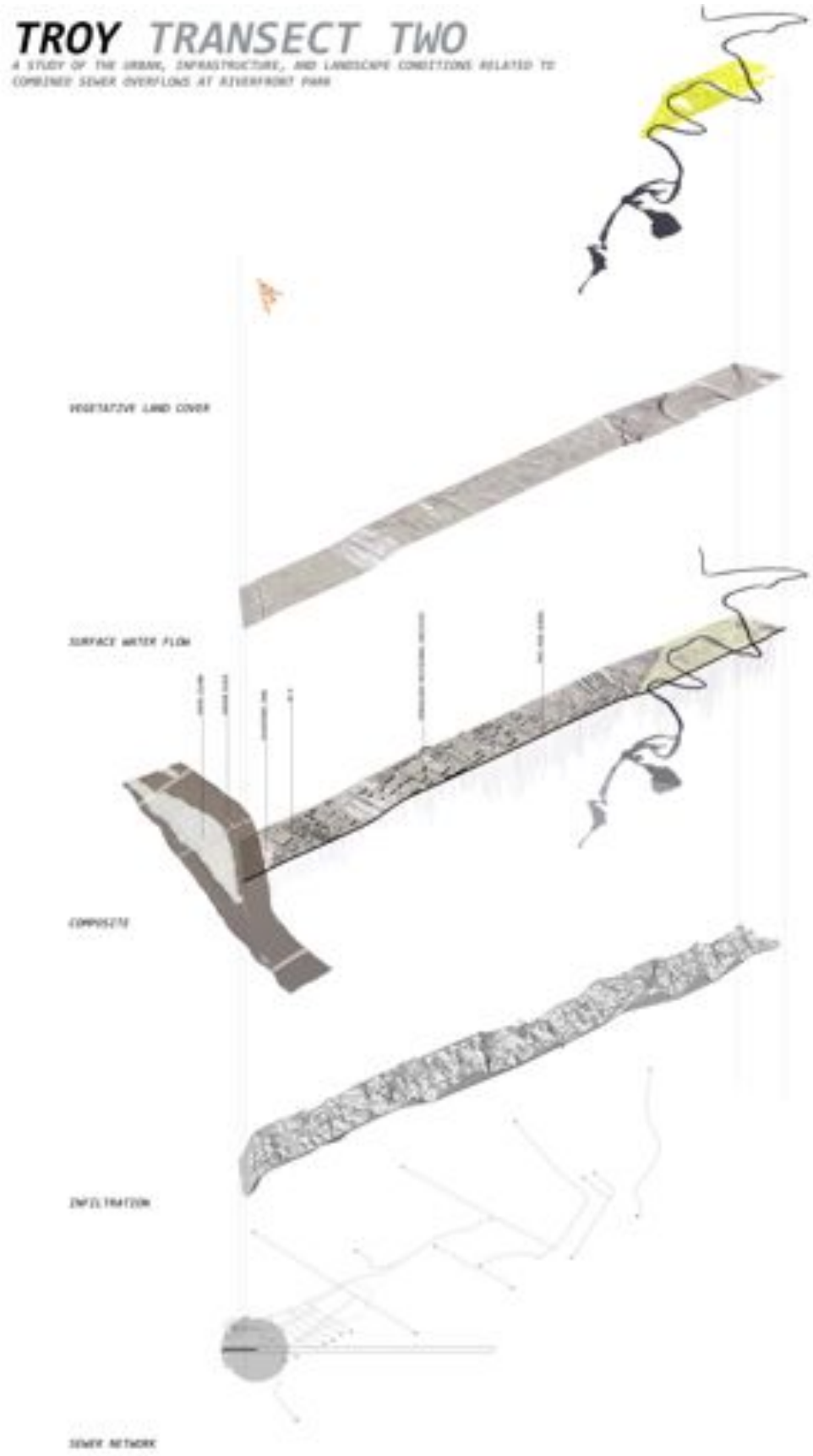

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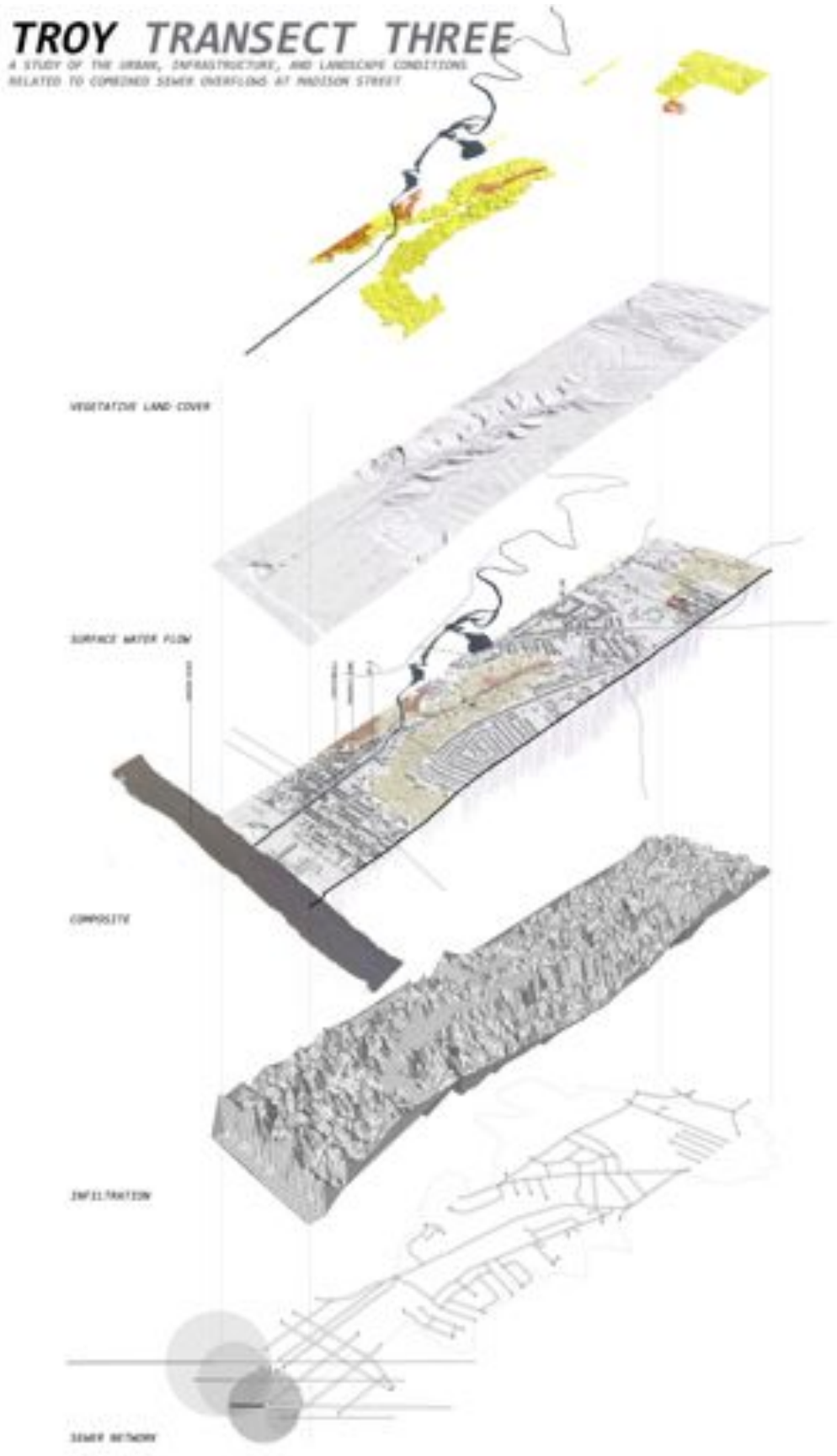

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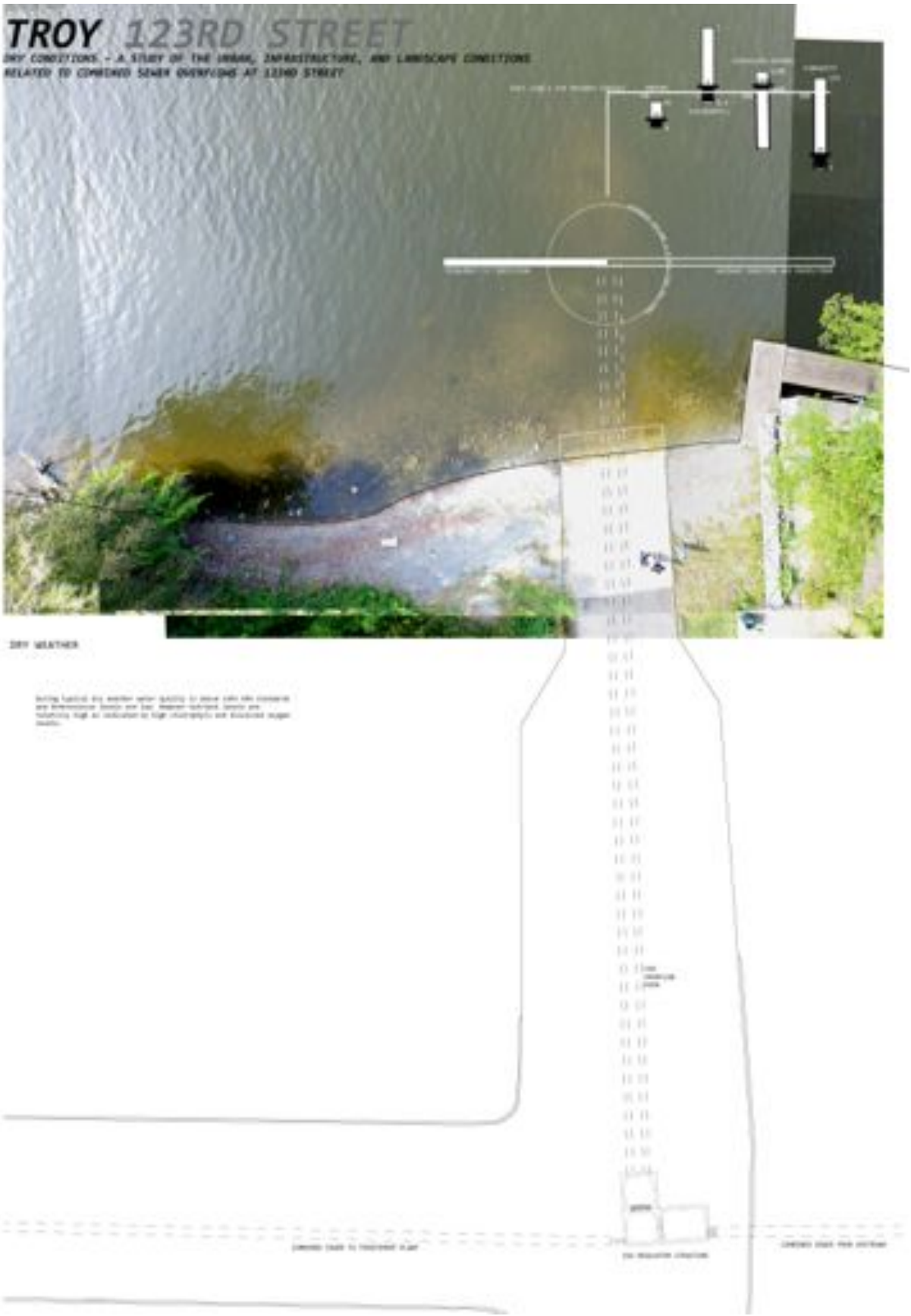

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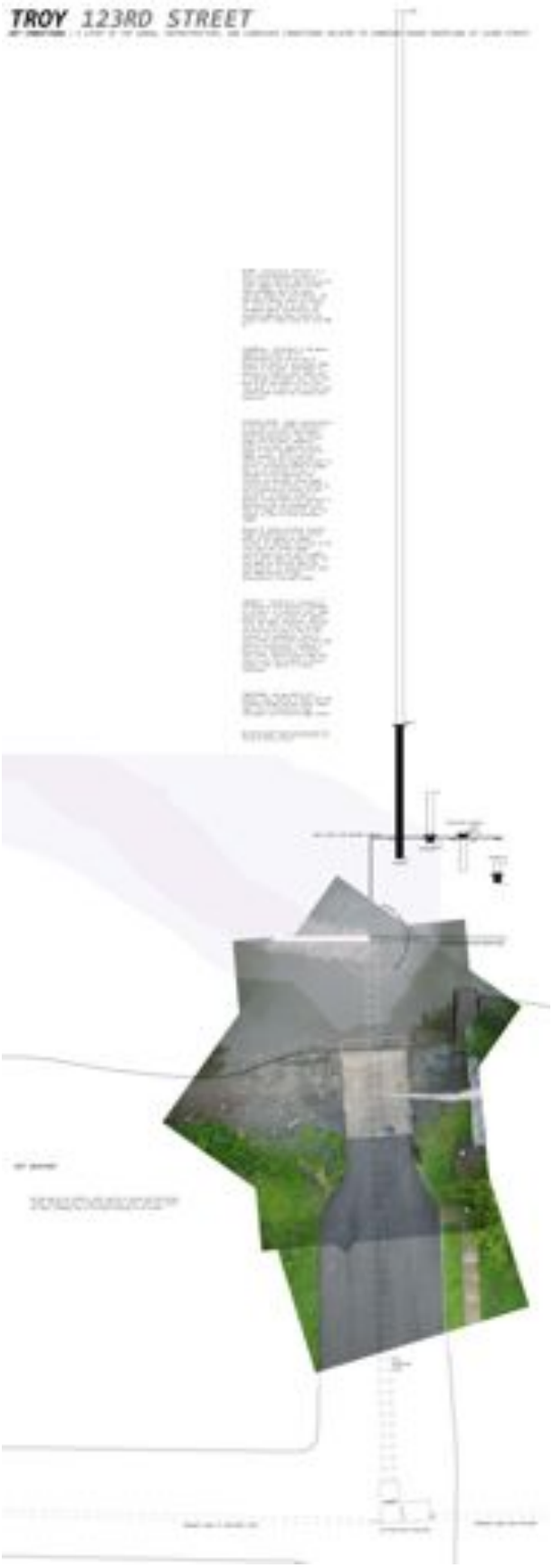

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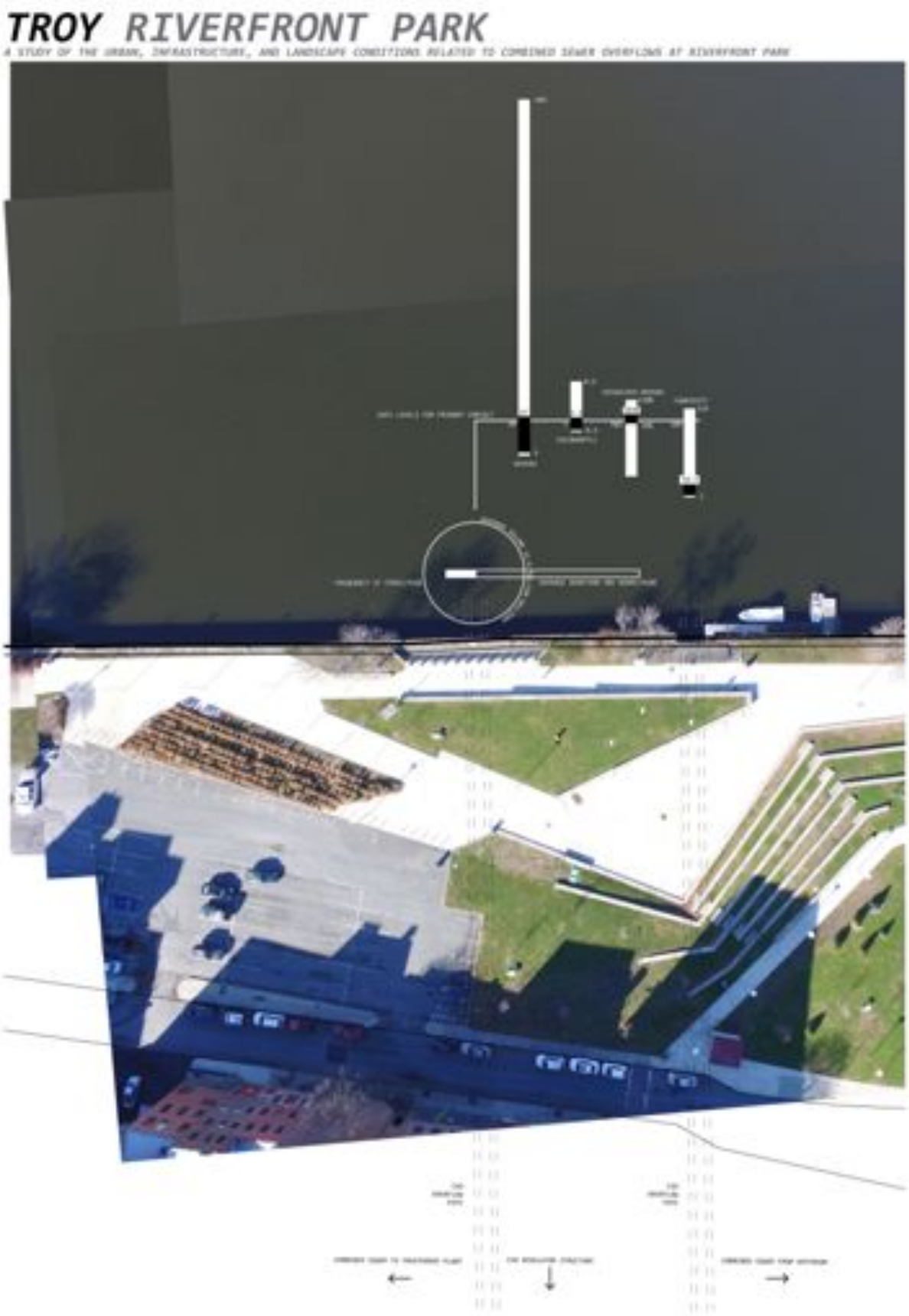

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