Spatial Storytelling Through Augmented Reality:

Toronto's Water and the Technocene

by
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Master of Architecture

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

This thesis utilizes augmented reality to illustrate visual and spatial stories of the Technocene regarding water in Toronto. The thesis begins by studying the etymology of the Technocene, and it establishes the need for storytelling through this definition. The thesis then assesses different visual storytelling methods to conclude that Augmented Reality(AR) is a practical approach when discussing the Technocene. After determining the need for Augmented reality, the various techniques and technologies of performing Augmented Reality are evaluated to create a technological foundation before designing the stories. The stories of water are then researched and developed into an AR experience by using the criteria to tell a situated and pedagogical story of the Technocene.

Throughout the development of the thesis, a criteria system was developed to help guide the design of the outcome for the thesis. Starting with pedagogical storytelling, the thesis utilizes the criteria to review existing research on situated storytelling and formulate a guideline for situated urban storytelling. These metrics are used to review visual storytelling mediums. Derivatives of these two metrics are also used in literature reviews of AR software to help guide the types of AR technologies and software used in designing the thesis. Finally, to assess the designed stories, all of the developed criteria are used to help explore AR opportunities for this thesis.

Toronto and its stories of water were chosen for their significance in terms of culture, ecosystem, and geography. Technocene is a multilayered framework that incorporates technology driven by social activities or issues to understand which environmental outcomes are induced by such activity. To visualize these stories, the site had to be an environment that has undergone dense urban growth to easily locate elements of the Technocene. Toronto has abundant city infrastructure and buildings built of engineered materials, being an appropriate site to spawn these stories. Four specific stories of lost rivers, porosity, flooding, and naturalization were chosen because of water's crucial role in the ecosystem and the geographical abundance of water in Toronto.

Acknowledgements

I want to thank my supervisor, Maya Przybylski, for providing me with clear and thoughtful guidance throughout the development of the thesis. Your guidance was crucial in directing my thesis in the right direction. I would also like to thank my committee member, Linda Zhang, for her insights and feedback, which significantly contributed to this work.

I want to thank my friends and classmates for always having a great time working together. It was indeed a memory to treasure for a long time. I thank them also for the numerous feedback and insights they have provided me throughout this journey.

I would also like to thank my family and loved one, for their constant support and love they have provided me with.

Lastly, I would like to acknowledge that this thesis was written and worked on the traditional territory of the Neutral, Anishnaabeg, and Haudenosaunee peoples. Where I have spent most of my time during this thesis, the Waterloo campus is situated on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River. The location of this thesis is the traditional territory of the Mississaugas of the Credit, Chippewa, the Wendat, the Anishnabeg, and the Haudenosaunee peoples. This thesis takes place in Toronto, where its name derives from the Mohawk word Tkaronto, which means the place in the water where the trees stand. Oak savannahs have existed throughout Tkaronto, providing and nurturing indigenous communities with shelter and nourishment. However, rivers like Garrison Creek and marshlands like the Ashbridges Bay Marsh have been subject to colonization. Turned into sewers and industrial lands, it is essential to acknowledge the stories of Tkaronto's water. Considering the geographical and taxonomical context and the stories discussed in this thesis, it is crucial to recognize the traditional waterways, indigenous rights to their water, and the traditional caretakers of Toronto's waters, land, and air.

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Chapter 1

Technocene

This chapter analyzes the terminology of the Technocene and the need for storytelling through augmented reality to create a spatial understanding of the Technocene. This chapter begins by analyzing the current research concerning the Technocene and researching examples and keywords that help situate the concept of the Technocene. The chapter derives a suitable storytelling method through literature reviews on location-based storytelling methods. These reviews establish the appropriateness of situated urban storytelling for delivering Technocene narratives in Toronto. Due to the significant use of visual media in situated urban storytelling, the chapter reviews existing efforts in visualizing complex frameworks like the Technocene. These existing visualization methods include speculative architectural drawing, photography, and film. These visualization methods are evaluated in terms of their benefits and limitations to create a critical framework that a visual story of the Technocene should entail. Using these criteria, the thesis analyzes the opportunities for augmented reality to fulfill the prerequisites of telling a visually situated urban story in the context of the Technocene.

1.1 Defining the Technocene

The Technocene is a novel framework for better understanding the current epoch. However, it may be difficult to grasp because it is a multi-layered and complex framework consisting of social drivers, the technologies being used, and the related implications on the environment. This section will explore different scholars' existing definitions of the Technocene and condense these definitions for this thesis.

Technocene is proposed as an alternative narrative to the Anthropocene in depicting the current ecological and geological period. Various scholars, including Alf Hornborg,[1] Herminio Martins,[2] Oliver López-Corona,[3] and Emanuele Giorgi,[4] have been developing a framework to more appropriately depict the current ecological and geological period over the last decade. Each of their respective theories will be assessed to formulate a definition for this thesis.

1. Hornborg, Alf. "The Political Ecology of the Technocene." In The Anthropocene and the Global Environmental Crisis, edited by Clive Hamilton, Christophe Bonneuil, and François Gemenne, 1st ed., 57–69. Routledge. 2015. https://doi.org/10.4324/9781315743424-5.
2. Martins, Hermínio, et al. "The Technocene: Reflections on Bodies, Minds and Markets." 2018. London: Anthem press.
3. Lopez-Corona, Oliver, et al. "The Rise of the Technobionts: Toward a New Ontology to Understand Current Planetary Crisis." 2019.
4. Giorgi, Emanuele. "The Co-Housing Phenomenon: Environmental Alliance in Times of Changes." The Urban Book Series. Cham: Springer International Publishing. 2020. https://doi.org/10.1007/978-3-030-37097-8.

According to Alf Hornborg, the the widely recieved "Anthropocene narrative" claims that human activities are the cause to climate change, and that these activities are innate features in the nature of the human species.[5] However, Hornborg argues that the Anthropocene narrative fails to wholistically contemplate this epoque because societal and political drivers are merely seen as natural features to humans, not as a seperate entity. The Anthropocene narrative lacks in explaining the power balances within different social categories and their respective "repercussions of industrialization."[6] Therefore, to assess and contemplate social phenomena, Hornborg explains that a new framework that is beyond "natural science" is required.[7] Hornborg concludes that the Technocene is a more appropriate description of the geological epoch since the late eighteenth century because "Modern technology […] implicates biophysical and socio-cultural dimensions."[8]

Herminio Martins explores the concept of the Technocene in the context of the physical human body and the "changes in social institutions that educate, employ, control, regulate and order our lives."[9] He explains that the "impact on the atmosphere of carbon dioxide emissions since the mid-eighteenth century" is more related to "technological agency than with the psychophysiological make-up of Homo sapiens sapiens."[10] An addition that Martins makes different from Horborg is that it is unclear that the human species would survive and outlive technology. To Martins, the Anthropocene is a subset of the Technocene, overlapping about three centuries.[11]

Oliver López-Corona also has a similar approach to the taxonomy of the Technocene. López-Corona explains that the "capital accumulation as a driver of Anthropocene" was "only possible by using technologies."[12] López-Corona proposes that the current epoque is instead the Technocene. His argument is based on the fact that since technology is what is used to extract energy and resources, it is the core actor in this discourse, making the Technocene a more appropriate terminology to describe this Epoque.[13] One additional insight that López-Corona introduces is that there is a need to categorize the Homo sapiens living in modern cities differently than before. López-Corona explains the coupling with technology shapes the "classical homo sapiens" into "Technobionts."[14]

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5. Hornborg, Alf. "The Political Ecology of the Technocene." In The Anthropocene and the Global Environmental Crisis, edited by Clive Hamilton, Christophe Bonneuil, and François Gemenne, 1st ed., 57–69. Routledge. 2015. https://doi.org/10.4324/9781315743424-5. 61.
6. Ibid, 62.
7. Ibid.
8. Ibid,
9. Martins, Hermínio, et al. "The Technocene: Reflections on Bodies, Minds and Markets." 2018. London: Anthem press. 1.
10. Ibid.
11. Ibid.
12. López-Corona, Oliver, et al. "It Is Not an Anthropocene; It Is Really the Technocene: Names Matter in Decision Making Under Planetary Crisis." Frontiers in Ecology and Evolution 8 (June):214. 2020. https://doi.org/10.3389/fevo.2020.00214. 1.
13. Ibid. 2.
14. Ibid. 3.

Emanuele Giorgi argues the need to implement the Technocene framework because the way humanity impacts the environment is "mainly due to the technological capabilities available today."[15] Giorgi additionally expresses the importance and the purpose of utilizing the Technocene narrative. Giorgi claims implementing the Technocene narrative will "highlight a deep crisis [derived from the] unawareness of the technological power and its proper use, [ultimately resulting in losing the] sense of responsibility towards" our environment.[16] Therefore, the Technocene framework is proposed as an appropriate outlook for learning and identifying the negative implications of technology and its use on the environment.

From these efforts in research and development of the Technocene narrative, it is possible to derive a definition of the Technocene for this thesis. This thesis will regard the Technocene as an alternative narrative to the Anthropocene, describing the impact of technology being used to extract and alter energy and resources of the earth systems. As opposed to the Anthropocene, the Technocene takes a more holistic approach, including societal drivers that influence the usage of technology and its implications on the environment and society at large.

Illustrating the Technocene through an example, López-Corona speaks of "old technologies [of] hydraulic engineering" that have already been proven to encompass the potential to drive ecosystemic changes.[17] López-Corona cites Michel Meybeck's work, which highlights the impact of "human activities" utilizing technology that deals with the natural water cycle, like "drainage, agriculture, the construction of artificial water bodies, the development of artificial water storage and flow regulations structures."[18] These impacts often negatively modify "terrestrial waterbodies [in their] chemical and biogeochemical" compositions.[19] These modifications are visible in our cities today through sewers, wastewater treatment centers, and even our city fabric and its non-porous surfaces. This example highlights the appropriateness of implementing the Technocene narrative when considering social and economic drivers affecting the environment and the ecology of crucial systems like water within the earth system. By assessing such systems and the implications of technology being used by society and social drivers, it is possible to view the current epoque more appropriately.

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15. Giorgi, Emanuele. "The Co-Housing Phenomenon: Environmental Alliance in Times of Changes." The Urban Book Series. Cham: Springer International Publishing. 2020. https://doi.org/10.1007/978-3-030-37097-8.
16. Ibid.
17. López-Corona, Oliver, et al. "It Is Not an Anthropocene; It Is Really the Technocene: Names Matter in Decision Making Under Planetary Crisis." Frontiers in Ecology and Evolution 8 (June):214. 2020. https://doi.org/10.3389/fevo.2020.00214. 3.
18. Meybeck, Michel. "Global Analysis of River Systems: From Earth System Controls to Anthropocene Syndromes." Edited by M. Falkenmark and C. Folke. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences 358 (1440): 1935–55. 2003. https://doi.org/10.1098/rstb.2003.1379.
19. Ibid.

When earth systems crucial to the survival of most living organisms, like the water cycle, are not respected but instead exploited, it accentuates the need for implementation of the Technocene framework to "raise awareness" and understanding of the threats in our environment.[20] With increased awareness of the Technocene, it will be possible to be critical in assessing different "types of technologies [and their] type of risk and scale" to help decide on methods of reconciliation with earth systems in the future.[21]

However, it is difficult to grasp the Technocene from written or verbal explanations because it is a more multi-layered spacial framework that includes "biophysical and socio-cultural and technical dimensions."[22] The Technocene dives especially deep into the network of intertwined societal drivers in resource and energy use, its usage of technology, and the resulting state of the environment. There is a limitation to reading about the Technocene and understanding it immediately, as the layers of different societal, technological, and environmental relationships are intertwined through varying scales. Therefore, overcoming this complexity results in a call for an easily accessible and legible format of information delivery in a more guided method by storytelling the Technocene framework by attempting to highlight and unravel these relationships visually.

1.2 Storytelling

To approach the task of understanding the Technocene through storytelling, we must first define the act of storytelling. From this understanding we can then indicate the goals of a good story, and the type of storytelling that is applicable for the Technocene. Storytelling is a method to transfer knowledge, wisdom, and lessons to others. The ancient Greeks thought of a story as encompassing "knowledge and wisdom."[23] These stories of knowledge and wisdom have been told verbally or through drawn media.[24] Storytelling's benefits of transferring information, knowledge, and wisdom in a more personable, interactive, "meaningful, and purposeful" method make storytelling an excellent method to explain the Technocene,[25] considering its need for a more accessible, entertaining, and participatory method of teaching and transferring information.

20. Giorgi, Emanuele. "The Co-Housing Phenomenon: Environmental Alliance in Times of Changes." The Urban Book Series. Cham: Springer International Publishing. 2020. https://doi.org/10.1007/978-3-030-37097-8.
21. López-Corona, Oliver, et al. "It Is Not an Anthropocene; It Is Really the Technocene: Names Matter in Decision Making Under Planetary Crisis." Frontiers in Ecology and Evolution 8 (June):214. 2020. https://doi.org/10.3389/fevo.2020.00214.
22. Hornborg, Alf. "The Political Ecology of the Technocene." In The Anthropocene and the Global Environmental Crisis, edited by Clive Hamilton, Christophe Bonneuil, and François Gemenne, 1st ed., 57–69. Routledge. 2015. https://doi.org/10.4324/9781315743424-5.
23. Yoder-Wise, Patricia S., and Karren Kowalski. "The Power of Storytelling." Nursing Outlook 51 (1): 37–42. 2003. https://doi.org/10.1067/mno.2003.2.
24. Landrum, R. Eric, et al. "The Pedagogical Power of Storytelling." Scholarship of Teaching and Learning in Psychology 5 (3): 247–53. 2019. https://doi.org/10.1037/stl0000152.
25. Yoder-Wise, Patricia S., and Karren Kowalski. "The Power of Storytelling." Nursing Outlook 51 (1): 37–42. 2003. https://doi.org/10.1067/mno.2003.2.

Understanding the Technocene is challenging, and storytelling is an excellent methodology for reasons of scale and interactivity. First, the Technocene encompasses an analysis that spans various scales. These scales can range from objects like concrete pavers and the technology used to create them to how they connect to larger systems like buildings, city infrastructure, and even the water system. Secondly, storytelling can connect these scales more efficiently by being more interactive and personable with how the information is transferred. We can start to identify and highlight these connections with storytelling by emphasizing revealing or hiding them with the agency of the storyteller. These benefits of storytelling will help the audience follow along and understand more cohesively in the context of the Technocene. With confirmation of storytelling's appropriateness as a methodology, we can start to find some guidelines for the thesis with criteria.

As addressed previously, understanding the Technocene benefits from storytelling to become more accessible to the public. To facilitate this process and to build a guideline for the design outcome of the thesis, we will start to incorporate and develop a series of criteria. Because the process of making the Technocene more accessible requires the introduction and education of the Technocene, we will start by addressing the goals of pedagogical storytelling. This criterion includes **creating interest** for the audience to draw them into the story, sharing information **familiar** method for the audience to easily recognize the information, providing a **structure** in the story to help understand and remember the story and its contents, and creating **rapport** between the storyteller and the audience to personally connect the two to help understand the story.[26] By utilizing this criterion on pedagogical usage of storytelling and applying it to how each goal can be met in the context of the Technocene framework, we can begin to develop more specific goals and guidelines to further help design the stories.

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26. Landrum, R. Eric, et al. "The Pedagogical Power of Storytelling." Scholarship of Teaching and Learning in Psychology 5 (3): 247–53. 2019. https://doi.org/10.1037/stl0000152.

Applying the pedagogical criteria in the context of the Technocene will help contextualize the thesis guidelines. To **create interest**, the stories should be situated within a location and context for the users to participate in unveiling underlying stories in familiar spaces. Situating the story will help users delve deep into the social drivers and environmental outcomes in elements of the built environment. To share these stories in a way that is **familiar** to the audience in the city, we need to consider utilizing visual media to portray the city, considering the abundance of visual media in our lives today. The **structure** can be added to the content of the stories by providing a clear progression in time or chronological order of events. This will allow for a more clear and coherent understanding of the story's contents. Finally, **rapport** can be established between the storyteller and the audience by utilizing visualization techniques from the discipline of architecture to create revelation on subjects that exist or are hidden in the city through sectional drawings and collaged visuals to engage the audience and enhance the delivery of information effectively. After analyzing the criteria for making a pedagogical story, we can begin to imagine the story's location.

Toronto was selected as the site for this project to storytell the Technocene because of its multilayered city infrastructure and the abundance of technology in its premises. The criterion analysis in the context of the Technocene with pedagogical storytelling addresses the importance of locationality and situatedness. This is because the stories that the Technocene portrays include human use of technology in shaping and altering the earth, and cities are the epitome of enhanced living with technology. Toronto is a city that contains public transit systems, a network of roads, sewage and drainage systems, and buildings of different scales and uses. This rich environment made of technological engagement makes Toronto a perfect location to spawn the stories of the Technocene.

The locationality and situatedness of the story are crucial in storytelling in the Technocene. Considering the importance of situatedness in storytelling in the Technocene, we need to analyze existing projects of location-based storytelling, or more specifically, situated urban storytelling, to help determine the direction of the design process. The following are two case studies on existing projects utilizing location-specific storytelling. We will assess these projects based on the four goals of pedagogical storytelling: **creating interest, familiarity, structure, and rapport**. From these assessments, we will be able to develop a second set of criteria to further develop the goals for designing the story.

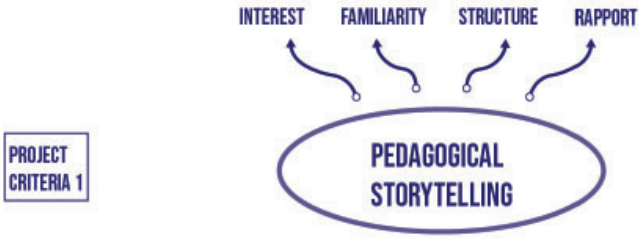


Fig. 1.1 Diagram illustrating the storytelling criteria for pedagogical storytelling.
image by author, 2024.

1.2.1 [murmur]

The first example of storytelling within the city is the project '[murmur],' Initially established in Kensington Market, Toronto, in 2003. Kensington market is a unique neighborhood in Toronto with various cultures and artists that have been continually shaped and evolved with the influx of newcomers from different backgrounds. Situated in this unique location, this project is a "documentary and oral history project" to record and reveal stories and memories in specific locations within the city. These stories consist of personal and historical stories or a combination of both. The stories were recorded and connected to a phone number, where each phone number and its respective story were placed on a plaque in each location to be found by the audience. The audience would call the number and interact with the story aurally, accompanied by visual and sensual feedback of walking along the paths or gazing at the views the storytellers experienced.[27]

27. "[Murmur]." Canadian Film Centre. Accessed February 21, 2024. https://cfccreates.com/content-hub/murmur/.

The project '[murmur]' utilized the situatedness of each site and their specific stories to effectively tell an aurally and visually interactive story. Using an intermediate device, such as a phone and recording, to convey the story, the project connects the storytellers and their atmospheres to the audience. Utilizing the existing environment where the story took place as a stage set, the project visually creates intimacy and rapport between the audience and the storyteller. Additional rapport was also built by having people in the neighborhood tell the story, giving the sensation that the story was being told from friend to friend over the phone, a familiar technology at the time. The only lacking point may be the structure. Since the story is being told aurally, it is not easy to assess the structure of the story itself. '[murmur]' is an excellent example of storytelling utilizing the city, as it was able to fulfill most of the criteria of delivering stories successfully with a timely approach in terms of technology and by achieving intimacy between the storyteller and the audience in a unique method in utilizing the environment as a canvas.



Fig. 1.2 image of a poster for the project, [murmur], on a streetpost.
image posted by Shawn Micalllef, 2023.

1.2.2 Who killed Hanne Holmgaard

The second example of situated urban storytelling is a project made within a research paper, 'Location-based Storytelling in the Urban Environment.' This research paper assesses the possibility of location-based fictional storytelling utilizing user interfaces of mobile devices in the urban setting. This project, designed in 2008, used Personal Digital Assistant (PDA), a device with a touch screen where the users could do simple digital tasks like viewing images, writing, and accessing the internet. This project utilizes the PDA's potential to deploy their storytelling system, 'Who Killed Hanne Holmgaard.'[28] This fictional storytelling system utilizes the capability of the PDA devices to better engage two users and to introduce cooperation in finding clues and paths to act as detectives who are working together to discover the mystery of Hanne Holmgaard's death during a stroll along the city of Aalborg in Denmark.

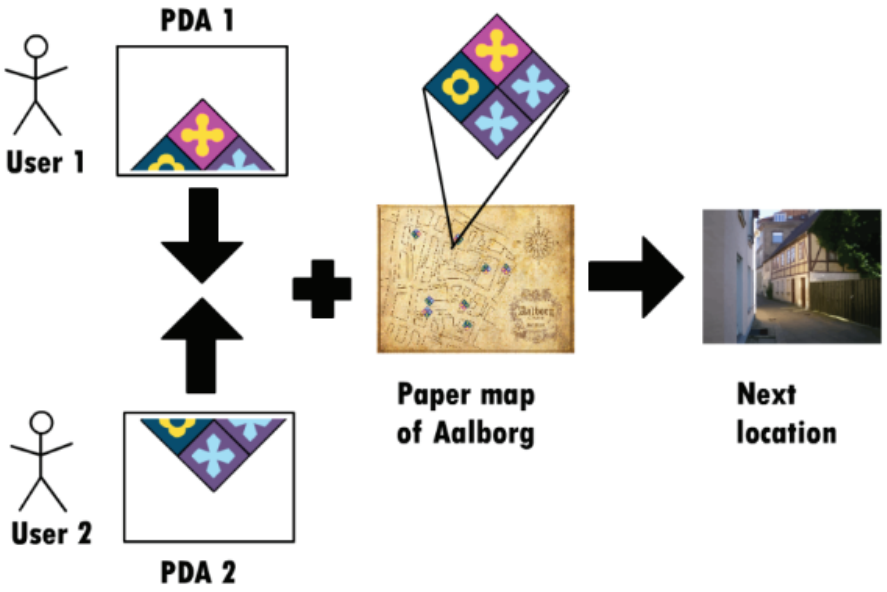


Fig. 1.3 Diagram illustrating the how user interaction and cooperation gives progression in the storytelling experience of the prototype system, "who killed Hanne Holmgaard".
image by research team led by Jeni Paay and JEsper Kjeldskov, 2008

28. Paay, Jeni, et al. "Location-Based Storytelling in the Urban Environment." In Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat, 122–29. Cairns Australia: ACM. 2008. https://doi.org/10.1145/1517744.1517786.

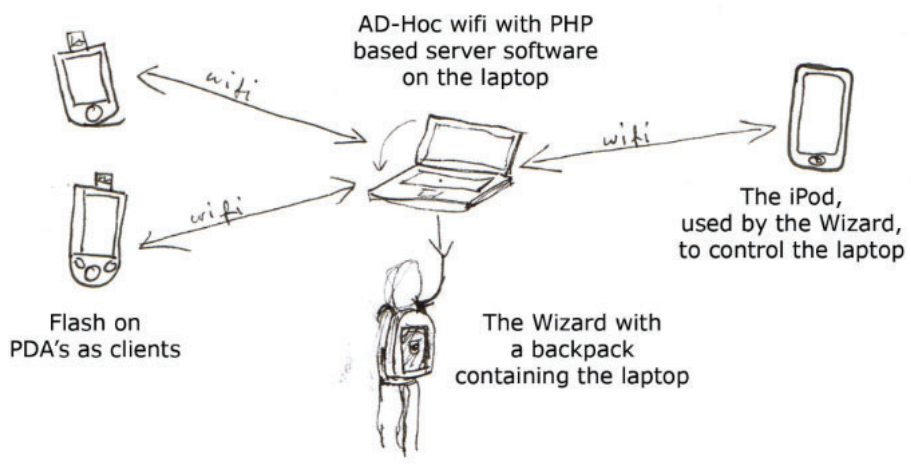


Fig. 1.4 Diagram illustrating the technology behind the experience, linking the relaitonship between personal digital assistants, laptop, and iPod.
image by research team led by Jeni Paay and JEsper Kjeldskov, 2008

This project is interesting as it utilized the situatedness of the system to tell a fictional story visually with the usage of technology and human interaction. The story added interactivity through the cooperation of both users using their PDA devices and other physical clues and objects to discover the story's mystery. The downside to this project is the limitations of the technology, which requires a laptop and iPod to control and manage the content and the Wi-Fi connection. It ultimately hinders the possibility of a more universal application, which is a limited experience. However, the attempts this project makes to help the audience better understand the story through physical, digital, and interactive cooperation make the experience a successful method of storytelling.

1.2.3 Takeaways

These existing projects using situated urban storytelling around the city demonstrate how this method has potential in storytelling the Technocene because of their use of technology, how they utilize the environment, and the situatedness of each site to tell a better story. These examples utilize physical elements of the city, like alleyways, buildings, and signposts, to spawn an interaction between the storyteller, the environment, and the user. Through this interactive process, these projects create interest and engagement, increasing their stories' delivery. They also utilized varying available

technology as a medium to bridge the real environment and their stories. This proposes the effectiveness of utilizing technology that the users are familiar with when telling a story. Another method employed in these examples of situated urban storytelling is the use of visual media in storytelling.

Visual media is crucial to understanding and portraying the story when using situated urban storytelling. Visual mediums have been used in both '[murmur]' and 'Who Killed Hanne Holmgaard.' In '[murmur],' the city itself was utilized to accompany the stories to help situate the audience in the story. In 'Who Killed Hanne Holmgaard,' a PDA device showing graphic content was used to direct the users and create interaction in discovering the storyline. Considering the importance of visual media and optic feedback in situated urban storytelling, there is a need to analyze existing visual mediums utilized in telling complex stories related to the Technocene. To do this analysis, we can start by creating criteria utilizing the takeaways from examples of situated urban storytelling.

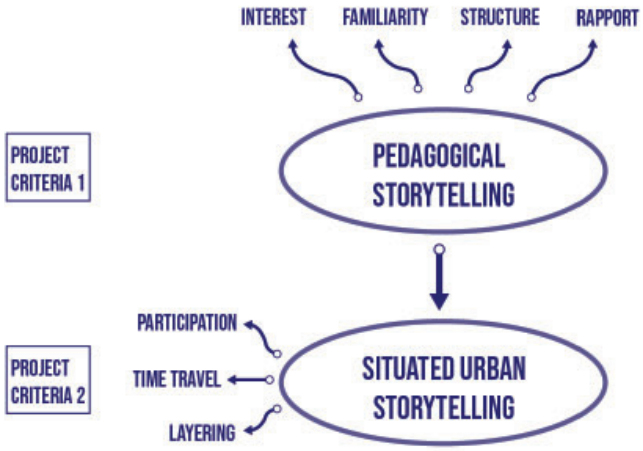


Fig. 1.5 Diagram illustrating the storytelling criteria with the addition of situated urban storytelling.

image by author, 2024.

From these projects, we can see the importance of **active participation** from the audience in discovering the story, through the methods and situatedness of the stories. We can also see the element of **time travel** in both projects, either aurally or spatially transporting the audience to a time when the stories took place. Finally, the aspect of **layering** experiences is also utilized. Murmur uses aural feedback to layer the stories into the physical space, while 'Who Killed Hanne Holmgaard' uses PDA devices to layer information into reality. From this, we can create the criteria of situated urban storytelling shown in Figure 1.5 to help guide the analysis of visualization methods.

1.3 Forms of Visual Storytelling

The widespread usage of visual storytelling methods in the likes of films, drawings, and photographs signifies its effectiveness for potential storytelling in the Technocene. Because the Technocene framework is layered with various social drivers, technologies, and ecosystemic outcomes on various physical scales, it would greatly benefit from visual storytelling of the layers and facets to highlight and choreograph the story's progression. To decide which type of visual media would fit the best for visual storytelling in the Technocene, we must assess existing methods of visual storytelling that attempt to tell complex stories similar to the Technocene. Examples have been selected to represent drawing, photography, and film. Each of these mediums will be assessed in terms of effectiveness and limitations utilizing the criteria of situated urban storytelling in Figure 1.5. From these takeaways, we can establish a basis for how AR is a potential storytelling method that improves upon the limitations while retaining the benefits of existing visual media.

1.3.1 Drawing - Design Earth, Mutual Existence

Drawing is a method that can illustrate one's imagination in the context of complex ideas like the Technocene. More specifically, in speculative design drawings, artists can be imaginative and projective in the contents of the drawings. Through imagination into the future, often engaging with contemporary issues regarding technology and human intervention, "design speculations can act as a catalyst for collectively redefining our relationship to reality."[29] In this style of design and drawing, artists can curate and layer different information in the drawing, allowing for seamless integration and juxtaposition of complex topics. Due to these characteristics, speculative design drawings are one of the effective methods for picturing scenes, actions, and networks in the context of a multilayered framework like the Technocene. The following projects, 'Pacific Aquarium' and 'Mutual Existence,' are examples of speculative design drawings and will be assessed using the criteria of situated urban storytelling shown in Figure 1.5

29. Dunne, Anthony, and Fiona Raby. "Speculative Everything: Design, Fiction, and Social Dreaming." Cambridge, Massachusetts ; London: The MIT Press. 2013.

In the 'Pacific Aquarium' drawing series, the research practice Design Earth utilizes speculative drawing to address the geological changes in the Clarion-Clipperton Zone.[30] These geological changes are revealed through the imagination of aquariums in the Pacific Ocean that depict resource extraction and climate change. The artist utilizes architectural representations like sections to allow people to visualize beyond the water's surface. Through this choice in drawing, it is possible to highlight and make more evident the relationship between the environment, humans, and their exploitation. The heat chimney is the subject of human exploitation and is shown to heat up the aquarium, which is a representation of humans altering the ecosystem through the usage of technology to suit their desires. We can also see in the drawing fumes that have an impact on a larger scale, affecting climate change through global warming. Through this speculative design drawing, the artist is able to imagine the future and create a visual statement that starts to make the audience recollect and contemplate the issue depicted in the drawing.

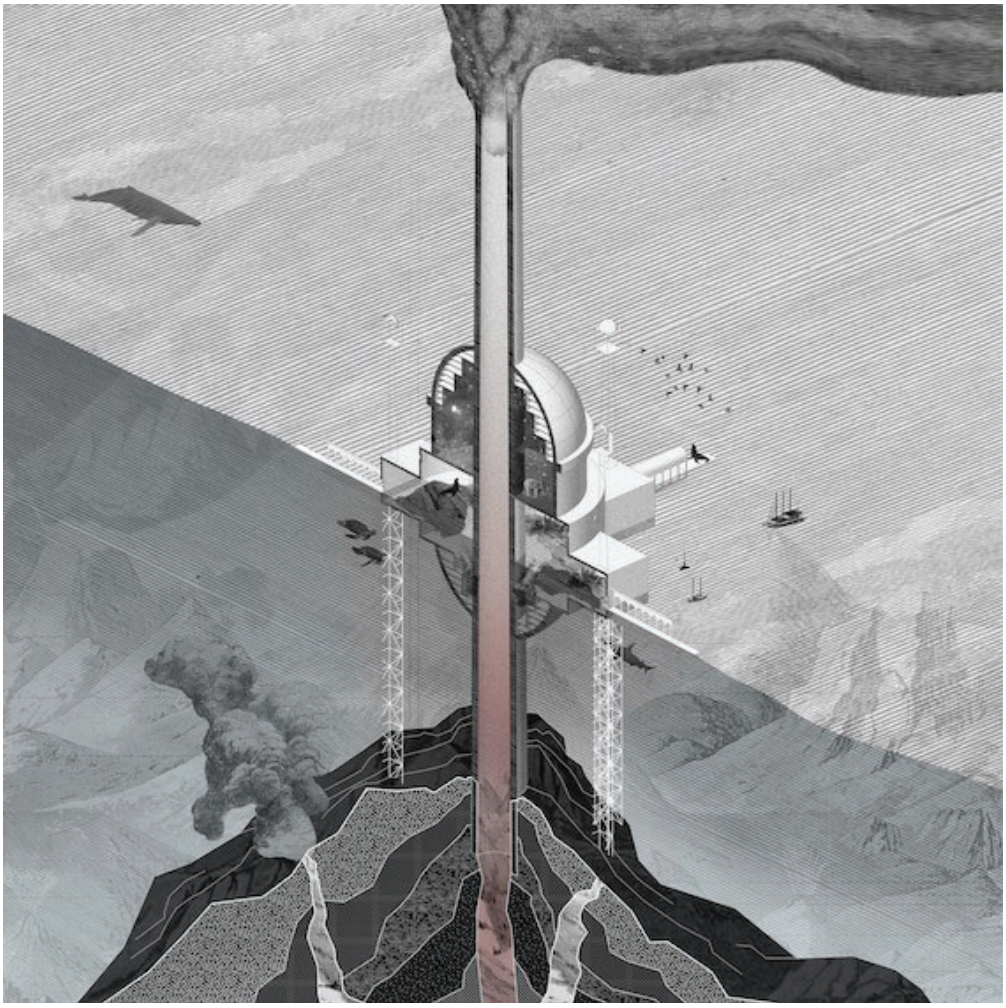


Fig. 1.6 A drawing from the drawing series, 'Pacific Aquarium'

© DESIGN EARTH, Pacific Aquarium, 2017.

26. "MAIN : DESIGN EARTH." Accessed March 5, 2024. https://design-earth.org/.

Another example of speculative drawings is the project 'Mutual Existence.' This project utilizes speculative drawings to visualize the existing relationships between cloud computing and its resource exploitation and propose a coupling of this relationship in different contexts to reconcile it. The speculations illustrate the possibility of such parasitic relationships mutually beneficial to the environment and humanity. The speculative interventions achieve mutualism by using excess heat from cloud computing in desalination and desert greening or bypassing water from the hydroelectricity plant through a cloud computing facility to create a greenhouse in northern Canada in the Hudson Bay. Such interventions achieve either creating an environmental buffer, carbon sequestration, or wildlife and human civilization preservation.

Like the project 'Pacific Aquarium,' 'Mutual Existence' utilizes architectural drawing techniques to provide a deeper understanding of cloud computing facilities' inner workings, energy flows, and their relationship to the environment. The usage of sectional perspective visualizes the process in which water passes through the computers and how the byproduct of heated water is used. Ultimately, it creates a more direct revelation of the underlying problems of climate change and the carbon footprint in the hyperconnected world we consume through drawings and the benefits of visualizing imagination and speculation.

As a result of this assessment, speculative drawing is good at **layering** complex ideas but is lacking in **time travel** and garnering **participation**. Speculative drawing can connect and reveal links in the network of the subject's composition. In the example, 'Mutual Existence,' the relationship between water and computers was revealed through architectural techniques of sectional perspective. In this project, imagination allows for connections between unrelated subjects to be overlaid and made explicit. Drawings are typically presented with text-based captions, establishing a static relationship where the audience perceives the information. The benefit of these static relationships is the uniqueness of the experience for different individuals. Depending on the experiences and the knowledge of each individual, the audience is able to create varying interpretations and perspectives. However, this static relationship is limited in creating active participation of the audience to discover the story themselves. Participation is critical in creating rapport and interest from the audience on topics like the Technocene and would greatly benefit from a more situated and participatory mode of visual media.

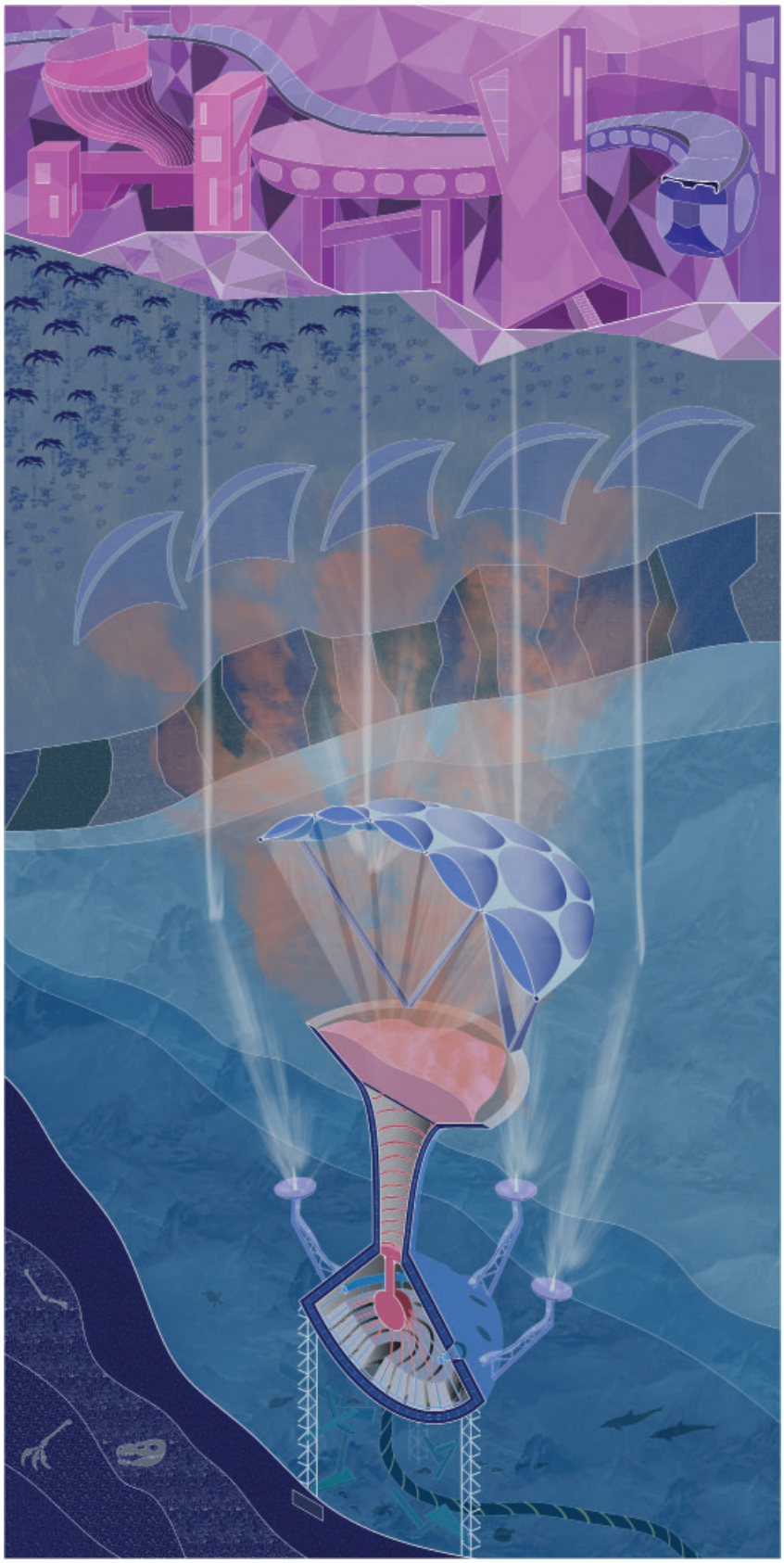


Fig. 1.7 Drawing from the project, Mutual Existence Oasis

image by author, 2023.

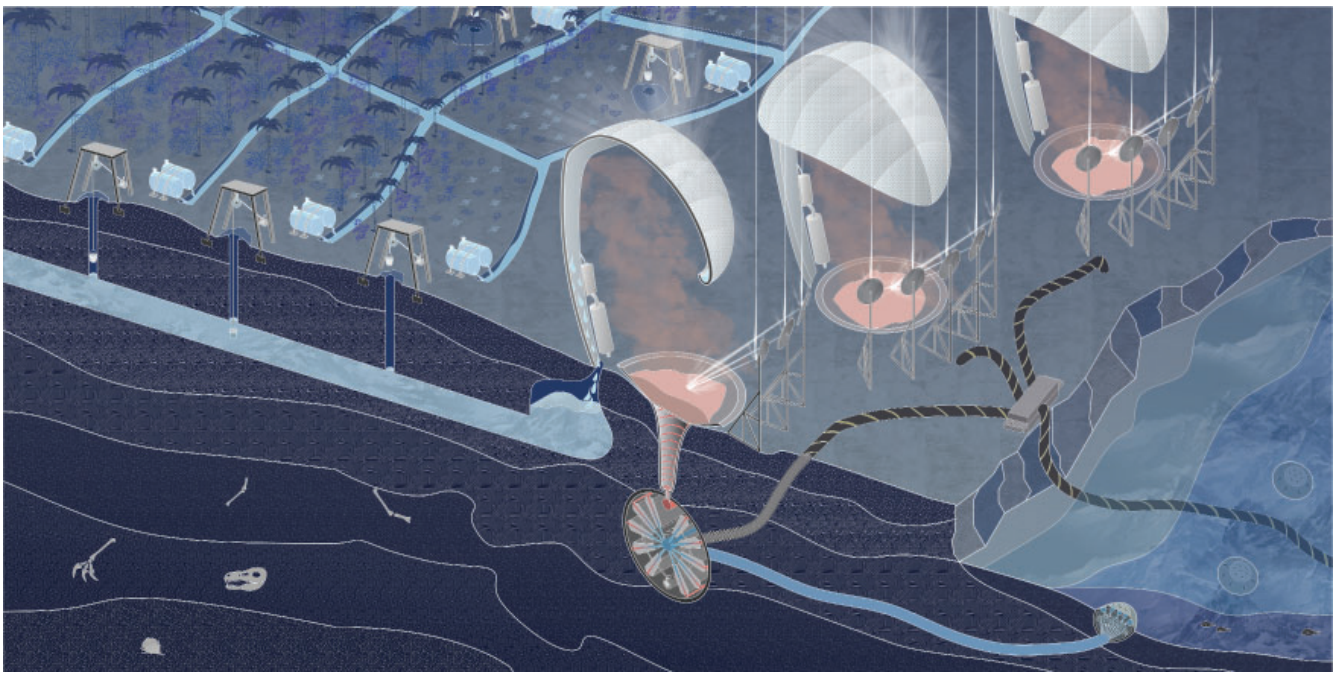


Fig. 1.8 Drawing from the project, Mutual Existence Oasis
image by author, 2023.



Fig. 1.9 Drawing from the project, Mutual Existence Arctic
image by author, 2023.

1.3.2 Storytelling through Photography

Photography is a tool for photographers to document the existence of a specific time and space.[31] Through photographs, the audience can travel in time and space through the lens of the photographer, experiencing the story frozen in time, testifying "to time's relentless melt."[32] In the context of aligned disciplines to the Technocene, examples of this method are exhibited in Edward Burtynsky's photographs depicting the Anthropocene. The photographs are captured in sites geographically inaccessible to the audience, like the hydro dams in China and lithium evaporation ponds in Chile. The photographer's intuition utilizes scale and compositions to pinpoint a specific action or a holistic view of a site to illustrate industrial sights undergoing environmental neglect and manipulation. The image of the hydro dam captures the scene of water being pushed out of the dam under high pressure to extenuate human intervention on the course of water. When looking at the lithium evaporation ponds in Chile, the photograph is taken on a larger scale to beautifully make explicit the abnormality in the form and color of the water overlaid on the barren land. These photographs record stories of environmental changes in time and make them more available to the public.

Despite this ability to teleport through time, the audience's experience in perceiving the photographed story is limited to precisely what the photographer intended and limits room for experimentation and participation between the visual media and the audience. Instead, the narratives offered by the photographs rely on the viewer's ability to imagine and analyze beyond the scene to understand and immerse themselves in the story beyond the photograph. Time and space allow for the photograph and its story to exist, but it is not evident what is beyond the frozen time and space. The layering of information is also lacking in photographs as they focus on the status quo of the specific subject rather than making explicit the multilayered facets of the story. Given the complexity of the Technocene framework, it is more appropriate to provide users with details on the drivers that made the environmental change, what kinds of technology are used, and the impact of such activity on site. In order to accomplish this, the audience should be able to travel beyond the captured time and space into the past and the future. Therefore, by utilizing the photograph's ability to travel time, and by magnifying it into different timeframes and specifying the exact situation and the participants, it would be possible to discover underlying layers of economic and social drives, material histories, and the Technocene narrative.

31. Süme, Selim. "Reflection of Time to Photography as an Existence - Orta Format." Accessed June 13, 2024. http://ortaformat.org/reflection-of-time-to-photography-as-an-existence-24.
32. Sontag, Susan. "On Photography." New York: Farrar, Straus and Giroux. 1977.



Fig. 1.10 Xiaolangdi Dam #1, Yellow River, Henan Province, China, 2011

© Edward Burtynsky, courtesy Nicholas Metivier Gallery, Toronto

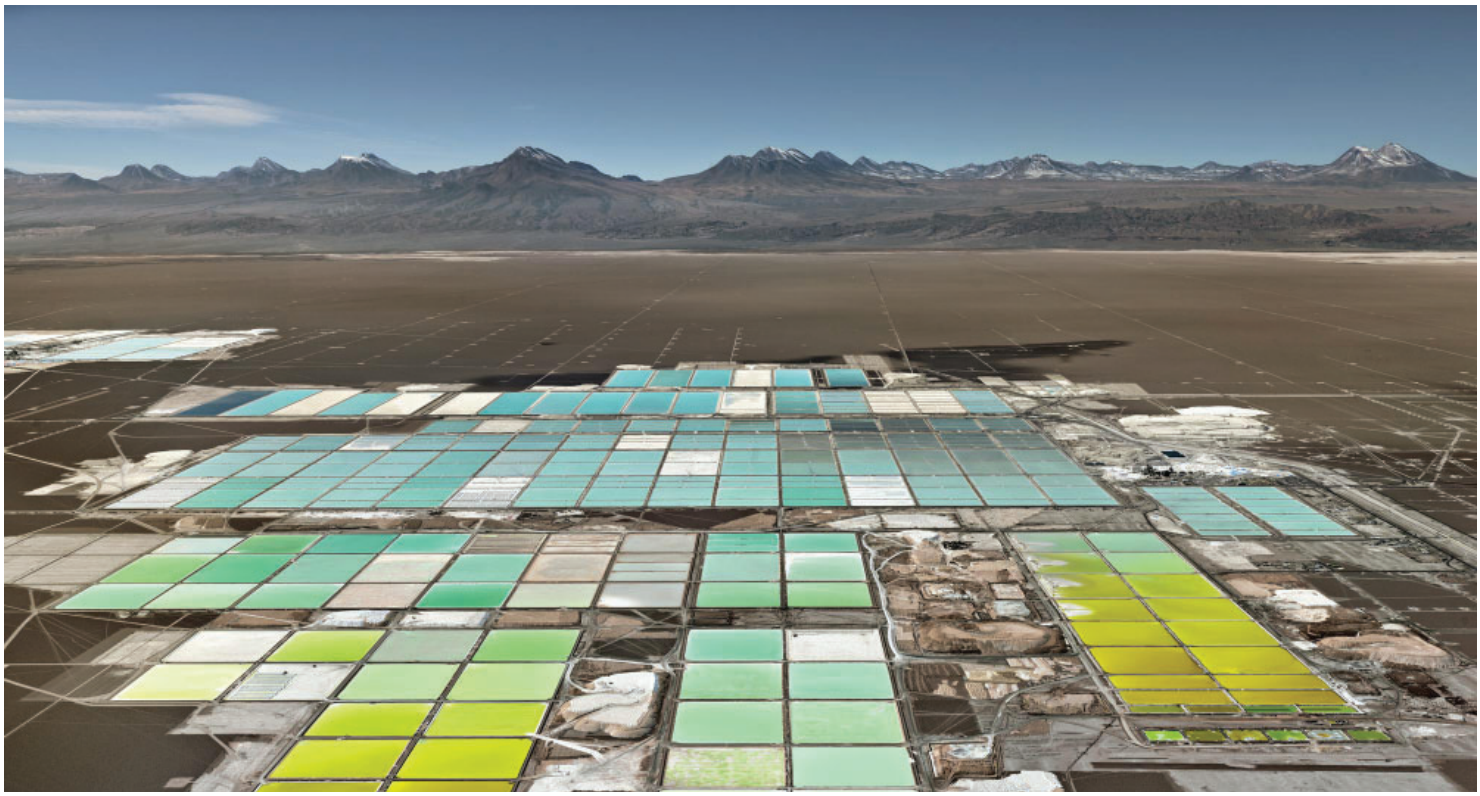


Fig. 1.11 Lithium Mines #1, Salt Flats, Atacama Desert, Chile, 2017

© Edward Burtynsky, courtesy Nicholas Metivier Gallery, Toronto

1.3.3 Storytelling through Film

Film is a form of visual media that allows for stories to be told more immersively by helping the audience become engaged in the time and space that the filmmaker created. Films typically progress with a storyline to convey and provoke lessons, emotions, and questions in our world. Liam Young's film, 'Planet City,' is an example that uses filmmaking to assess the future with novel technology speculatively and, through this, engage directly with the Technocene. It utilizes worldbuilding to depict climate change as "no longer a technological problem, but rather an ideological one, rooted in culture and politics."[33] Through this depiction, the filmmaker can engage the audience in questioning today's environmental crisis.

Storytelling through film more spatially engages the audience compared to drawings or photographs. Films engage the audience through the usage of scenes and time travel. Scenes start to spatially register the environment more effectively through the movement of the camera and the transitions of scenes to engage the audience through the designed progressions. This can allow the users to understand better the story's focal discourse from the emphasis that the scene progressions allow. The different layers of scenes also help show portions of the overarching story in their specific context. In a way, scenes invite the audience to travel in time and space with the camera, experiencing and living in the filmmaker's story. These factors combined allow for immersion of the users to engage more deeply in the story.

However, films also have limitations. Like photography, viewers in the film are merely viewers, not actively participating in discovering the story. The film or the experience does not react to the user's actions, limiting the additional interactivity and rapport that could be established.

33. "Film — Planet City." n.d. Accessed February 26, 2024. https://planetcity.world/Film.

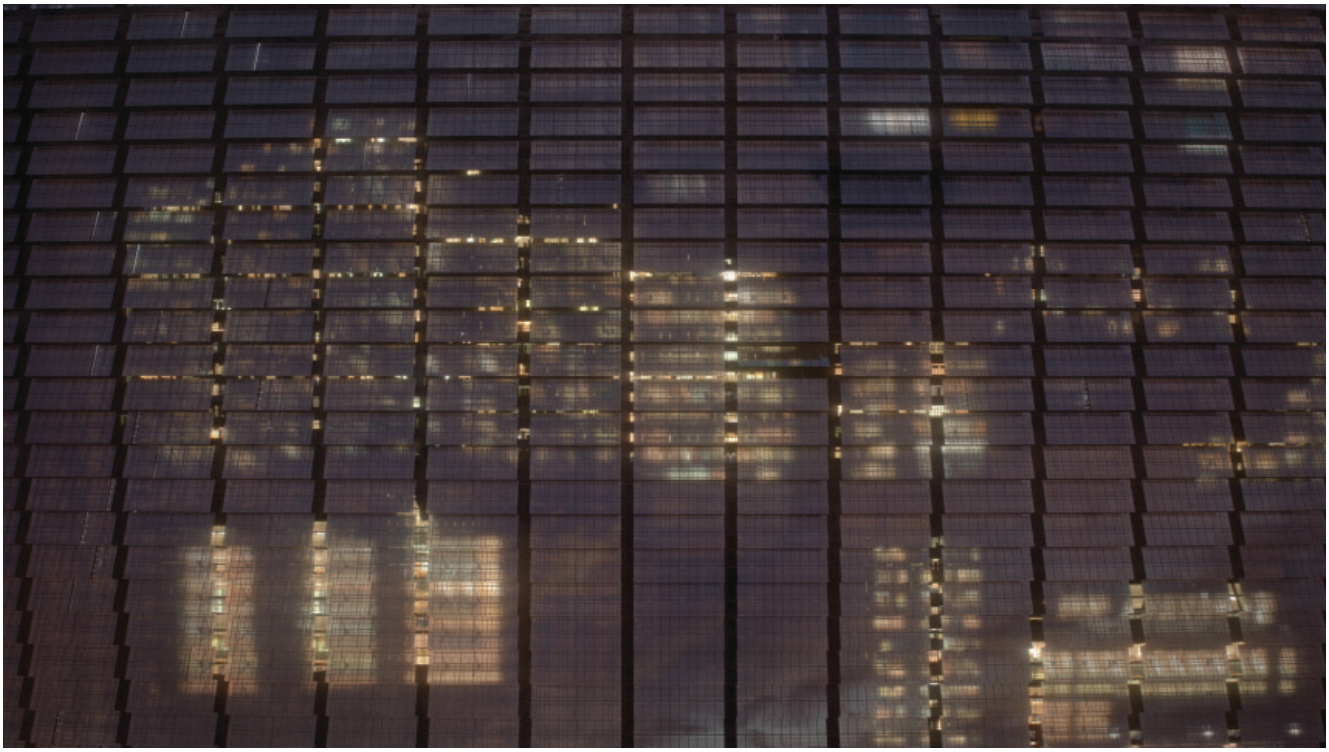


Fig. 1.12 A still image of solar fields from the film, Planet City by Liam Young

© Liam Young, Planet City, 2020



Fig. 1.13 A still image of indoor farm, from the film, Planet City by Liam Young

© Liam Young, Planet City, 2020

1.4 Limitations, and things to learn

Reviewing the different mediums of visual storytelling to tell a situated story of the Technocene reveals that the three existing media are limited in achieving active participation but seldom good at time travel or layering and revealing information. The common denominator from the three forms of visualization was that the viewers did not actively participate in discovering the story. Implementing participation will add a layer of discovery to the experience, which will engage the users by inviting them to create their own unique experiences. The existing visual media must also be improved to achieve situated time travel, improving upon what is already possible from photographs and films. Photographs can freeze an atmosphere and space in time and give the user a glimpse of the scene. Films have started to bring the possibility of engaging users to travel in time and space within the medium. However, these media need more ability for users to actively participate in time travel. Situating the story to a physical location of the user and helping the user spawn the stories of the past, present, and future will better engage the user in the story. Drawings and films can layer information within the medium to connect related topics and juxtapose them to create a deeper understanding. However, it lacks the real-time spatialization that tells the story in the location where the user is located. The story and its situatedness are still distant from the viewer. From this analysis, we can start to guide the project in discovering a method to tell a situated story that considers situated time travel, active participation, and the overlaying of information in real-time spatialization. Fortunately, another form of visual storytelling method is available to us, which has the potential to retain the benefits of the three forms of visualization while overcoming the shortcomings: Augmented

Methods	Participation	Time Travel	Layering
Drawing	No	No	Yes
Photography	No	Yes	No
Film	Limited	Yes	Yes
Augmented Reality	Yes	Yes	Yes

Fig. 1.14 Table of Visual Media and their appropriateness to the Technocene

image by author, 2024.

1.5 What Makes Augmented Reality an Appropriate Proposition

Augmented Reality (AR) is a form of enhancing the existing world by overlaying content to create a more diverse and interactive experience. It operates differently from photography, film, and drawings due to its clear situatedness and its ability to engage users by making them participate in the experience with physical movement via either haptic feedback on devices or by physically walking around. AR is an appropriate method to visualize situated urban stories, specifically of the Technocene because it can improve the limitations of situated time travel, active participation, and real-time layering of information of the existing visual mediums, as shown in Figure 1.14. With AR, it is possible to achieve situated time travel using user interfaces (UI) like sliders to span through stories of the past, present, and future visualized as digital content above the existing environment. AR also promotes active participation of the user through haptic feedback with UI elements, as well as the animations and actions each button presents to the user. By having the freedom to interact with the situated environment, users can be better immersed in exploring the story of the Technocene. The physical movement of the users in an AR experience helps users discover the story themselves instead of receiving the story. Additional information such as material history, composition, and social and economic drivers can be overlaid as digital content using images, 3D models, animation, and text. The overlaying of information ultimately acts as a bridge between the existing environment and the digital environment.

By utilizing its ability to render digital content over the real world, we can bridge the gap between the real world, where the stories are taking place, and the digital world, where the modern world focuses on developing. By utilizing novel technology to understand the effects of human usage of technology in the urban setting, it is possible to raise awareness of the topic of the Technocene more effectively. Instead of entirely opposing new technologies due to their environmental or social impact, careful utilization to improve the reception of our existing world starts to amalgamate the two worlds for a brighter future.

Because of the ability to achieve situated time travel, the layering of information to bridge the real and digital, and the ability to increase interaction through active participation of the users, AR is a suitable form of visualizing that would benefit situated urban storytelling of the Technocene. With this in mind, we must now analyze the existing methodologies of AR, existing AR projects, and applicable technology to start designing the AR experience of storytelling in the Technocene.

Chapter 2

Augmenting Our Reality

Before applying Augmented Reality (AR) methodologies to design the story of Technocene in Toronto, we must understand the meaning of AR and why ocular-centric AR is appropriate for the Technocene narrative. AR is an interactive experience where digital content and information are superimposed on the real world in real-time.[34] In a broader context, this interactive experience encompasses the augmentation of how we perceive the world through our bodily senses. Although the contemporary focus in AR is generally ocular and haptic-centric, many forms of AR exist to augment different human senses. Studies have shown the possibility of augmenting gustation,[35] olfactory,[36] and aural[37] senses of the human body. Aural forms of AR exist already in our daily experience, like museum audio guides at SFMOMA that detect our location to explain artworks.[38] To tell a situated urban story of the Technocene, AR engaging the ocular sense is the most appropriate mainly because it is possible to perform situated time travel. Visually augmenting reality by layering stories of the past or future is a more approachable method of telling the story of the Technocene for the purposes of this thesis. With the establishment of using visual AR, we can move into the existing projects and technologies to create a technological background in the field of AR.

This chapter will review existing types of AR, AR applications, AR's use in architecture, applicable AR tools, technologies. To review these topics, we will build upon the criteria system created in Chapter 1 for storytelling the Technocene to assess the capabilities of AR. Through this analysis, we can create a basis to define and guide the design technologically, identifying the exact technology and tools to achieve situated time travel, active participation, and layering of information to visualize a situated urban story of the Technocene.

34. Cipresso, Pietro, et al "The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature." Frontiers in Psychology 9 (November) :2086. https://doi.org/10.3389/fpsyg.2018.02086. 2018.
35. Nakamura, Hiromi, et al. "Augmented gustation using electricity." In AH '11 Proceedings of the 2nd Augmented Human International Conference. New York, NY: ACM. 2011.
36. Halabi, Osama. "Augmented reality flavor: cross-modal mapping across gustation, olfaction, and vision." 2021. https://doi.org/10.1007/s11042-021-11321-0
37. Lyons, Kent., et al. "Guided by voices : An audio augmented reality system." 2000. In Proceedings of the International Conference on Auditory Display (pp. 57–62). Atlanta, GA: Proceedings of ICAD.
38. Chun, Rene. "The SFMOMA's New App Will Forever Change How You Enjoy Museums." Architectural Digest. Architectural Digest, 2016. https://www.architecturaldigest.com/story/the-sfmomas-new-app-will-forever-change-how-you-enjoy-museums.

2.1 Augmented Reality Methodology

There are variants and types of visual AR used today. They are more specifically classified based on how their technology/framework is set up, and what the principles are in the method that augmentation occurs. These technological frameworks typically require an input device, sensors, and a display.[39] The input allows the users to interact with the digital content, like user interfaces and software, in combination with processing power from the device. The sensors collect real-world data for the users to augment, such as GPS and accelerometers. The display allows users to visualize augmentation, such as Goggles, handheld device screens, and projectors. These different technological frameworks, compositions, and their purpose are used in different ways and can be classified into two variants: Marker-based AR and Marker-less AR.[40]

2.1.1 Marker-based Augmented Reality

Marker-based AR requires physical markers in the scene that are inputted to the interface/device for the software to detect (QR codes or strongly contrasted or defined markers). After detection, the AR content will be displayed on the device, basing itself on the marker.[41] This methodology utilizes an input device of a camera to read through the existing environment. It utilizes software as a sensor to detect the marker, and this interaction would be displayed on the device's screen. The benefit of marker-based AR is its adaptability. The marker could be located anywhere in the world and would perform the way it was intended for. However, the experience may be limited due to its reliance on the marker's existence to generate AR content.

Requirements:

- Camera
- Interfeace/Device
- Physical markers

39. Arena, Fabio, et al. "An Overview of Augmented Reality" 2022. https://doi.org/10.3390/computers11020028
40. Brito, Pedro Quelhas, "Marker versus Markerless Augmented Reality. Which Has More Impact on Users?" International Journal of Human–Computer Interaction, 34:9, 819-833, 2018. DOI: 10.1080/10447318.2017.1393974
41. Brito, Pedro Quelhas, "Marker versus Markerless Augmented Reality. Which Has More Impact on Users?" International Journal of Human–Computer Interaction, 34:9, 819-833, 2018. DOI: 10.1080/10447318.2017.1393974

2.1.2 Marker-less Augmented Reality

Marker-less AR is a type of AR that does not require any distinct markers in the physical environment. Instead, it relies more on computer software and algorithms to detect the depth and geometries of the environment and display virtual media. There are three general types of Marker-less AR.

GPS Location-based AR: GPS or Location-based AR is a type of AR that utilizes the GPS, accelerometer, gyro meter, and compass of a device like a smartphone to detect the orientation and location of the user to give real-time augmentation of their environment by displaying overlaid content.

Requirements:

- Camera
- Interfeace/Device
- GPS
- Accelerometer
- Compass

Superimposition AR: Superimposition AR utilizes a method in which the software will detect the environment through the device and superimposes a virtual object on top of the scene to augment the scene.[42]

Requirements:

- Camera
- Interfeace/Device

Projection AR: Projection AR utilizes a projector and possibly a sensor/camera to first project virtual content onto physical spaces like walls, storefronts, and buildings. After projection, interactivity is made by sensing where and how the user is moving to highlight interactive reactions in the projected medium.

Requirements:

- sensor/camera
- Projector
- Physical environment



Fig. 2.1 Man using smart glasses at work, using gestures to navigate
image by Vitaly Gariev, 2024. https://unsplash.com/photos/a-man-in-a-tie-is-using-a-laptop-while-wearing-a-virtual-headset-WbE4SEHbwrY

42. Van der Veen, Manuel. "Crossroads of seeing: about layers in painting and superimposition in Augmented Reality." AI & Soc 36, 1189–1200 2021. https://doi.org/10.1007/s00146-020-01060-5

2.2 Existing Augmented Reality Applications

To assess the appropriateness of AR methodologies in telling a situated story of the Technocene, we must assess how the two methodologies of Marker-based and Marker-less AR have been utilized in existing AR applications. AR examples will be assessed in their specific use of AR methodology and their technology's potential in meeting the criteria of situated storytelling of the Technocene: to create active participation, to achieve situated time travel, and to layer information. Since not all examples include situated time travel within their experience, their ability to anchor reactive digital content will be assessed instead. The following are assessments of AR's use in industries such as social media, sales, marketing, and education.

2.2.1 Social media augmented reality facial filters

Filters on social media platforms like Instagram are a form of marker-based AR that has dynamically changed the industry of content creation through its ability to achieve active user participation in augmenting reality. The experience initially creates a marker from the facial data it takes from your input camera. The digital filter is then anchored and overlaid on top of your face, the marker.[43] The user can actively participate in creating the experience, which is a vital element in storytelling the Technocene.

2.2.2 Virtual Try-On

AR is also a tool that is used for marketing and sales. Online fashion sales platforms offer virtual try-on services. This is a form of marker-based AR in which a user takes a video of themselves to create a marker of their face and then virtually put on articles of clothing or eyewear.[44] The experience and the technology resemble AR face filters, where they can anchor virtual content and overlay it onto the real environment. This has the potential to be translated into situated time travel, where the stories of the past or future can be digitally overlaid and anchored to the real world.

43. "What's Behind Augmented Reality Face Filters? – Quantilus Innovation." n.d. Accessed July 8, 2024. https://quantilus.com/article/whats-behind-augmented-reality-face-filters/.
44. Huffman, Mark. "If You Use Virtual Try On Software Your Face and Body Images May End up in a Database." December 9, 2022. https://www.consumeraffairs.com/news/if-you-use-virtual-try-on-software-your-face-and-body-images-may-end-up-in-a-database-120922.html.



Fig. 2.2 Virtually trying on shoes
image by ronstik, 2021, https://www.istockphoto.com/photo/virtual-fitting-room-woman-trying-on-shoes-online-with-digital-tablet-gm1341853099-421458097

2.2.3 Sky guide

Sky Guide is a Location-based AR application that is similar to Pokémon GO. The app allows users to stargaze more interactively. It starts to identify stars, constellations, and planets by automatically adjusting the viewing direction on the device.[45] The technologies being utilized in this application are GPS sensors and accelerometers within mobile devices. These sensors help locate where the AR content can be generated by accessing the location information and the orientation and movement of the user. This methodology is highly applicable for storytelling in the Technocene, where users can start to discover stories situated in specific parts of the city where AR content can be visualized.

45. Altynpara, Evgeniy. "Location-Based Ar Apps Development: The Absolute Guide." n.d. Cleveroad Inc. - Web and App Development Company. Updated October 17, 2023. https://www.cleveroad.com/blog/location-based-ar-apps-development/.

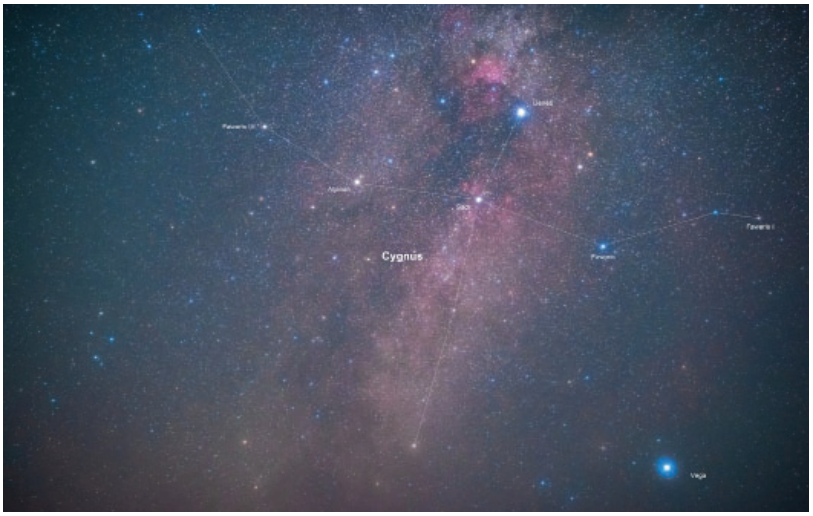


Fig. 2.3 Marking out constellations in the sky
image by bjdlzx, 2021, https://www.istockphoto.com/photo/cyhnus-in-the-milky-way-and-the-bright-deneb-star-gm1335028887-416926710?searchscope=image%2Cfilm

2.2.4 Ikea Place

Ikea Place is an AR application developed by Ikea. It utilizes superimposition AR to place furnishings into the user's spaces virtually. This technology gathers real-world data, such as planes and their locations within the environment, through cameras and ray casting. Through this technology, the 3D furniture models can be placed on invisible planes located above the floor.[46] Plane detection technology is critical in storytelling the Technocene because it translates real-world data to anchor and place objects in the experience.



Fig. 2.4 AR furniture app visualizing armchair in the room
image by Miroslav Georgijević, 2022. https://www.istockphoto.com/photo/augmented-reality-interior-design-gm1369710702-439419033.

46. "Launch of New IKEA Place App – IKEA Global." n.d. IKEA. Accessed July 8, 2024. https://www.ikea.com/global/en/newsroom/innovation/ikea-launches-ikea-place-a-new-app-that-allows-people-to-virtually-place-furniture-in-their-home-170912/.

2.2.5 Sandbox AR

'Sandbox AR' is an educational projection-based AR that will project topographical data onto a sandbox, changing the projected topography as the sand in the sandbox changes its shape and form.[47] Unlike the other forms of AR, this methodology does not utilize a handheld device to act as the input device, the sensor, or the screen. Instead, these factors are split between a camera that records the changes in the topography of the sand and the sensors that are linked with the camera to send this information to the projector, which will project topographical lines onto the sand. When thinking of the applicability of this technology to storytelling in the Technocene, it would be very good at creating stories situated in specific locations but is limited in creating a portable experience because of its setup.

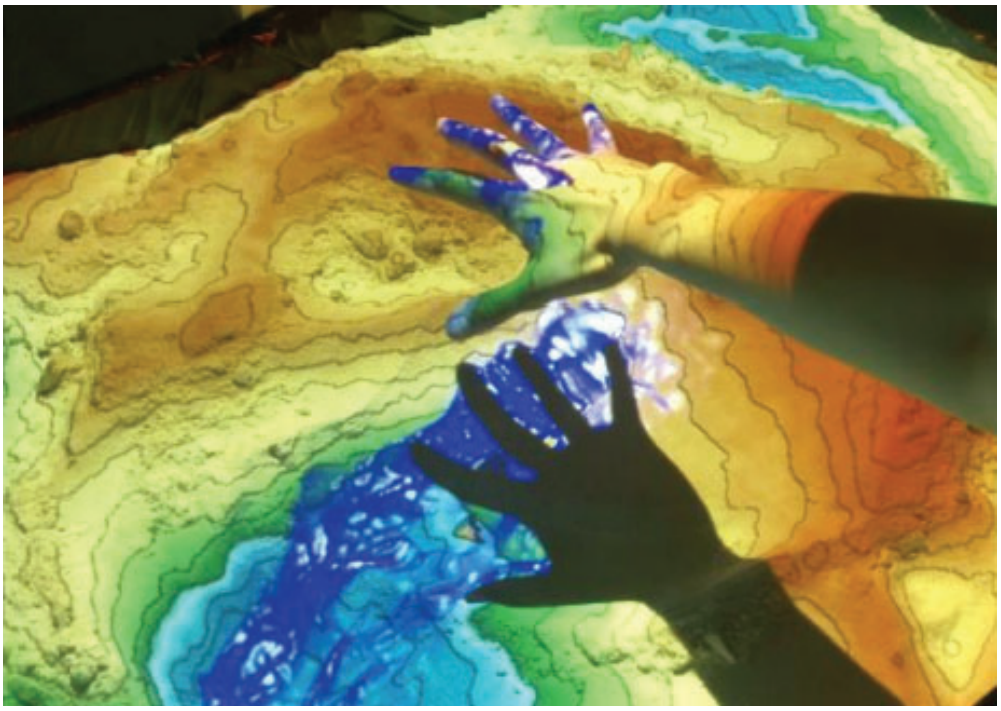


Fig. 2.5 AR Sandbox using projection AR image by Rebekka Bärthele, 2023

47. Reed, Sarah, et al. "Augmented Reality Turns a Sandbox into a Geoscience Lesson." July 26, 2016. http://eos.org/science-updates/augmented-reality-turns-a-sandbox-into-a-geoscience-lesson.

The review of existing AR applications utilizing marker-based and marker-less methodologies of visual AR finds both methodologies appropriate for telling a situated story of the Technocene because of their ability to actively engage the users and the ability to layer and anchor digital content. Both methodologies engage the user to participate through the use discovery. Finding a marker to generate content or finding the geographical location to discover the AR experience are methods that make this experience participatory. Using markers and plane detection allows the experiences to anchor overlaid content to the real world. This can be developed into situated time travel, where the digital content constitutes past and future visual stories. With the potential of existing AR products, we need to analyze research utilizing such technologies in design and architecture to gather specific technologies utilized on a scale similar to the scales of stories the thesis aspires to visualize.

2.3 Augmented Reality in Architecture

It is valuable to assess AR's use in architecture because the scale of objects and environments being used are similar to the physical scale of AR stories for the Technocene. Situated urban stories engaging the Technocene benefit from taking place in cities. Thanks to their varying scales of buildings and materials, urban areas allow for a rich collection of locations and stories. These locations can range from smaller objects to sewage drains and bricks to alleyways and buildings. With these scales, the Technocene stories will connect to more extensive networks, which could address impacts on the city itself. Architecture also formulates within a similar standpoint regarding scale in buildings, streets, and communities. Therefore, by analyzing AR technologies utilized in architecture, we can collect feasible AR technologies for visualizing the technocene.

The potential of AR and its ability to layer additional information into the existing reality has attracted architectural researchers to study it and incorporate it into their workflow. These studies and research projects incorporate AR utilized to display the Building Information Model (BIM), AR for public participation in Urban Planning, and AR for revitalizing public space. The projects in the studies will be measured and reviewed to gather information and insight on how parts of their work could be ultimately utilized for situated urban storytelling of the Technocene.

In Chapter 1, we have looked at the criteria for pedagogical storytelling to better educate the Technocene framework. From these criteria, we have derived a new criteria for situated urban storytelling for the Technocene narrative. The two most important goals in each criterion shown in Figure 1.5 were to engage and interact with the audience and to be able to situate the stories in the environment. Considering these goals from Chapter 1 and assessing the feasibility in terms of approaching the AR technology, the following will be the criteria on which evaluation will be made to assess these studies shown in figure 2.8: **interactivity** and ability to engage users, ability to be utilized in **public spaces**, effective **representation**, **approachability** or the threshold and cost of technology (sensors, applications, devices), and the **learning** curve for the technology and software being utilized. The projects will be marked on a scale of 0 to 5, where the higher the number, the more successful the project is at meeting the criteria. As a result of this analysis, we can gather AR technology and appropriate techniques in terms of scale for situated storytelling of the Technocene, which would later be used to assess existing AR Tools.

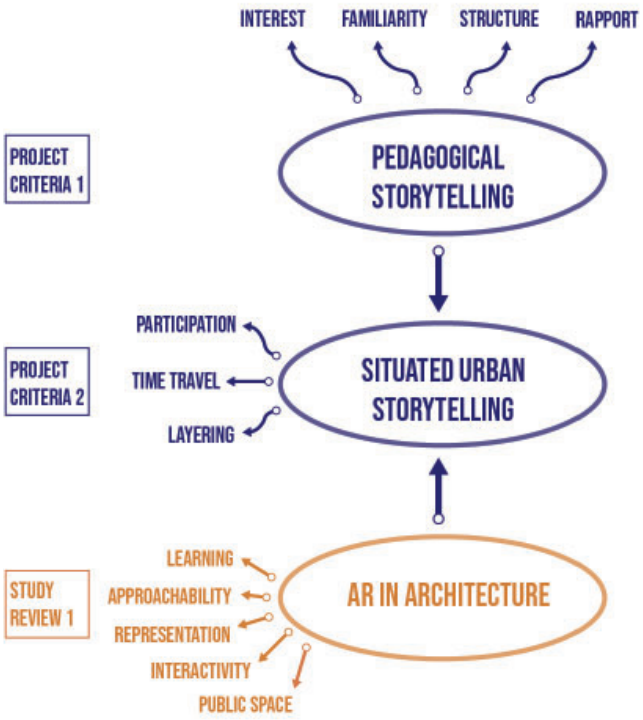


Fig. 2.6 Diagram illustrating the storytelling criteria for AR in Architecture

image by author, 2024.

2.3.1 BIMxAR for Architectural Learning

This is a literature review of 'BIMxAR: BIM-Empowered Augmented Reality for Learning Architectural Representations' by researchers: Ziad Ashour, Zohreh Shaghaghian, Wei Yan

Ashour, Ziad, et al. "BIMxAR: BIM-Empowered Augmented Reality for Learning Architectural Representations." 2022.

This research project uses AR and BIM to improve the understanding of architectural representations and achieve AR-integrated learning for students. The BIMxAR uses a type of Marker-less AR that relies on the device's GPS and IMU (accelerometer).[48] The users can locate and overlay building information of an existing building through this type of AR. This project overlays the technical building information such as structures, material configurations, and sectional views onto an existing building to help understand the building components in more detail. In this project, users can start to select building components like curtain walls and view their attributes.[49] This tool is the beginning of developing a more interactive platform to understand the buildings we inhabit.

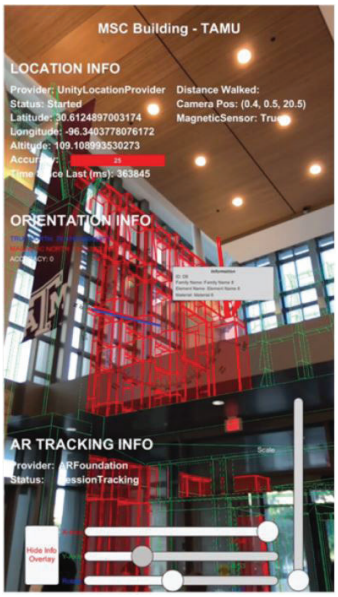


Fig. 2.7 First registration using GPS and IMU of interior
image by research team led by Ziad Ashour, 2022

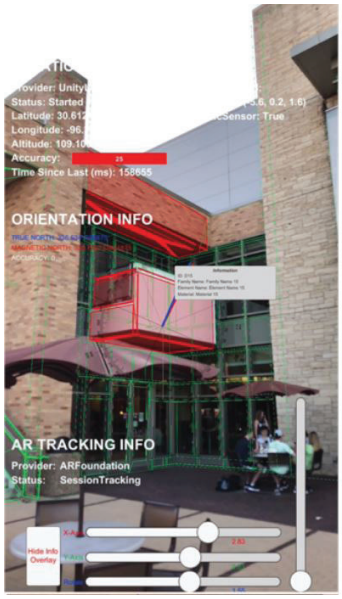


Fig. 2.8 First registration using GPS and IMU of exterior
image by research team led by Ziad Ashour, 2022

48. Ashour, Ziad, et al. "BIMxAR: BIM-Empowered Augmented Reality for Learning Architectural Representations." 2022. 3-4.
49. Ibid, 9-10.

We can start by assessing the project's interactivity to evaluate this tool. This project is a moderately interactive experience that allows users to explore the building through an AR BIM model to learn more about the built environment. To create this interaction, the users utilize UI buttons and their physical movement and orientation to experience the building.[50] However, the project does not further entertain the users due to the predetermined experience. This project is therefore marked with a score of 3 in terms of interactivity.

Leading into the use of public space, this project only utilizes public space holistically but rather is confined within a building. The AR experience in this project takes place exclusively at the Memorial Student Center building on the Texas A&M University Campus.[51] Although it is a public space, it is limited to the building, and there are limitations in exploring spaces adjacent to the building and its relationship to other buildings and public spaces. This project is therefore marked with a score of 2 in terms of use of public space.

The representation method utilized in the research project could be more approachable and visually engaging. The project utilizes visual trackers and UI to help orient the user in the building and illustrates building components with a wireframe model.[52] This is effective and efficient in delivering information. However, there could be room for entertainment to better engage the users with information, such as building components that may be monotonous to the untrained eye. This project is therefore marked with a score of 2 in terms of representation methods.

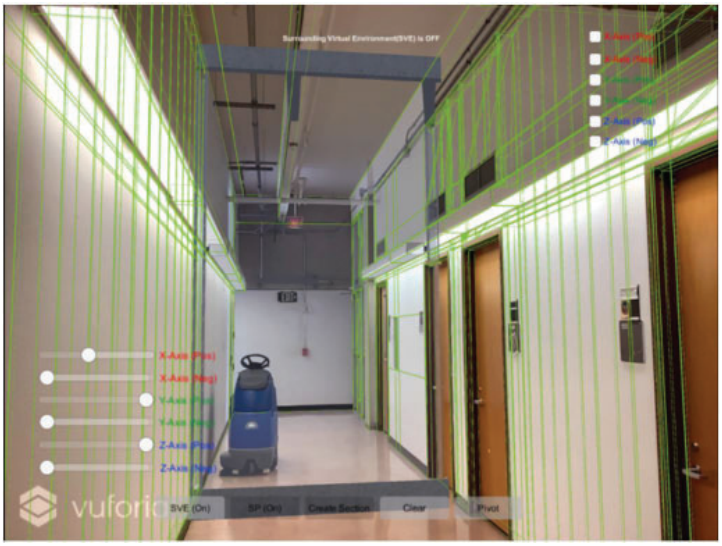


Fig. 2.9 Augmentation with BIM wirefram model, with sliders to control location and orientation
image by research team led by Ziad Ashour, 2022

50. Ashour, Ziad, et al. "BIMxAR: BIM-Empowered Augmented Reality for Learning Architectural Representations." 2022. 20.
51. Ibid, 4.
52. Ibid, 10-11.

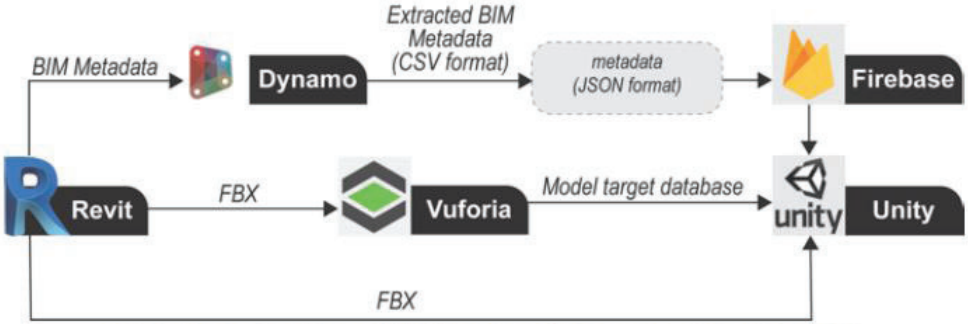


Fig. 2.10 Workflow of programs

image by research team led by Ziad Ashour, 2022

In terms of approachability and the cost of technology, this project is quite successful in being accessible for development. The project utilizes Unity and its in-house AR Foundation in combination with the Vuforia engine to generate the AR experience.[53] Unity and Vuforia engines are both free applications for students. They utilize approachable, smart devices that are easily found, like an iPhone or an iPad, to host the application. Because of their use of low-cost and approachable technology, the approachability of this project is marked with a score of 4.

Finally, regarding the learning curve of software utilized to develop this project, the project requires a moderate amount of learning to achieve the AR experience. This project utilizes BIM software, Vuforia, and Unity.[54] It is challenging to achieve working proficiency in all three software applications and implement location-based alignment in the AR experience. This project is therefore marked with a score of 3 in terms of a learning curve in the software.

53. Ashour, Ziad, et al. "BIMxAR: BIM-Empowered Augmented Reality for Learning Architectural Representations." 2022. 4-5.
54. Ibid, 10.

As a result of analyzing the 'BIMxAR' research project, the software and the methods utilized in this project are moderately applicable to telling the story of the Technocene. The software utilized in this project is approachable in terms of software and technology and is highly applicable to achieving the story's situatedness using location-based AR. However, the representation methods need to be revised to create enthusiasm in users when directly applied to stories of the Technocene. This leads to issues in interactivity, which can be affected negatively, along with the project's existing problems in its predetermined experience, which inhibit engagement. Therefore, by utilizing the software and technology and using different methods in the representation and usage of public space, we can start to visualize a more interactive method catered to the story of the Technocene.

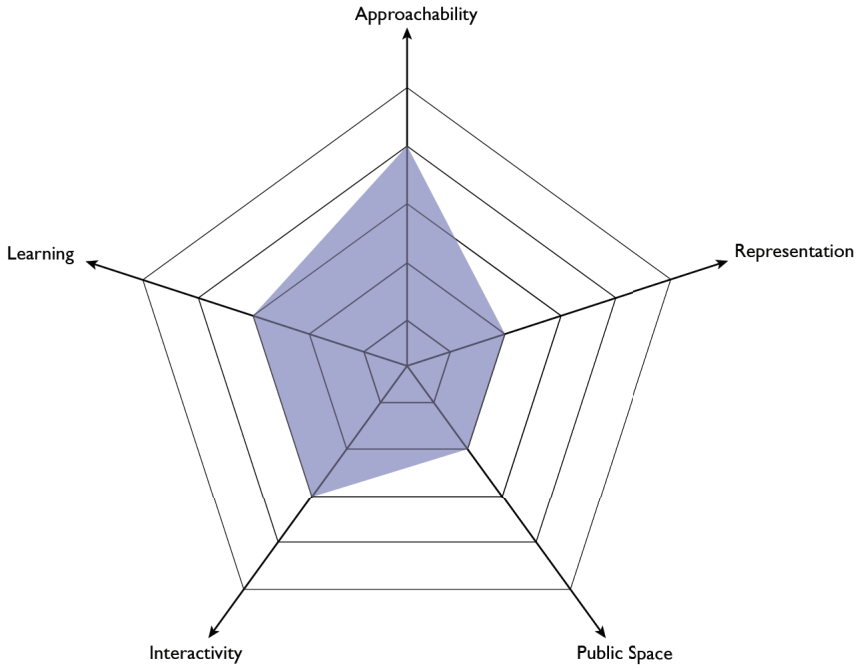


Fig. 2.11 Diagram of Criteria for BIMxAR

image by author, 2024.

2.3.2 AR Public Participation in Urban Planning

This is a literature review of 'An augmented reality study for public participation in urban planning' by researchers: Ursina Boos, Tumasch Reichenbacher, Peter Kiefer, Christian Sailer

Boos, Ursina Christina, et al. An augmented reality study for public participation in urban planning, Journal of Location Based Services, 17:1, 48-77, 2023. DOI: 10.1080/17489725.2022.2086309

This research studies the effectiveness of AR in representing new developments in urban settings to the untrained eye in comparison to traditional methods in architectural representation like 2D plans, perspective sketches, and physical models.[55] The research was conducted by engaging the public in an AR app that visualizes a 3D model of a potential new building. The users were given three levels of detail (LOD) in the visualization and were asked to answer a questionnaire on its effectiveness compared to traditional representation methods.[56] This research aims to help the public understand urban planning and building design and its impact on the environment through AR technology.



Fig. 2.12 Construction spans visualizing prospective devleopment

image by research team lead by Ursina Boos, 2023.

55. Boos, Ursina Christina, et al. An augmented reality study for public participation in urban planning, Journal of Location Based Services, 17:1, 48-77, 2023. DOI: 10.1080/17489725.2022.2086309. 48-50.
56. Ibid.



Fig. 2.13 Three LOD in a perspective view compared

image by research team lead by Ursina Boos, 2023.

We can start by assessing the project's interactivity to evaluate this research tool. This project was moderately interactive within the actual application itself. However, it was interesting how surveys were conducted to create data on the efficacy of AR outside of the experience itself. The application utilizes location AR and superimposition to visualize the prospective building on its site.[57] Although it is not the focal point of the study, it would have been interesting to gather information about the site and its adjacencies through interaction within the AR itself. This project, therefore, is marked with a score of 3 in terms of interactivity.

This project is successful in terms of its ability to engage users in public space. It engages the users in the process of visualizing future building developments and further creating new public spaces. This engagement is made by giving the users agency in picking out what kind of visualization technique and what level of detail is helpful in understanding the visualization of future buildings. This project, therefore, is marked with a score of 4 in terms of use of public space.

57. Boos, Ursina Christina, et al. An augmented reality study for public participation in urban planning, Journal of Location Based Services, 17:1, 48-77, 2023. DOI: 10.1080/17489725.2022.2086309. 54-55.

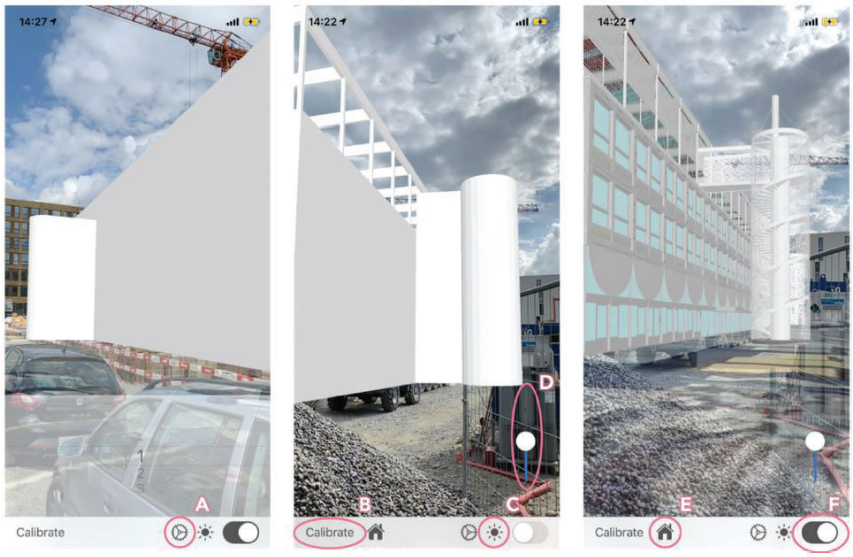


Fig. 2.14 Three LOD in AR interfaces compared

image by research team lead by Ursina Boos, 2023.

In terms of representation, this project does not excel at representing the AR content in its context. The project seems monotonous in its visual stylistic choice in the range of LOD, but this is understandable considering the context of the study. Potentially, an additional LOD could be made where more textures, materials, and glazing could start to make the AR representation more realistic. This project, therefore, is marked with a score of 2 in terms of use of public space.

This project is good at utilizing approachable technology. The methodology utilized in this project includes 3D modeling software to generate the buildings and integrate the model into an AR application utilizing Swift and ARKit 3.[58] These tools utilized are quite approachable as they are available free to use. Also, counting on the fact that these applications were designed to interact with the public utilizing personal handheld devices, it lessens the threshold in terms of the cost of technology. This project, therefore, is marked with a score of 4 in terms of approachability.

The learning curve of this methodology is also quite approachable, considering it is a straightforward implementation of GPS AR without the need to place the 3d model and make it fully interactive. There are also only a few numbers of programs that are needed to achieve this level of AR. This project, therefore, is marked with a score of 4 in terms of use of its learning curve.

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58. Boos, Ursina Christina, et al. An augmented reality study for public participation in urban planning, Journal of Location Based Services, 17:1, 48-77, 2023. DOI: 10.1080/17489725.2022.2086309. 54-55.

As a result of assessing this project's capabilities with our criterion, we can find that the usage of public space, the technology, and its threshold to learning the technology is quite applicable for implementing AR visualization of the Technocene. This application utilizes public space and its users to help engage in creating their communities by helping them understand the implications of new developments. The software and devices utilized in this project are free and deployed on accessible devices like smartphones. The structure of how the application is made is also quite linear, from the 3D model and the AR software to the application. However, how the application interacts with the users is limited and is also represented monotonously, limiting the spark of interest from users. As a result, from this application, we can learn from its choices in technology and its app structure and implement a better representation of AR content to increase interactivity when designing the AR story of the Technocene.

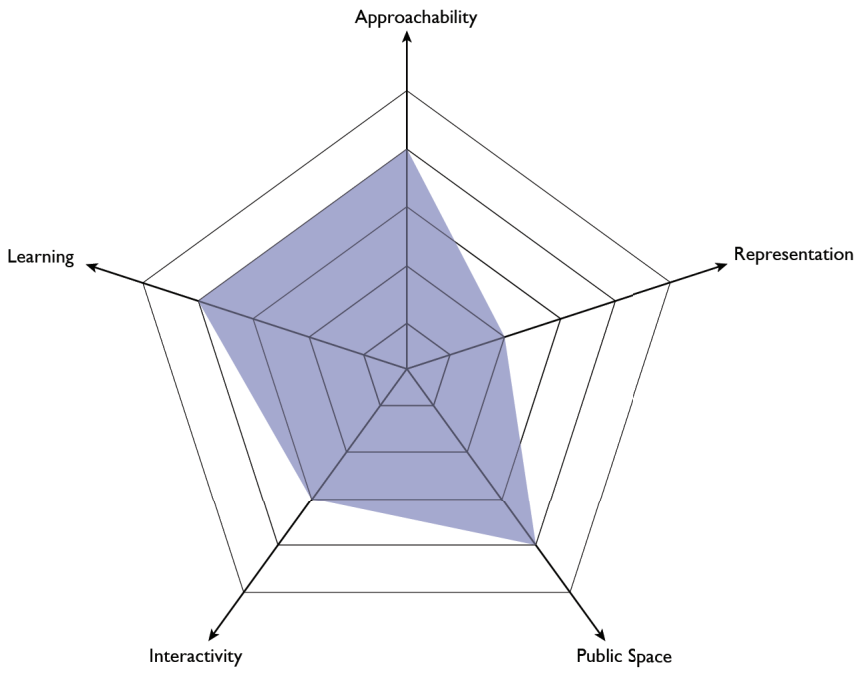


Fig. 2.15 Diagram of Criteria for AR Public Participation in Urban Planning

image by author, 2024.

2.3.3 Public Space revitalization through Augmented Reality

This is a literature review of 'Merging the Physical and Digital layer of public space' by researchers: Chiara Farinea, Aretti Markopoulou, Aldo Sollazzo, Angerlos Chronis, Mathilde Marengo

Farinea, Chiara, et al. "Merging the Physical and Digital Layer of Public Space - The PobleJoc Installation Case Study." 2017. 10.52842/conf.ecaade.2017.2.725.

This study assesses the possibility of AR in bridging physical and digital spaces in an urban street setting in Barcelona through a series of physical installation projects. This project is a collaborative installation from five architectural schools in Barcelona. It utilizes the public streets of Barcelona and hosts spaces for interaction through furniture like table tennis tables, benches, urban planters, and market stalls.[59] Each of these furniture modules would have a QR code to be detected by a mobile AR app, displaying layered information about the modules and their activities. AR apps also utilize drones to detect the movement of these furniture modules and inform users of their locations.[60] This project aims to utilize AR to enhance public spaces by creating unexpected expressive public spaces and forms of self-organized activities by the users.

The project excels in terms of interactivity. It has various uses in which AR could be incorporated into the urban setting. The users engage in various physical experiences, like table tennis, lounging, and markets. They further enrich this experience by utilizing the AR application. Not only does the AR application inform the users about information about the modules, but it also provides locations to engage users in the discovery of public spaces throughout the city. This project is thereby marked with a score of 5 regarding interactivity.

Additionally, the study revitalizes public use of space in a more dynamic manner using AR. The furniture modules not only provide various experiences but also inform people of natural life, physical activity, and social interactions with AR. This project is thereby marked with a score of 4 regarding public space.

59. Farinea, Chiara, et al. "Merging the Physical and Digital Layer of Public Space - The PobleJoc Installation Case Study." 2017. 10.52842/conf.ecaade.2017.2.725. 727-728.
60. Ibid.

In terms of representation, the minimal visuals in the AR make the delivery of information obvious and coherent. The type of AR the experience wishes to deliver is also relatively straightforward, being primarily text-based UI. This helps simplify the content that needs to be represented and makes the UI interactions more linear. This project is thereby marked with a score of 4 in terms of representation.

This project utilizes highly approachable technology through the use of marker-based AR applications and devices that are cost-effective. An example of software that could be used for marker-based AR is Vuforia or Unity, which is free to use. It does not require too much sophistication in terms of devices, and it is easily deployed on smart devices. Overall, the technology being used is quite approachable, marking this project at a score of 5 in terms of approachability.

In terms of the technology's learning curve, this project is also approachable with its use of Marker-based AR. It is a less complicated option than its counterpart, Marker-less AR because it only requires a physical marker for augmentation. The choice of AR technology keeps the learning curve relatively low in this project. Therefore, this project is marked with a score of 5 in terms of learning curve.

As a result of assessing this project's ability with our criterion, we can find that this project excelled in every criterion. This project was especially successful in representation, interactivity, and the use of public space, which were criteria that were often found deficient in the other two projects. This success had to do with the focus of the project being specific on revitalizing public space through interactive activities bridged by augmented reality. The AR content was clear and coherent so as not to distract the users from this engagement. With this last assessment, we must now conclude how certain limitations and benefits of the three projects can be applied in designing the story of the Technocene.

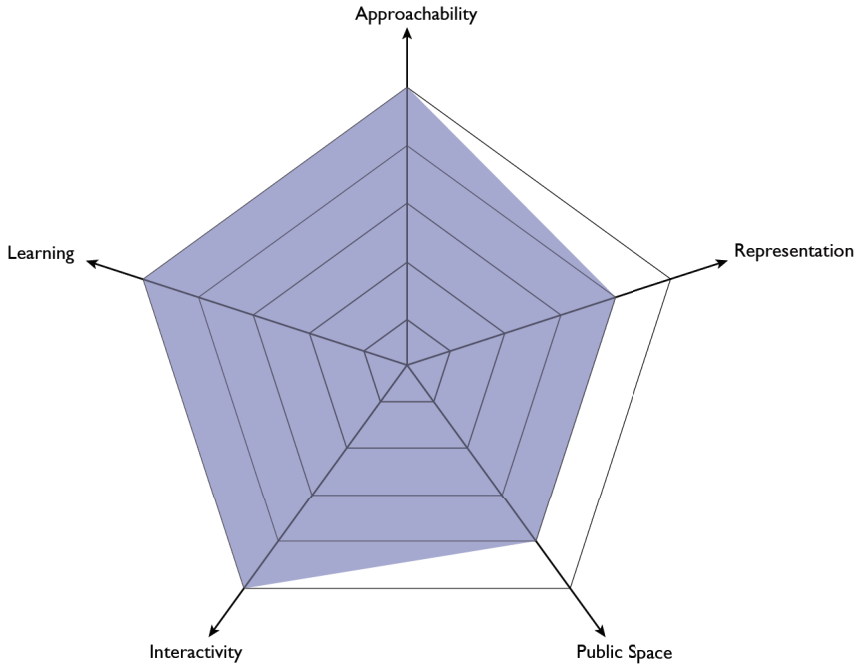


Fig. 2.16 Diagram of Criteria for Public Space revitalization through AR
image by author, 2024.

The assessment of these three projects utilizing AR in the field of Architecture, Urban design, and community engagement, we learn that the process of designing an AR experience is a balance of coherent representation (UI) and the desired interaction in the public space being defined by the capabilities of the technology. The AR content's representation should enhance the users' interaction with the public space and engage the users in the experience. However, this process highly depends on what type of technology is available. In the projects that were assessed, the technologies utilized include marker-based AR and forms of marker-less AR, such as superimposition AR and GPS AR. These projects have also used more specific technologies like plane detection, occlusion, and UI interaction. Understanding the technology's capabilities precedes the stories, interactions, and representation. Thus, we must analyze the technologies vital for creating situated urban storytelling of the Technocene before we start the design process.

2.4 Augmented Reality Technologies

To create and imagine an AR application, it is useful to analyze and map out the exact technology needed to create each interactive experience. A few examples of AR applications will be assessed on their usage of plane detection, occlusion, image detection and tracking, and UI Interaction and how and where they could be utilized to tell the story of the Technocene.

2.4.1 Plane detection

Plane detection is one of the most valuable technologies in AR, as it allows the application to read the environment and the existing planes to place digital objects seamlessly into the environment. In the research paper 'Public Participation in urban design with augmented reality technology based on indicator evaluation' written by Yuchen Wang and Yin-Shan Lin, the usage of plane detection technology is a crucial workflow used to place digital objects in the real world.[61] Through Unity, they were able to utilize ray casting to form point clouds where the rays collide with inanimate objects in the environment, then started to use the points to compute planes in the environment. Once the plane is successfully detected, the digital content can be placed on top of the coordinates of the plane to be manipulated through UI and gestures to align and move the object for placement.

This technology is also highly applicable and valuable when storytelling the Technocene. We can use this technology to not only place 3D objects into the environment but also to place 2D images. We can also initiate storylines if these images or objects are placed in the correct coordinates, improving the users' interactivity. This will immerse the users in the AR experience and allow them to explore the storyline by having an agency to interact with their environment.

61. Wang, Yuchen, and Yin-Shan Lin. "Public Participation in Urban Design with Augmented Reality Technology Based on Indicator Evaluation." Frontiers in Virtual Reality 4 (April): 1071355. 2023. https://doi.org/10.3389/frvir.2023.1071355.

2.4.2 Occlusion

Occlusion in AR environments is crucial in immersing users in the environment in a more realistic way. Occlusion is the technology to wrap detected planes, such as walls and furniture, with an invisible material shader to hide any portion of the digital content that is meant to be hidden away according to the spatial setting of the environment.[62] If we were to spawn digital objects into the environment without occlusion shaders, the 3D objects would be seen floating around in space, disregarding the spatial orientation of the environment. An example would be a scene with a 3D digital person walking out of an alley into a street. Without occlusion, the person would not be hidden from the wall while walking out but rather look like the person is floating above the wall. Therefore, implementing occlusion in AR environments makes the experience more realistic and more enjoyable as it portrays the world the way it is in real life.



Fig. 2.17 Occlusion technology used to occlude digital water plane with wall

image by author, 2024

62. Alfakhori, Muhammad, Juan Sebastián Sardi Barzallo, and Volker Coors. 2023. "Occlusion Handling for Mobile AR Applications in Indoor and Outdoor Scenarios" Sensors 23, no. 9: 4245. https://doi.org/10.3390/s23094245

2.4.3 Image detection and image tracking

Image tracking is also crucial when the AR content needs to be precisely located at specific points in the environment. Image tracking is used when specific data or images are required to be shown and linked to particular objects and conditions in the environment. The camera will scan the environment to find the image or the marker and then will be able to generate content on top of the detected image. This will be useful in applications where certain buildings or physical materials must be tagged with digital objects for an immersive AR experience.

This usage of image tracking fits in very nicely when designing the AR stories of the Technocene. Stories and information can be spawned by detecting images of real-life objects and linking the Technocene network through the tracked image. This would enhance understanding by showing a direct correlation between objects and their material, social, and economic histories.



Fig. 2.18 Image tracking used to place content on tracked image

© Copyright 2024 PTC, "Image Targets | Vuforia Library." n.d. Accessed June 3, 2024. https://developer.vuforia.com/library/objects/image-targets.

2.4.4 Interaction using User Interface

Enhancing interactivity in the AR experience by using User Interface (UI) buttons and sliders is essential. In designing the AR stories of the Technocene, UI sliders would be a crucial tool to introduce interactivity through UI buttons and situated time travel. UI markers/buttons can be located on particular objects in the AR experience to be pressed and to reveal information and context about each object. UI sliders can trigger different content according to the slider's position when dragged by hand gestures. This can become a time slider and achieve situated time travel by creating a chronological flow and order in the story and the experience. Through these methods, we can enhance understanding through creating an interactive experience. Having identified the viability of such technology for this thesis, we must assess existing tools and platforms that contain these technologies to discern which platform would be the more appropriate and approachable in designing the stories of the Technocene.

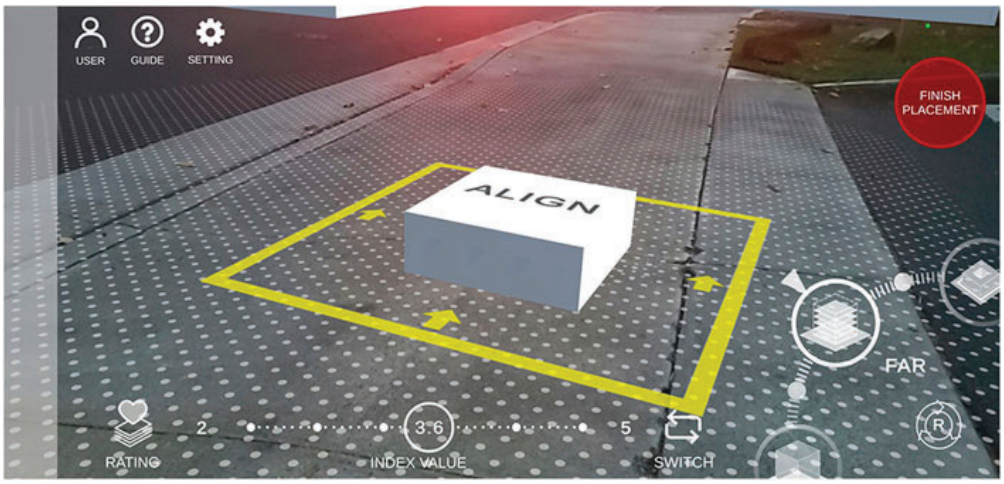


Fig. 2.19 UI interaction shown through the various buttons.

Image by Yuchen Wang and Yin-Shan Lin. 2023.

2.5 Augmented Reality Tools

Various developments in AR tools and software have accompanied the interest in AR and its rising popularity. Many of these tools support marker-based AR and different forms of marker-less AR. These tools facilitate developers in exploring AR through a more user-friendly method with facilitated interfaces. By assessing existing AR engines and platforms' capability to perform the technology assessed from the AR examples in chapters 2.3 and 2.4, we can decide on the most approachable and effective option to design the situated urban stories of the Technocene.

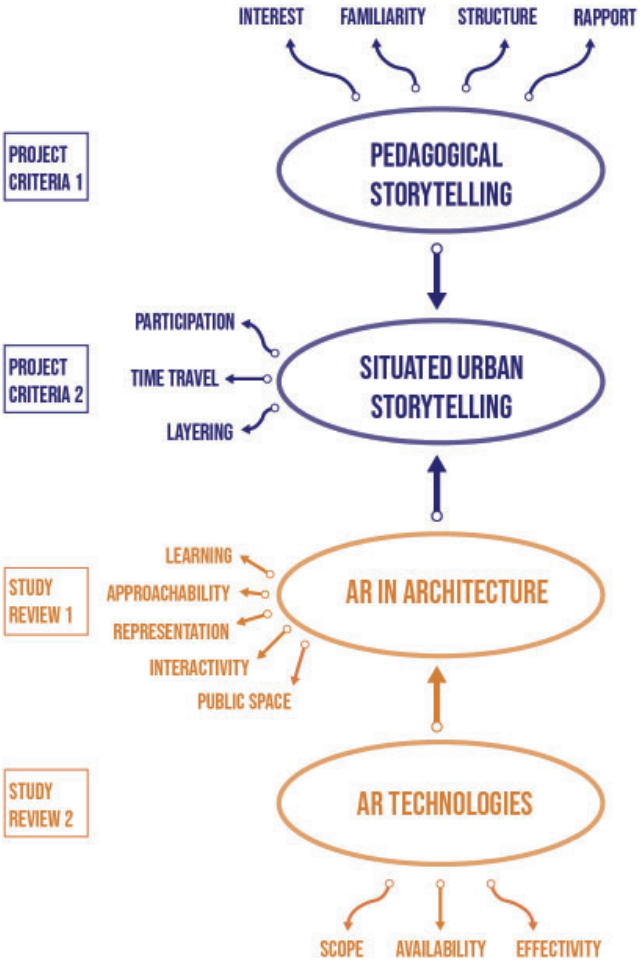


Fig. 2.20 Criteria for AR Technologies image by author, 2024.

The efficacy of each AR engine in storytelling the Technocene will be assessed using the criteria shown in figure 2.25: the **scope** of technologies included in the program, **availability** in terms of supporting platforms and cost, and **effectivity** and appropriateness to the Technocene's subject. This criterion is derived from the criteria utilized to assess AR in Architecture in order to more directly fixate a program to test for the purpose of designing the story.

2.5.1 AR Toolkit

AR Toolkit is an open-source software development kit (SDK),[63] a software library for building AR applications. It has various software and technology within the toolkit, allowing it to perform image tracking, plane detection, and UI buttons.[64] It utilizes computer vision algorithms to calculate real-time camera position and orients AR content relative to the movement by tracking markers in the image from the camera.[65]

When assessing the AR Toolkit with our criterion, we found that it performs very well regarding the scope of the provided software, availability, and effectiveness. In terms of scope, the AR toolkit offers Global Positioning System (GPS) and compass integration, camera integration, and automatic detection of markers.[66] It can be utilized for both marker-based AR and marker-less GPS-based AR. It also supports Linux, macOS, Windows, Android, and iOS platforms. It is also offered as a plug-in for Unity, a free-to-use application to deploy AR applications. This makes AR Toolkit a highly available program. In the context of storytelling, the Technocene AR Toolkit has all the prerequisite software to help perform situated time travel, UI interactivity, and overlaying of the real world with digital content. Because the program can meet all these prerequisites, the AR Toolkit is a viable option for storytelling the Technocene.

63. Artoolkitx.org "ArtoolkitX." artoolkitX. Accessed April 17, 2023. http://www.artoolkitx.org/.
64. Artoolkit. "Artoolkit/artoolkit5." Accessed April 17, 2023. https://github.com/artoolkit/ARToolKit5.
65. Lamb, Phillip. "ARToolKit." Artoolkit Home Page. Accessed April 17, 2023. http://www.hitl.washington.edu/artoolkit.html.
66. Vaniukov, Slava. "Mobile AR App Development Toolkit [Updated for 2020]." Medium. Quick Code, May 21, 2020. https://medium.com/quick-code/mobile-ar-app-development-toolkit-updated-for-2020-71708633e0b6.

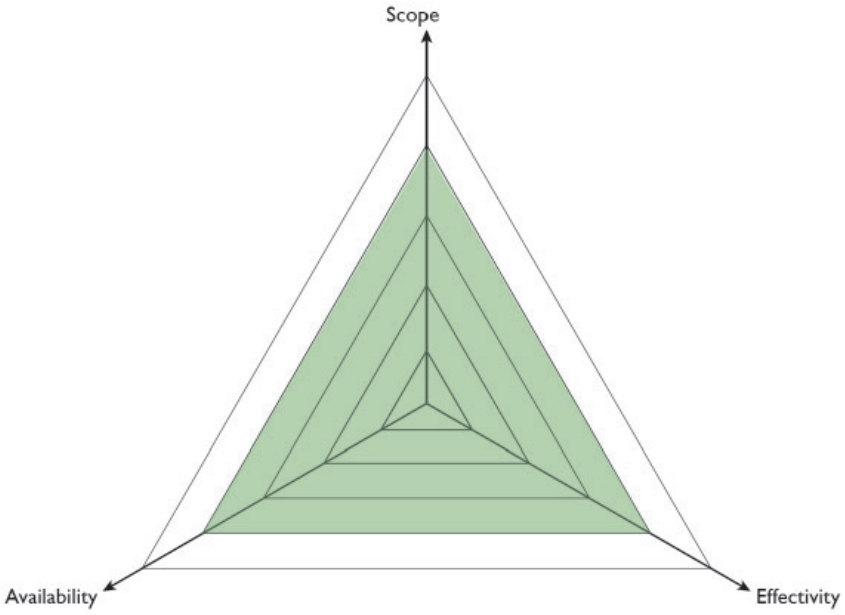


Fig. 2.21 Diagram of Criteria for ARToolkit image by author, 2024.

2.5.2 ARCore

Google's ARCore is an AR "SDK that offers cross-platform APIs to build immersive experiences on Android, iOS, Unity, and Web."[67] Various projects were created using ARCore, including an AR concert stage by Gorillaz.[68]

ARCore excels in all criteria, including scope, availability, and effectiveness. In scope, ARCore offers motion tracking, anchors(markers), depth and environment understanding, and light estimation. ARCore can detect flat surfaces like floors to start understanding the environment, the structure, and the lighting conditions so that AR content can be placed correctly and conditioned.[69] AR is also highly available, already included in the Unity AR Foundation package, and is free to use. This makes it even more available than AR Toolkit, which must be installed as a plugin. ARCore also effectively narrates the Technocene thanks to software like plane detection and environment understanding. This helps with accurately placing AR content onto the real world, allowing the program to perform effectively in situated time travel and overlaying content to the real world. Since the program can meet all the prerequisites of visualizing the Technocene stories while being highly available, ARCore is a highly viable option for this thesis.

67. "Build New Augmented Reality Experiences That Seamlessly Blend the Digital and Physical Worlds" Google. Accessed April 17, 2023. https://developers.google.com/ar.
68. Silva, Stevan. "Gorillaz Turn the World into a Stage with Augmented Reality." Google. Google, December 14, 2022. https://blog.google/products/google-ar-vr/gorillaz-maps-music-video/.
69. "Build New Augmented Reality Experiences That Seamlessly Blend the Digital and Physical Worlds" Google. Accessed April 17, 2023. https://developers.google.com/ar.

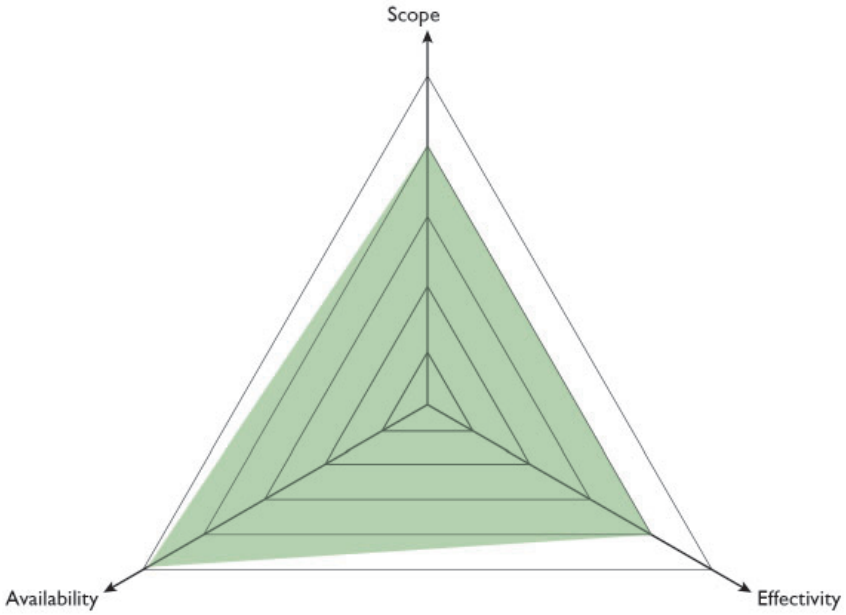


Fig. 2.22 Diagram of Criteria for ARCore image by author, 2024.

2.5.3 Vuforia Engine

The Vuforia engine is an AR SDK that incorporates advanced computer vision functionality to allow the AR application to recognize images, objects, and spaces to interact AR content with the existing environment.[70]

When assessing the Vuforia engine with the criterion, the Vuforia engine excels in scope and effectivity but could be better in terms of availability. The Vuforia engine has a vast scope in terms of AR application development. It can recognize images, track targets, scan objects, and use virtual buttons. It adds another layer of interactivity with the user.[71] It is also available as a plugin for the Unity game engine, which supports Android and iOS. The Vuforia engine could be better regarding availability as only limited access is granted with the free basic plan compared to the paid alternative. Like the other programs, Vuforia is highly effective in its potential to visualize the stories of the Technocene. It meets all the prerequisites of situated time travel and overlaying of information. However, the limited availability trumps the benefits of the Vuforia engine.

70. "Getting Started with VUFORIA Engine in Unity." Getting Started with Vuforia Engine in Unity | VuforiaLibrary. Accessed April 17, 2023. https://library.vuforia.com/getting-started/getting-started-vuforia-engine-unity#about.
71. Vaniukov, Slava. "Mobile AR App Development Toolkit [Updated for 2020]." Medium. Quick Code, May 21, 2020. https://medium.com/quick-code/mobile-ar-app-development-toolkit-updated-for-2020-71708633e0b6.

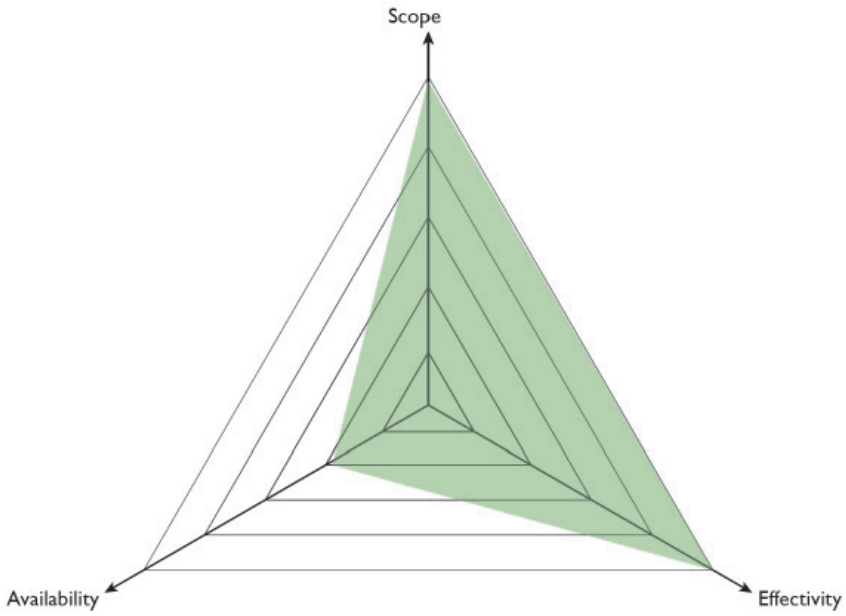


Fig. 2.23 Diagram of Criteria for Vuforia engine image by author, 2024.

As a result of assessing the existing AR engines and platforms, ARCore is the most viable engine for storytelling in the Technocene. ARCore is very approachable and utilized on different platforms; many are free. It can also perform marker-based and marker-less AR and additional technology like GPS AR, ray casting, and plane detection. These tools and technology can help the AR experience achieve situated time travel, layering of information over the real world, and improve interactivity for the users. Being practical and approachable, ARCore is a viable engine for storytelling in the Technocene. Having identified the most appropriate AR engine, we can now begin to select stories to be visualized.

Chapter 3

Stories of Water

In this thesis, the Technocene framework will be told in stories of Toronto's waters due to its significance in geography, ecosystem, and culture. In Toronto, the water exists in all parts of the city in the form of a lake, a ravine system that includes deep ravines and forests, and even sewers made of lost rivers. The geographical abundance of water helps us find glimpses of the exploitative relationship water has with technology, spanning from the past to the present and even the future. This complicated context with water in Toronto makes it a vital story to be told and highlighted in the Technocene in a situated storytelling manner.

Being the core necessity of most living things in our ecosystem, water has been a commodity heavily engineered to suit human needs in cities. Water has undergone commodification for industries of growing cities, altering natural water systems with sewers and water treatment facilities. Technology is evident in the construction of these facilities, industries, and the engineering of water. This alteration also leads to infringing water's significance in terms of cultural values.

Culturally, water has great significance in indigenous communities. Water is a "sacred [...] lifeblood that flows through lakes, rivers and oceans" for many indigenous communities.[1] However, with the growth of cities and industries, water's cultural significance has been neglected, leaving it subject to contamination and commodification. Despite this history of ecosystemic and cultural neglect and its geographical abundance, it is difficult to find and learn wholistic stories of water, including their cultural and economic drivers, technology, and outcomes. Therefore, this thesis aims to uncover these stories through the lens of the Technocene to promote a visual understanding.

72. C. B. C. "Water Is Sacred to Indigenous People. They Have Been Fighting to Protect It for Decades | CBC Radio." CBC. April 22, 2023. https://www.cbc.ca/radio/unreserved/water-is-sacred-protecting-1.6818685.

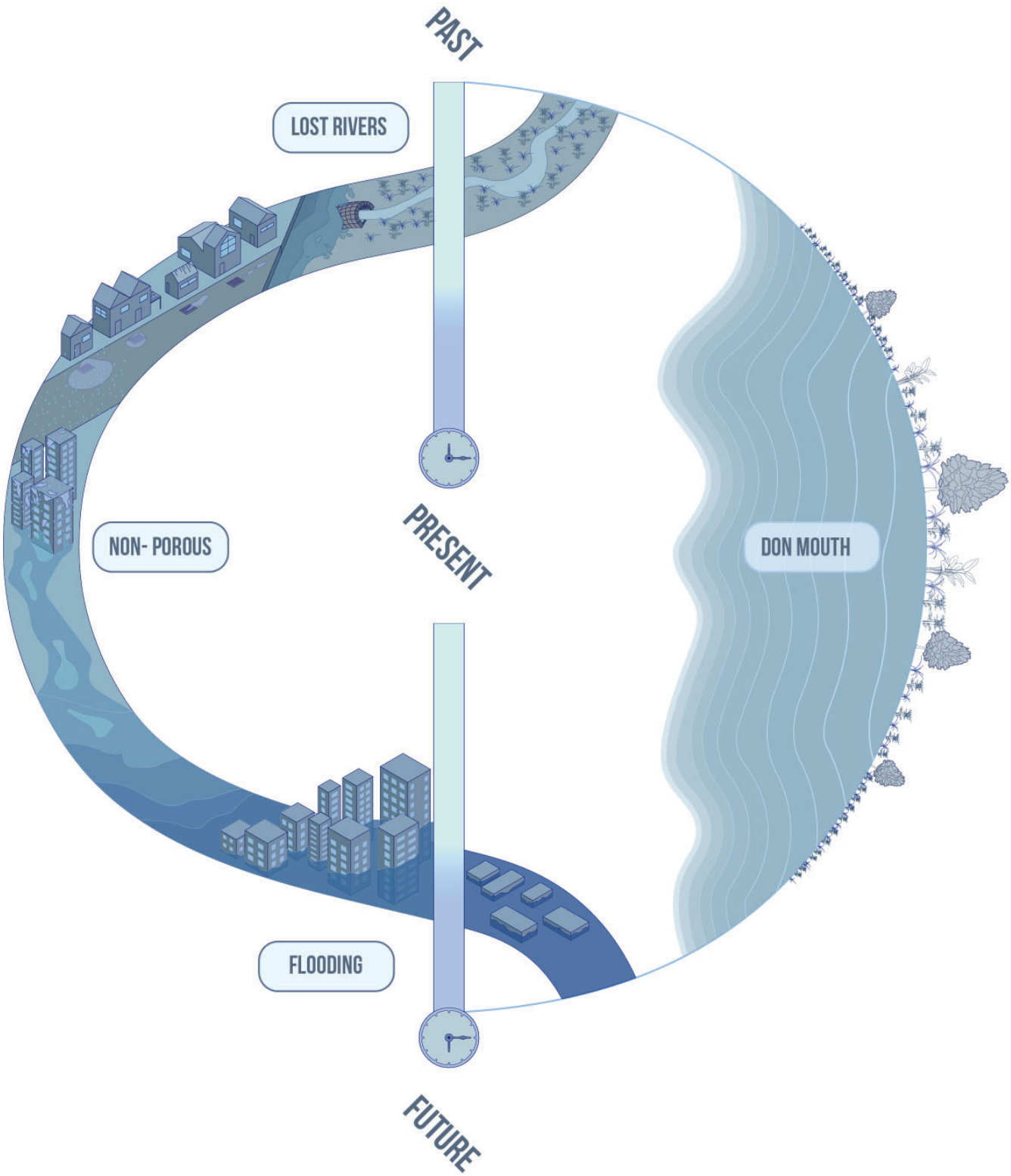


Fig. 3.1 Diagram showing the relationship between the stories of water image by author, 2024.

This chapter presents stories that highlight different aspects of water in the Technocene through different timeframes and how water has been altered and affected due to technology and engineering in Toronto's growth. The selected sites respectively highlight the story of lost rivers, the story of porosity, the story of flooding, and the story of naturalization in the Don Mouth. The stories have been structured to allow for situated time travel to tell the overall course of the water cycle and its relation in history, the present, and the future. The sites and their stories follow along a path that moves from the west of Downtown Toronto to the east end of Toronto beyond the Don Valley.

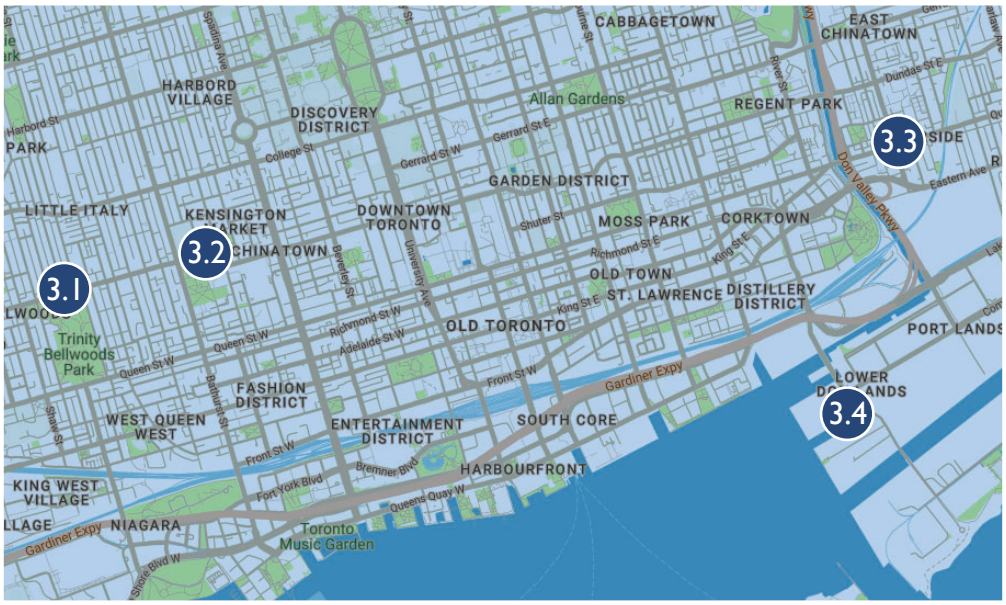


Fig. 3.2 Map of Toronto showing site locations of stories with sub-chapter numbers
Image by author using Google Maps, 2024.

3.1 Story of Lost rivers

Prior to settlements, Toronto blossomed with a network of vast water systems. However, the growth of Toronto came with a change in the water systems enacted through technological development in the scale of the city. An example of such change is the rivers and ravine systems in Toronto, which have been lost along with the growth of Toronto ever since 1802.[73]

73. "Lost Rivers of Toronto Map." n.d. Accessed March 3, 2024. https://www.lostrivers.ca/disappearing.html.

Garrison Creek is one of the ravine systems that has been lost. As opposed to its purpose of being a part of the water cycle in the past, it now serves a different purpose as an underground sewer system, flowing under the city instead of along the city surface.[74] The site is located where the traces of Garrison Creek can be found today, at Trinity Bellwoods Park.

In this story, we will examine the story of Garrison Creek's transformation in Trinity Bellwoods Park. The story will include the general history of Garrison Creek, the social drivers that pushed for such transformation, the change in a streetscape that resulted from the transformation, and the social and environmental implications of such change.

3.1.1 History of Garrison Creek

Garrison Creek is a ravine system developed about 12,000 years ago, developed from the retreat of glaciers.[75] Civilization has utilized the creek for various uses, gradually shifting its state and shape to eventually burying it underground. The park has undergone many physical changes in the landscape, significantly impacting the river-sewer transformation. Despite these transformations, some cultural characteristics of the creek still remain today, being a local sledding location in the winter.[76] These combined traits, rich historical context, and importance for local activity make it a great location to tell the story of lost rivers in the Technocene through situated urban storytelling.

To understand why Garrison Creek was transformed, we must understand the social position of the creek in its context and the social drivers that initiated the transformation. Initially, the settlements and civilization adjacent to Garrison Creek were farms and estates. These settlements utilized the creek as an open-air sewer to dispose of manure and other pollutants. Eventually, these pollutants started to create discomfort in the community's livelihoods. This created the need for the creek to be "buried in the 1920s"[77] However, a century ago, sewers were not designed for the growing population and expanding city infrastructure. As a result, we can start to monitor instances of the system failing, even within the premises of the park in extreme weather conditions.

74. Bateman, Chris. "A Brief History of Garrison Creek, Lost but Not Forgotten." n.d. Accessed March 3, 2024. https://www.blogto.com/city/2012/03/a_brief_history_of_garrison_creek_lost_but_not_forgotten/.
75. "Garrison Creek." ArcGIS StoryMaps. November 1, 2022. https://storymaps.arcgis.com/stories/6a8c76e97a134f9d8cb2a3dcf12c2b1a.
76. Bateman, Chris. "A Brief History of Garrison Creek, Lost but Not Forgotten." n.d. Accessed March 3, 2024. https://www.blogto.com/city/2012/03/a_brief_history_of_garrison_creek_lost_but_not_forgotten/.
77. "Garrison Creek." ArcGIS StoryMaps. November 1, 2022. https://storymaps.arcgis.com/stories/6a8c76e97a134f9d8cb2a3dcf12c2b1a.



Fig. 3.3 Burying the creek to replace open air sewer with an underground sewer
Wikimedia commons, Digging a sewer along Garrison Creek, 1890s



Fig. 3.4 Construction of the new sewer, photographed from within the sewer
City of Toronto Archives, Fonds 200, Series 376, File 1, Item 15

Alongside the changes made to the creek itself, there were also changes in the context of the geography. The creek passed by Crawford Street, leaving a situation where a bridge was needed to connect the other sides of the creek.[78] The original wooden bridge was demolished for a new concrete arch bridge to be constructed in 1915. However, this bridge was wholly buried with soil excavated from the construction of the Line One subway line in the 1960s. This also concerns the bridge's lack of purpose without a stream of water underneath it. The burying of the bridge was executed to create more buildable land on the western side of the bridge and to designate the eastern side of the bridge as a park.



Fig. 3.5 Crawford Street Arch Bridge, what is now buried under the street
City of Toronto Archives, Fonds 1231, Item 1615, Crawford Street Bridge, West side, 1915

78. "Crawford Street Bridge." n.d. Read the Plaque. Accessed June 4, 2024. https://readtheplaque.com/plaque/crawford-street-bridge.

The geography was changed to better human life by utilizing technological methods such as sewer construction, bridge construction, and water management. The combination of geographical change to the creek and its adjacent environment and the juxtaposition of such historical fact to the status quo makes it a compelling story to be told through the lens of the Technocene.

3.1.2 Current state of Garrison Creek

Despite the transformation of the creek, historical stories have started being uncovered today with the efforts of individuals like Helen Mills and the Lost River Walks, introducing the lost rivers and changes that have happened to our water system to the public.[79] Some activities, like sledding along the creek's banks, are a shared story from the past to the present, still happening today on the hills of the park.[80]

There are also indications of the lost river at the site, shown in the form of stormwater drains and plaques indicating its history. However, the erosion near the sewer is an indication of the system being poorly maintained, possibly a sign from the creek wishing to be revitalized. Bringing more attention to these historical stories tied to elements of the present with situated urban storytelling will enhance understanding of the Technocene and its stories. By spanning through time and space utilizing augmented reality, the users can interact with the creek and its history and be immersed in the story it wishes to reveal.



Fig. 3.6 Stornwater sewer erosion blocking off access ofr public safety in Trinity Bellwoods Park
photograph by author, 2023.

79. "Introduction." n.d. Accessed July 1, 2024. https://lostrivers.ca/content/Introduction.html.
80. Bateman, Chris. "A Brief History of Garrison Creek, Lost but Not Forgotten." n.d. Accessed March 3, 2024. https://www.blogto.com/city/2012/03/a_brief_history_of_garrison_creek_lost_but_not_forgotten/.

3.2 Story of Porosity

When considering the city's relationship to water and rain, people are often more busy avoiding the puddles or water that form in irregularities of the asphalt and concrete that make our streets. It is easy for people to disregard why our city reacts in such a way to water and where the water ends up. This story desires to reveal how and why our cities are impermeable and works to help discover the implications to the environment in the non-porous city.

The City of Toronto has an expansive maze of streets and building blocks covering the city in engineered systems that repel and direct rainwater to sewers, modifying the environment's porosity. By studying a typical residential and mixed-use streetscape, we can assess the inner workings of the city and how it reacts with regard to water porosity. From this knowledge, we can form the foundations for the story of porosity. The following section will research the material histories of the building materials, the social drivers that caused the creation of such non-porous streets, and their impact on the overall water cycle.

3.2.1 Material stories of the city surface

Various building materials comprise the surface of the city. A street is made of concrete pavers, asphalt, and patches of grass and planters. These surface materials each have varying permeability to rain. In cases of impermeable materials, stormwater sewers take place in the streets to guide the runoff water to wastewater treatment facilities. To understand how water reacts within the city, we should try to understand the material properties of the building materials that compose our city in more detail. In Toronto, the asphalt and concrete used in the city are highly impermeable to water. To understand the impermeability of concrete and asphalt, we must understand its ingredients and related material stories.

Concrete, made of cement and gravel, has a maximum slope of 4% when utilized as pedestrian pavers and 2% on roads.[81] Concrete utilizes a mixture of gravel or crushed aggregate like limestone. When cured, the aggregates are bound with the cement to form a solid material impermeable to water. When we trace the material history of these aggregates, we find that they are sourced from nearby gravel pits of limestone quarries. An example of a quarry near Toronto is the Elora Quarry. Elora quarry and its rich limestone bedrock deposits have made it a local source for numerous building projects. It was commercially utilized for 18 years until its commercial life ended.

Within this time, the limestone from this site has been utilized as lime for plaster and mortar for projects in locations like Toronto following the "building boom" in 1918 and 1919.[82] Today, it is used in a somewhat different way. After clearing industries and their waste, it is now a local favorite for sunbathing and swimming.[83] Today, 75% of the gravel used in the Greater Toronto Area is sourced from the Oak Ridges Moraine and the Niagara Escarpment. These ecologically essential regions are home to 40% of Ontario's rare wildlife species, increasing a need for consciousness of the source of our building blocks in our city.[84]



Fig. 3.7 Elora Quarry, showing use for sunbathing and swimming
Evelyn Shepherd 1957. Wellington County Museum and Archives. A2010.66. ph 32304.

81. City of Toronto. "Construction Specification for Concrete Sidewalk and Concrete Raised Median." City of Toronto. 2016.
82. Thorning, Stephen. "Village's Quarry Created by Elora White Lime Co." Wellington Advertiser. August 8, 2019. https://www.wellingtonadvertiser.com/villages-quarry-created-by-elora-white-lime-co/.
83. Ibid.
84. "4. Where Our 'Virgin' Aggregate Comes From | Toronto Environmental Alliance." n.d. Accessed June 3, 2024. https://www.torontoenvironment.org/gravel/sources.

Asphalt is a material that can be seen wherever the city has roads for transportation. Like concrete, asphalt utilizes gravel and aggregate. However, for asphalt, a byproduct of petrol named bitumen is used as a binding agent. Being naturally water resistant, asphalt is not a porous material. Therefore, it must be applied with a slope of around 2% to roads and streets for irrigation.[85] Bitumen is a water-resistant material that is found in Canada. In Canada, Bitumen can be found in Alberta's oil sands in "Athabasca, Cold Lake, and Peace River. Bitumen has historically been utilized by the "Aboriginal people" to "caulk canoes." Asphalt paved streets in Alberta and Ottawa in the 1920s in the modern era.[86] Canada has one of the largest deposits of bitumen in the world, located in Alberta.[87] Not only does this bitumen travel through Canada to pave the roads and streets within the country, but it is also exported worldwide.[88] The street also consists of grass and soil that is either sparsely distributed along the street below the trees or in yards and parks. These two materials are more permeable than other solid materials, allowing water to be absorbed in the environment.

After recognizing the material of our impermeable street, we must learn why these highly engineered materials were chosen for the cities in the Technocene. Prior to the 20th century, the streets of Toronto were paved with wood or brick to escape the muddy streets that were prevalent in Toronto.[5] These materials were much more permeable and porous than their counterparts today. The grooves and openings between the materials allow rainwater to be absorbed by the soil underneath. However, brick streets were indicatively less modern, and wooden streets had sanitation issues and odor from horse urine.[89] The cycling lobby also played a part in the movement for Toronto to start to pave the streets of Toronto with a more modern and engineered asphalt material.[90] As a result of various social drivers like a desire for modernism and a better lifestyle, Toronto is left with a non-porous city fabric that poses concerns about its environmental impli-

85. Hildebrand, Eric D. "Cross Slope and Climate Change: Implications for Highway Design and Road Safety." 2021.
86. Gray, G. "Bitumen." 2013. https://www.thecanadianencyclopedia.ca/en/article/bitumen.
87. Pedchenko, Larysa, et al. "Development of Natural Bitumen (Bituminous Sands) Deposits Based on the Technology of Hydraulic Mining by Boreholes." Edited by V. Bondarenko, I. Kovalevska, F. Cawood, M. Hardygora, O. Malova, and R. Lysenko. E3S Web of Conferences 123: 01036. 2019. https://doi.org/10.1051/e3sconf/201912301036.
88. Government Of Canada, Statistics Canada. "Canadian Imports and Exports of Crude Oil and Bitumen." May 4, 2022. https://www150.statcan.gc.ca/n1/daily-quotidien/220504/cg-a005-eng.htm.
89. Moore, Oliver. The Globe and Mail. "Toronto's Forgotten History under Foot," June 21, 2019. https://www.theglobeandmail.com/canada/toronto/article-torontos-forgotten-history-under-foot/.
90. Ibid.

3.2.2 Implications of Impermeability

Implications arising from impermeable city surfaces derive from the disturbance in the water cycle caused by the depletion of underground aquifers due to the disparity of water absorption in the soil. When the water that the soil should have absorbed instead is directed to sewers and wastewater treatment facilities, it creates portions of the city where there are unequal amounts of water being absorbed by the soil. When this irregular pattern of water absorption is repeated, the soil is not given the expected natural amount. This hinders the ability of the underground aquifers to replenish, leading to depletion.[91] Depletion in the underground aquifers may lead to issues in the city of unsettling surfaces, sinkholes, and ecosystems failing.[92] Instead of the rainwater traveling into water bodies of lakes, rivers, and underground aquifers, the city in the Technocene started to bypass the underground aquifers and release treated water into lakes. This also leads to problems related to street permeability. It is essential to have permeable streets due to their ability to diminish the heat island effect in urban environments by cooling surfaces. It is also beneficial in mitigating runoff and filtering out pollutants from entering directly into our stormwater treatment facilities.[93] However, the current streets in Toronto typically do not respect these principles of street permeability and depletion of underground aquifers, making this story an important one to be told.

With this assessment, we can incorporate AR and situated urban storytelling to design an experience where building elements and their material components can be tracked to their sources and material history. This will create a deeper understanding of our cities' built environment and its relationship to water in terms of the porosity of the city fabric.

91. US EPA. `"Ground Water." Reports and Assessments. November 2, 2017. https://www.epa.gov/report-environment/ground-water.
92. Ibid.
93. Ibid.

3.3 Story of Flood

Flooding is a natural disaster that could happen in any part of the city. However, unforeseen levels of flooding can be expected in Toronto due to climate change. Moreover, the city's surface porosities do not allow water to be effectively absorbed by the environment, making cities introduce extensive measures to overcome such obstacles.[94] Such measures include storm water sewers and treatment plants that flow underground the city, replacing the various ravine and creek systems of the past. However, due to the design of the city's surfaces, flooding seems to be an inevitable future in Toronto. In this section, we will assess the story of flooding in Toronto and the impact of flooding on the community, transportation system, and wastewater system.

3.3.1 History of flooding in Toronto

Historical floods in Toronto have majorly affected Toronto, showing the potential danger of such activity in an urban city like Toronto. The 2013 flood in Toronto has left many lingering consequences, leading to numerous measures and plans by the city for preparations against future floods. Many of these measures are tied to the disturbances due to the flood. Occasions of floods start to disrupt the city's inhabitants' peace in terms of their housing, transportation, and economic repercussions.[95] In a city like Toronto, high-rise condominiums and other forms of housing populate the city. These forms of living utilize basements, elevators, and other forms of technology that the people rely on. However, the infrastructure we use for comfort is the main source of discomfort in times of flooding. Elevators and basements fill up with water, which completely inhibits escape. In the 2013 flood in Toronto, multiple incidents of citizens being trapped in elevators and basements were reported.[96] This history of floods leaves many doubts about the current mitigation tactics and the future of Toronto in cases of flooding.

94. Young, Jay. "The Toronto Flood of 2013: Actions from the Past, a Warning for the New Normal?" Active History (blog). July 16, 2013. https://activehistory.ca/blog/2013/07/16/the-toronto-flood-of-2013-decisions-of-the-past-a-warning-for-the-new-normal/.

95. Sills, David. "A Billion Dollar Flash Flood in Toronto – Challenges for Forecasting and Nowcasting." 28th AMS Conference on Severe Local Storms. 2016.

96. C. B. C. "A Decade Ago, Toronto Was Underwater. Here's What's Changed since the 2013 Flood | CBC News." CBC. July 8, 2023. https://www.cbc.ca/news/canada/toronto/10-years-after-historic-floods-in-toronto-city-reflects-on-whats-changed-1.6898788.

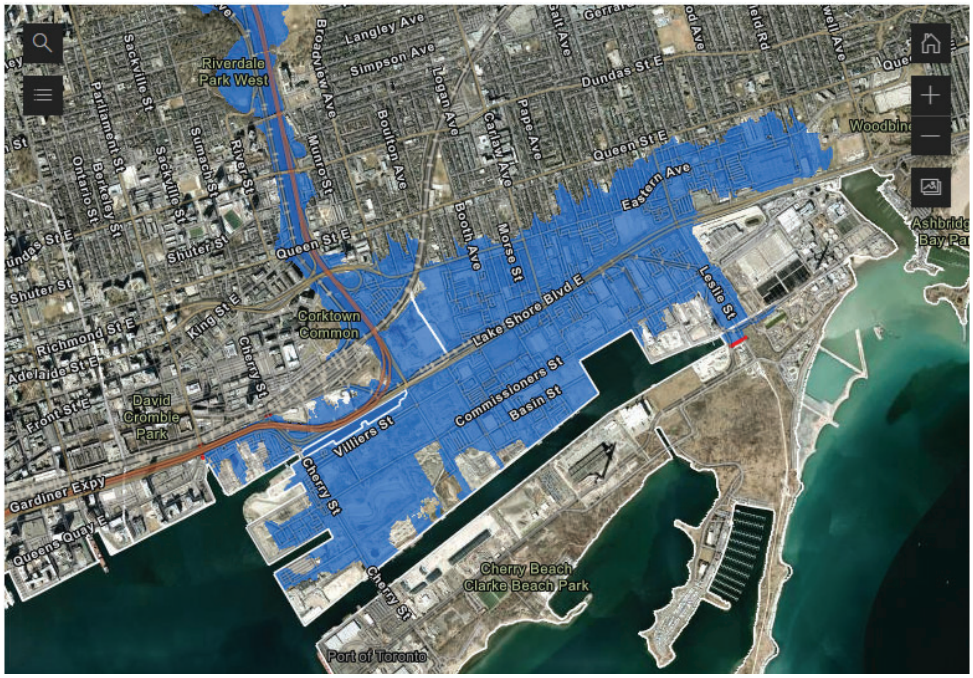


Fig. 3.8 Plan view of Toronto showing the TRCA flood plain to locate the proximity of the plain to Queen street

screenshot by author, 2024. https://trca.ca/conservation/flood-risk-management/flood-plain-map-viewer/.

3.3.2 The Future of Flooding in Toronto

The current floodplain in Toronto covers most of the Don's mouth and is very close to Queen St. West. Due to extreme flooding due to climate change, we can expect the flood to go beyond Queen St. west. The typical water speed in the Don River is $4m^3/s$, sometimes reaching a peak of $1700m^3/s$ in extreme storm conditions.[97] Toronto's stormwater system is not designed for weather with this intensity for modern citizens living in Technocene. Abnormal climates in the future will take advantage of the fragile sewer systems, ultimately resulting in natural disasters triggered by abnormal storm conditions. After the 2013 flooding crisis in Toronto, the City of Toronto has decided to update its sewer system with 3.1 billion dollars, spanning ten years since 2014. This commitment comes near to an end in this year of 2024.[98] Utilizing situated urban storytelling will benefit in telling the future impact of the Technocene in Queen Street West due to its situation being subject to a spread of flood in the future.

97. Corp, Pelmorex. "Why Toronto's Don Valley Parkway Floods so Often." The Weather Network. February 5, 2019. https://www.theweathernetwork.com/en/news/weather/forecasts/why-torontos-don-valley-parkway-floods-so-often.
98. P, John. "Remembering the Toronto Flood of 2013: July 8: Snapshots in History - Local History & Genealogy." 2017. https://torontopubliclibrary.typepad.com/local-history-genealogy/2017/07/remembering-the-toronto-flood-of-2013-july-8-snapshots-in-history.html.

3.4 Story of Naturalization

Ashbridges Bay Marsh, now called the Don Mouth, is a region that has been heavily affected and shaped by the growth of Toronto. Starting as a beautiful marsh with plentiful natural vegetation, which allowed for refuge for wildlife and migratory birds, it has been affected by the rise of industries and the growth of Toronto as a city. Today, the Don Mouth is undergoing a revitalization plan to restore the rich wildlife it once had while undergoing a cleanse of the contamination from past industrial activity. Highlighting and transporting the past, present, and future stories will be able to tell the situated Technocene story wholistically.

3.4.1 History of Ashbridges Bay Marsh

The historical Ashbridges Bay Marsh was what the Don Mouth used to be about 200 years ago. A rich environment with wildlife, including fish, muskrats, and birds, inhabited it. The rich wildlife provided to the early civilizations as a source of nutrition and industries like muskrat trapping. In the winter, the bay not only had recreational value in winter sports like skating, but the ice was sawed and cut to be stored in sawdust "until the following summer."[99] However, with growing livestock industries and settlements, the area became contaminated with sewage deposits by the 1880s.

An example is the cattle byres, which housed "up to 4000 head of cattle over the winter months" and emitted "up to 80,000 gallons" of manure drained into the marsh daily.[100] These concerns began the plan "to drain and fill the marshlands" to create a new port and land for industries.[101] By 1920, "only a fragment of the original Ashbridges Bay remained," leaving the wildlife and their habitats in danger due to geographic and systematic change in the ecosystem.[102] Once the industries began to be relocated out of the Don Mouth in the 1970s, there was a call for a new plan to bring back the ecosystem of the past in the Ashbridges Marsh Bay.

99. Herbert, Sam. "ASHBRIDGES BAY from MUD ROADS & PLANK SIDEWALKS Part 6." 2017. https://leslievillehistory.com/2017/11/13/ashbridges-bay-from-mud-roads-plank-sidewalks/.
100. Bonnell, Jennifer. "Don River Valley Historical Mapping Project." n.d. Accessed March 4, 2024. https://maps.library.utoronto.ca/dvhmp/ashbridges-bay.html.
101. Ibid.
102. Ibid.



Fig. 3.9 Drawing the Ashbridges Marsh Bay prior to environmental change Lucius O'Brien, 1873

3.4.2 Projected future of the Don Mouth

The Don Mouth Naturalization project resulted from a design competition in 2007 by Waterfront Toronto to finalize a master plan for the bay in 2014. The master plan became a ten-year project with various restorations of historical habitats, rehabilitation of water channels from the Don River, and the provision of recreational public space for Toronto.[103] The contaminated soil is covered and treated with black charcoal to filter contaminants and keep the water clean. Today, potential signs of naturalization are starting to appear in the construction sites in the bay. New species of fish are starting to return to the marsh. Seedlings stored under the contaminated soil have started to sprout, kept away in a time capsule for 200 years, waiting for a chance at life.[104] This brings hope to our waterways, recognizing the need for such change to bring balance to our ecosystem.

103. "Project Timeline." n.d. Waterfront Toronto. Accessed March 4, 2024. https://portlandsto.ca/project-timeline/.
104. Rassy, Swidda. "Here's What a $1.25-Billion Urban Regeneration Project Looks Like." Toronto Life (blog). June 7, 2022. https://torontolife.com/city/heres-what-a-1-25-billion-urban-regeneration-project-looks-like/.



Fig. 3.10 Don Mouth Master Plan by Waterfront Toronto

Waterfront Toronto, 2020, via https://dailyhive.com/toronto/new-waterfront-park-plan-toronto.



Fig. 3.11 Native plant seedlings escaping the time capsule

Vid Ingelevics and Ryan Walker 2022. via https://torontolife.com/city/heres-what-a-1-25-billion-urban-regeneration-project-looks-like/.

In this chapter, the story of Toronto's water was selected in this section based on their location along the city, the water cycle, and time. The story starts in the west of Toronto with the story of lost rivers, moving towards the east of the site in the order of the story of porosity, flooding, and naturalization. This linear progression of sites allows for a more engaged and holistic experience of Toronto, starting from park spaces to streets and to the lake. Each story also accounts for a portion of the water cycle, from the river, the rain, the collection of rain, and the lake. Different time periods of Toronto's growth as a city are also represented within each site, moving from the past of the lost rivers and the present-day impermeable building materials to the future of Toronto with rising flood plains. The story of naturalization provides a holistic approach, giving insight into the past of the Ashbridges Bay Marsh, the shift towards industrialization, and the future of revitalizing the Don Mouth.

These selected stories each contain the elements of the Technocene framework by delivering the drivers that introduced environmental change, the technology used in the process, and the implications of the outcome. Having selected appropriate stories to wholistically illustrate Toronto's water in the Technocene, it is possible to start designing visual stories with AR.

Chapter 4

Augmenting the Stories of Water

In this chapter, the stories of water researched in Chapter 3 will be designed into pedagogical situated urban stories using Augmented Reality. These stories will utilize UI elements like buttons, sliders, pop-ups, and gestures to help the user discover and learn about the stories of water to better understand Toronto's water through the lens of the Technocene framework. Various illustration techniques like sections, drawings, and other visual styles will aid the overall consumption of the information of the story.

The designed stories will be assessed on their success using three criteria: pedagogical storytelling, situated urban storytelling, and the criteria of illustrating the Technocene. This series of criteria, developed in the progression of the thesis, will serve as a guideline and framework to design the stories and mark the story's success. Pedagogical storytelling criteria require the creation of interest, delivering information in a familiar method, creating structure, and creating rapport with the audience. The criterion of situated urban storytelling consists of achieving situated time travel, garnering active participation, and visual layering information. In this chapter, the criteria for illustrating the Technocene are developed. It stems from the original goal of the thesis, to educate and portray the Technocene framework. This criterion looks at the complexity of the subject itself, whether or not the story includes all facets of the Technocene framework: the social drivers, the technology, and the outcome, or ecosystemic change. These criteria in Figure 4.0 will be made into a table for each section of the story to assess if the story meets all criteria elements.

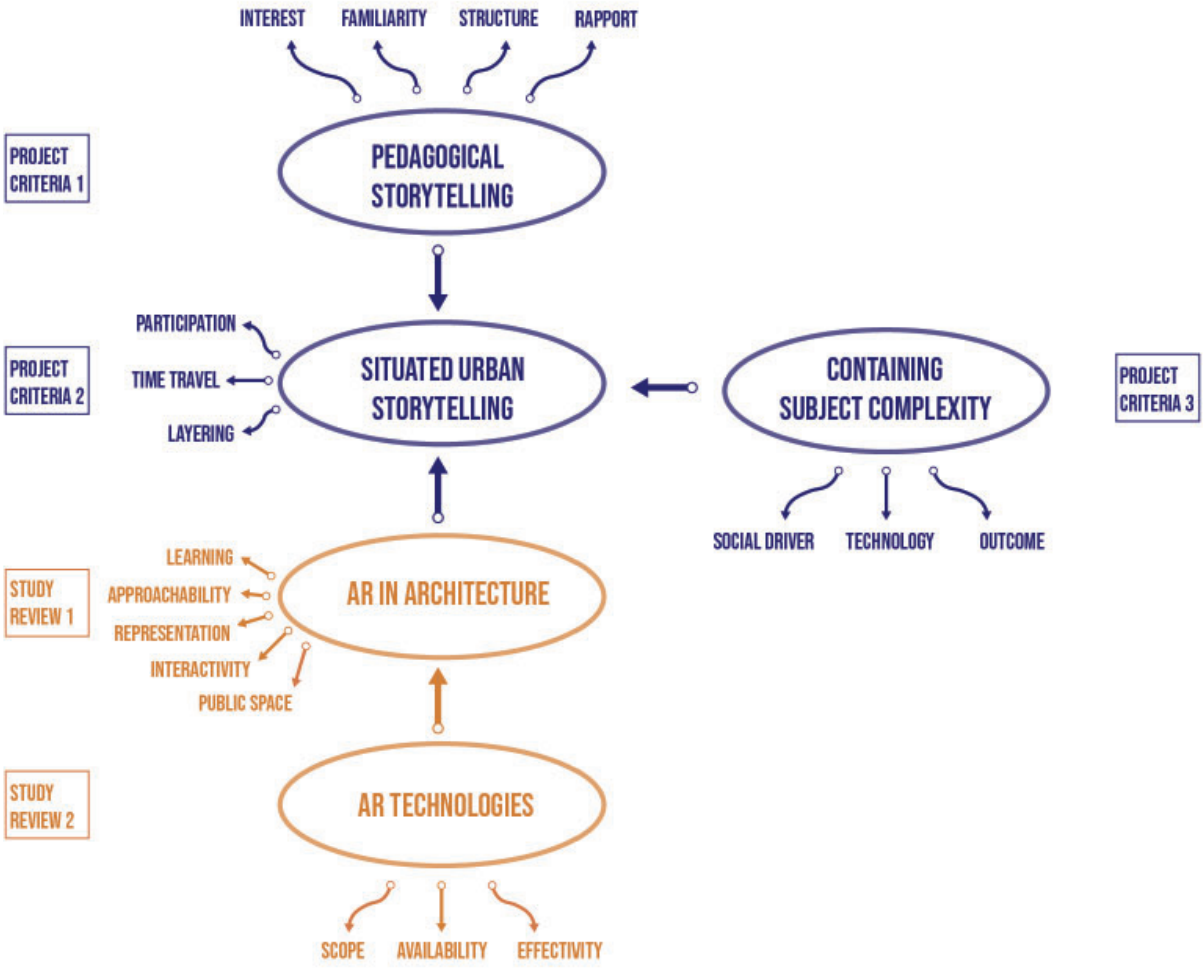


Fig. 4.0 Combined project criteria for the design of AR experiences image by author, 2024.

4.1 Story of Lost Rivers

This AR experience of the lost river, Garrison Creek, described in chapter 3.1, will be told through AR and situated urban storytelling. UI elements like time sliders, buttons, and gestures are used to help the users discover the past. This discovery will include social drivers like settlements and their pollutants transforming the creek into a sewer, the technology used to create this transformation, and the changes in the adjacent landscape like the Crawford Bridge. With this AR experience, users can better understand Garrison Creek and its lost ecosystem in the Technocene.

The experience begins with detecting the AR marker to trigger the narratives to appear. Once the scanning is complete, the users are given a time slider marking 5 different phases. Through this slider, the users can move chronologically from the present to the past, revealing the history of the lost river. The first time marker shows the present state of the sewer in its distress. The second time marker travels to when the Crawford Bridge was buried, addressing the changes in the adjacent landscape. The third time marker illustrates the Bridge before its burial. The fourth time marker moves into a time when the creek was buried and constructed into a sewer. Lastly, the fifth and final timeline visualizes the creek in its original state when the settlements began to pollute it, turning it into an open sewer.

Fig. 4.1.2 Marker located to spawn time slider
image by author, 2024.



UI to show scanning status

Time Slider, sliding the bar to span through different time markers

Marker being scanned by the camera

Fig. 4.1.1 Locating the marker to start the AR experience
image by author, 2024.

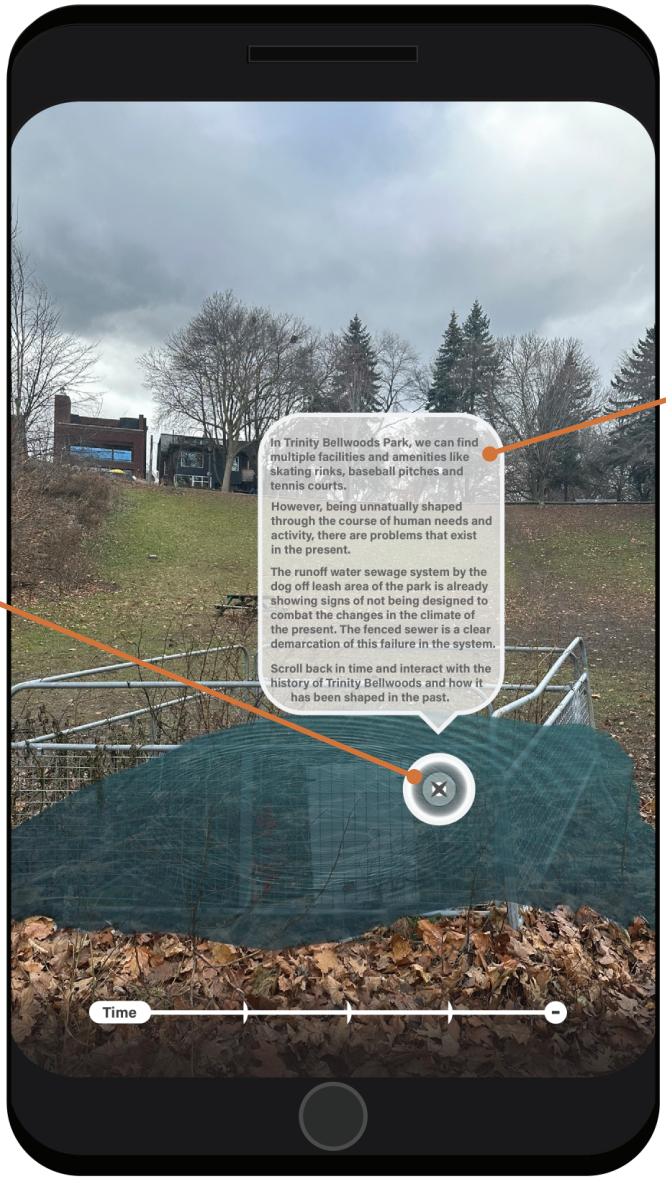


Fig. 4.1.3 Moving along time-line to access the first time marker
image by author, 2024.



The AR experience begins with detecting the marker. The marker can be anything with a distinct image in contrast to the background. In this case, we use the sign attached to the fences restricting the eroded sewer. When the marker is detected in Fig. 4.1.2, the time bar slider appears, which will act as a trigger to reveal stories looking into the past of Garrison Creek. In Fig. 4.1.3, we initiate the story's revelation by sliding onto the first time marker, the status quo of the failing sewer system in Trinity Bellwoods Park.

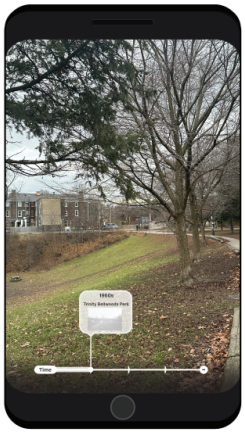
Fig. 4.1.4 Overflowing sewer shown above environment image by author, 2024.



Text Pop-up UI to deliver more detailed information

UI Buttons clicked to reveal Pop-up

Fig. 4.1.5 Moving along the timeline to reveal the second time marker created by author utilizing image: © City of Toronto Archives, Fonds 1231, Item 1615, Crawford Street Bridge, West side, 1915



By triggering the first storyline, we can see a flooded sewer with a UI button to reveal the story in text. After reading the text, the user can slide the time slider to the following time marker to return, as shown in Fig. 4.1.5. In this timeline, we can see an image in the pop-up UI above the time slider. Moving into Fig. 4.1.6, the user can slide this image outside the pop-up and stretch the image to the correct position to reveal visualizations of the historical bridge that rests under Crawford St.

Fig. 4.1.7 Soil covering the historical bridge, click to reveal the past bridge
image by author, 2024.



Pressing the UI button will trigger the next scene, revealing the bridge

Shaded area showing extents of the soil covering the bridge

Fig. 4.1.8 Uncovering the historical bridge
image by author, 2024.

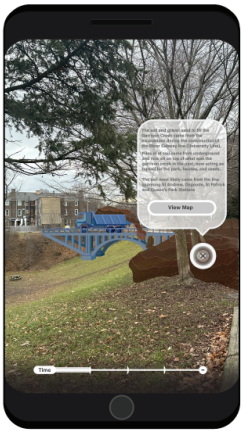


Image dragged to fit into space layered above the existing environment to trigger next scene

Fig. 4.1.6 Dragging the historical image of the bridge into place
created by author utilizing image: © City of Toronto Archives, Fonds 1231, Item 1615, Crawford Street Bridge, West side, 1915

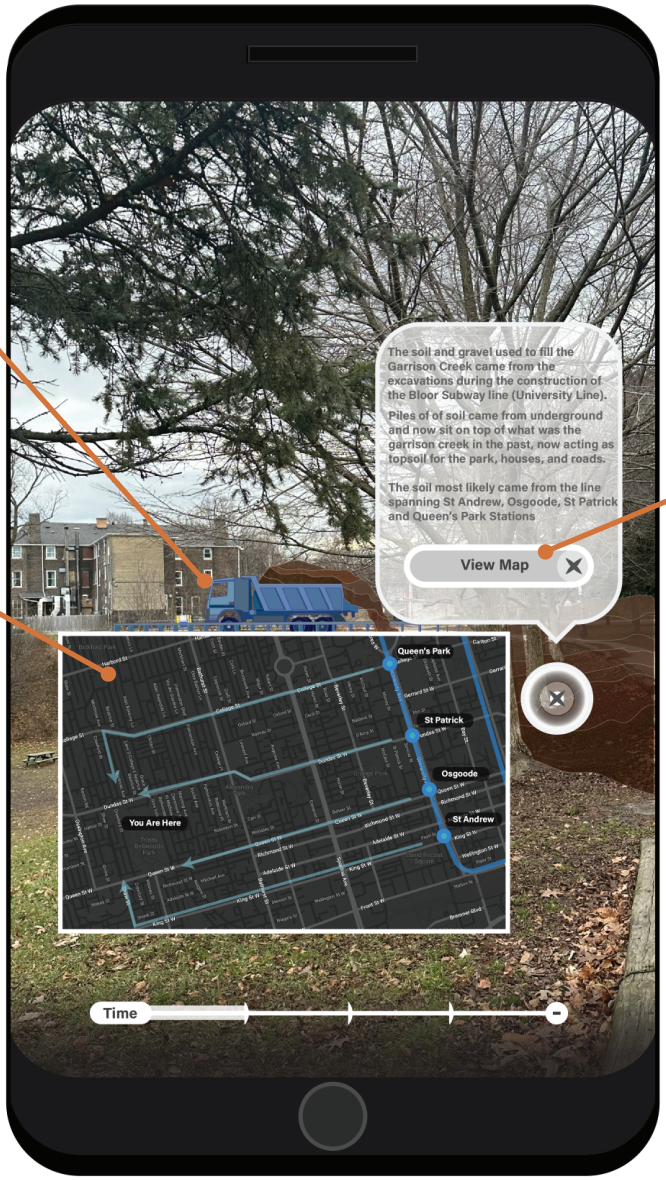


In Fig. 4.1.7, we can see the shaded location of the historical bridge. We can visualize how the historical bridge looked by clicking the " Reveal " UI button. In Fig. 4.1.8, we can visualize the bridge and the stories of how and where the soil buried the bridge came from.

Fig. 4.1.10 Visualizing a map of where the soil was excavated image by author, 2024.

Digital representations of the bridge, and the soil covering the site

Map showing the route of the soil being transported to site



UI button to reveal the map

Fig. 4.1.9 Uncovering Bridge

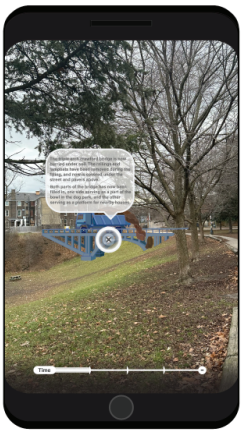


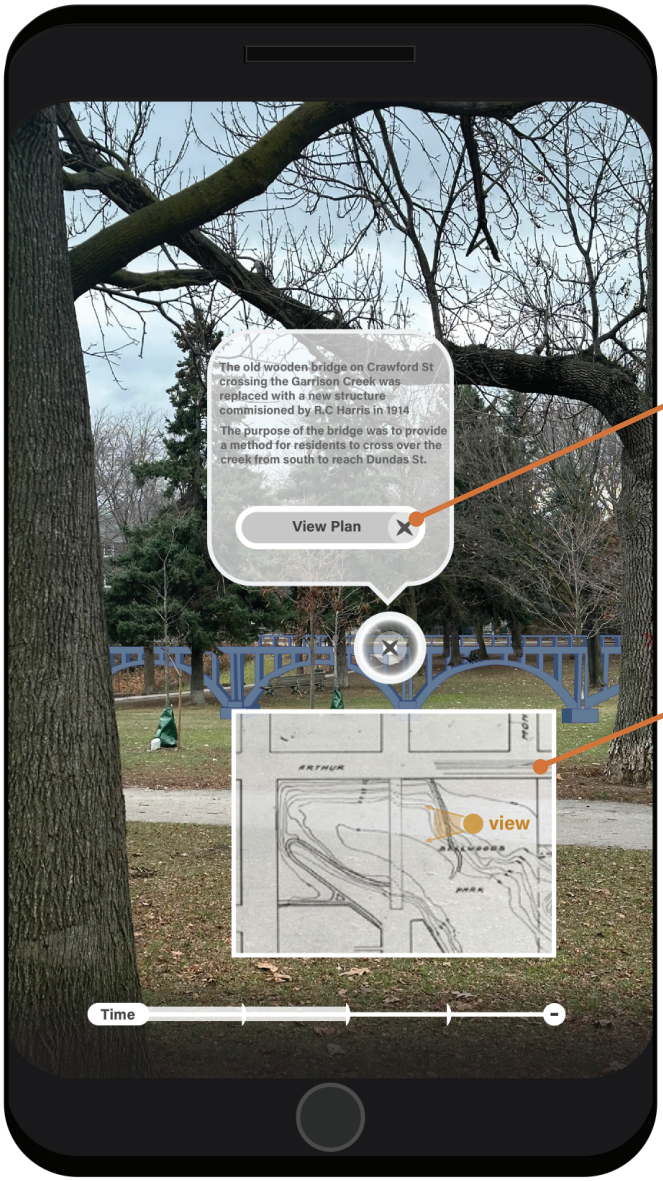
Fig. 4.1.11 Moving along the timeline to reveal the third timeline image by author, 2024.



In Fig. 4.1.8 and Fig. 4.1.9, the users can press the UI buttons to reveal facts about the bridge's burial presented in the text. In Fig. 4.1.10, the users can press the UI button "View Map" to reveal a map of which subway excavation site the soil came from. We can also see how the soil got to the site and through which streets the soil may have passed.

Starting from Fig. 4.1.11, moving the time bar slider, we now move into the third time marker, where we reveal in more detail how the bridge has transformed over time and the drivers in inducing that change.

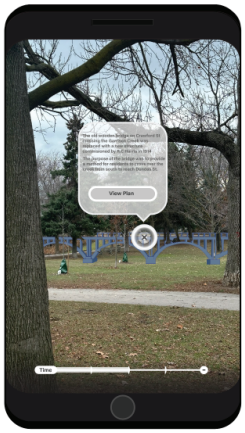
Fig. 4.1.13 Locating the bridge utilizing a historical site plan created by author utilizing image: © wikimedia commons, Trinity college plan, 1913



UI button to reveal the plan

Historical map showing the location of the bridge

Fig. 4.1.12 Visualizing the hidden bridge image by author, 2024.



In Fig. 4.1.12, by clicking on the UI button on the bridge, we can reveal details about the bridge. Furthermore, in Fig. 4.1.13, we can click on the "view plan" UI button on the text UI to reveal an image of the historical plane of the bridge and locate the current view.

Fig. 4.1.15 Dragging the historical image of sewer construction to overlay on site created by author utilizing image: © wikimedia commons, Digging a sewer along Garrison Creek in the 1890s



Image pop up to be dragged into the environment, stretched to trigger the next scene

Fig. 4.1.14 Moving along the timeline to reveal the fourth time marker created by author utilizing image: © wikimedia commons, Digging a sewer along Garrison Creek in the 1890s



Fig. 4.1.14, we now reveal the fourth time marker by sliding the time slider. Here, he focuses more on the creek's history, specifically on the sewer construction of the creek. In Fig. 4.1.15, by dragging the image on the pop-up and stretching the image onto the site, we can overlay it and travel to when the sewer was being built.

Fig. 4.1.17 Using an image of the past to visualize the sewer's story created by author utilizing image: © City of Toronto Archives, Fonds 200, Series 376, File 1, Item 15



Historical image juxtaposed with the digital twin overlaid on the environment

Fig. 4.1.16 Revealing the construction site from placing the image
image by author, 2024.



In Fig. 4.1.16, we travel to a time when the creek was transformed into a sewer by visualizing how the construction site might have looked in the past. Here, we can click on the UI button to reveal stories and historical images of the sewer construction from the past. We better understand and locate the lost ravine system by juxtaposing the current environment with the historical scene.

Fig. 4.1.19 Visualizing when the creek was a open air sewer image by author, 2024.



Fig. 4.1.18 Moving along the slider to reveal the last time marker image by author, 2024.



In Fig. 4.1.18, we can see how this transition to the creek was initiated. Sliding the time slider to the final time marker allows us to visualize the creek along with drivers like cattle farms and settlements that utilized the creek as an open-air sewer. In Fig. 4.1.18 and Fig. 4.1.19, the users can press the UI buttons to read about the details of these social drivers that induced the engineering of the river into what it is today.

This AR experience of the lost river, Garrison Creek, in Trinity Bellwoods Park presents a pedagogical and situated urban story by exploring the criteria of pedagogical storytelling and situated urban storytelling. As shown in Figure 4.1.20, this story creates **interest** by engaging the users to **participate** in the journey to physically discover the chronological story of the lost river. This experience **travels in time** using UI sliders to move from the present into the past and **layer** historical images and digital content to better understand our lost river, Garrison Creek. This chronological story, deployed in commonly used smart devices, adds **familiarity** and **structure** to the story by creating an easiliy accessible story with chronological progression to increase the absorption of information. Finally, the digital content is stylistically drawn using an architectural and cartoon-like method. This method is chosen because it adds to familiarity with an additional layer of architectural sections and perspectives, ultimately increasing **rapport** with the audience.

Considering the criteria of containing Technocene subject complexity, this story follows the guidelines to visualize the story. It illustrates settlements and cattle manure that polluted the creek as **social drivers**, the **technological** methods that transformed the creek into a sewer, and the **outcome** shown in the failing sewer system and the changed landscape.

	Criteria	Story of Lost Rivers
Pedagogical Story	- Create Interest	UI elements, element of discovery on site
	- Familiarity	Usage of smart devices, Digital media
	- Structure	Chronological progression from present to the past
	- Rapport	Expressing storyteller's aesthetics through drawing
Situated Urban Story	- Time Travel	UI slider element allowing for visualizing the past lost river
	- Participation	Create participation by exploring physically and through UI
	- Layering	Layering of digital content on environment
Technocene subject complexity	- Social Driver	Settlements, Open Sewer, Buildable land
	- Technology	Soil relocation, Sewer construction, Water treatment
	- Outcome	Failing sewer system, distruption in ecology

Fig. 4.1.20 Lost Rivers Criteria, assessing if the goals have been met image by author, 2024.

4.2 Story of Porosity

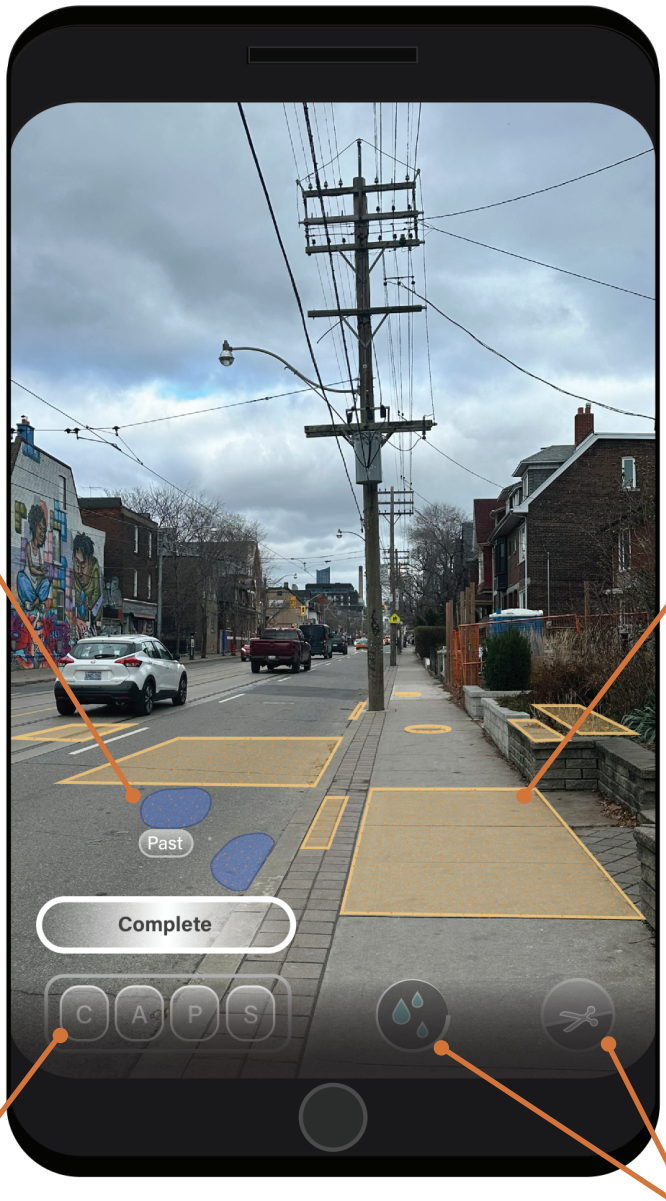
This portion of the AR experience explains the stories described in chapter 3.2 relating to the porosity of the city, namely the engineered surfaces and their supporting infrastructure, and the social drivers and environmental outcomes of non-porous cities. The porousness of an environment in terms of water relates to how the materials on the environment's surface react to water, either shedding or absorbing the rain. This is highly important in the cities of the Technocene, as the engineered surfaces of the city fabric often repel water to provide surfaces and water management systems that are simple to maintain. However, this comes at the cost of impermeable surfaces that lead to various issues with water pollution, the heat island effect, and aquifer depletion.

In terms of the context and the content of this experience, it situates its story in Toronto, a block east of Trinity Bellwoods Park on Dundas St. Here, varying residential and retail building typologies with various surface materials and their different levels of porosity in absorbing rainwater can be found. This material study consists of concrete, asphalt, and planters. These materials are studied based on their material histories, material properties, slope, and how they react to water. At the end of the experience, we can visualize how the water cycle has changed under the city fabric and their outcome in changing the water cycle.

Architectural visualization techniques of sections and diagrams are used to explain the inner workings of the materials and the water cycle in more detail. The user can progress the story by interacting with UI, triggering different portions of the story to reveal itself chronologically. The following visualizations will explain essential aspects of the storyline, their visualization technique, and the AR technology to visualize the story in AR. This experience will be assessed using the pedagogical situated urban storytelling criteria to reflect upon the outcome.

To begin the AR experience, the application scans the environment to detect planes and materials. After completing the scanning, the AR experience is primarily divided into three parts. The first part is the social drivers that induced the materials of the streets to change from the materials of the

Fig. 4.2.2 Planes are detected based on their material image by author, 2024.



Blue shaded planes marking historical materials

scanned material planes in orange shaded planes

Fig. 4.2.1 Locating planes in the environment image by author, 2024.



Fig. 4.2.3 Revealing the buried paving material, bricks image by author, 2024.

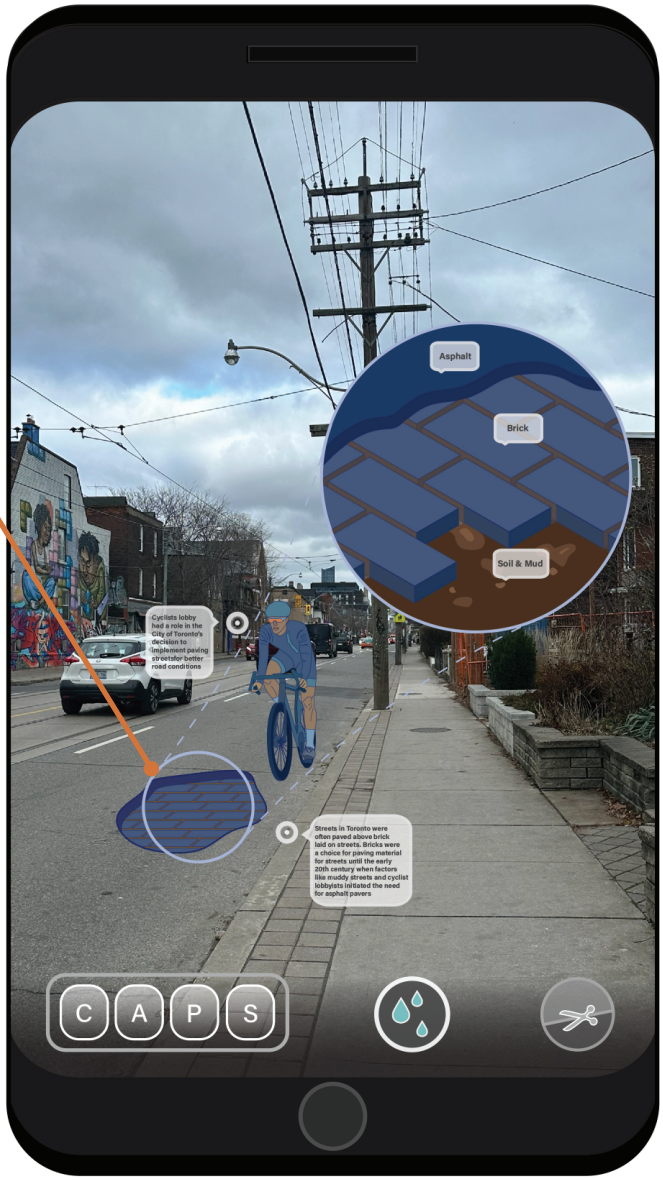


UI buttons made of the first letter of Concrete, Asphalt, Planters and Sewer. When pressed, they will trigger scenes about that material or city infrastructure

UI buttons each representing a function to simulate rain, or to cut a section of the environment for a holistic view

The AR experience begins with detecting the existing planes and materials. As represented in Fig. 4.2.1, the app utilizes ray casting to send out rays from the camera and creates a cloud of points wherever the ray meets a surface. The collection of these point clouds starts to be registered into different material planes, as represented in Fig. 4.2.2. The orange-shaded planes represent different materials in the street, and the blue-shaded planes are stories relating to the social drivers in how the streets have started utilizing engineered building materials that are found today.

Fig. 4.2.4 Illustrating the social driver, cyclist lobby, introducing asphalt as paving material
image by author, 2024.



Digital illustrations overlaid onto the environment to tell a visual story

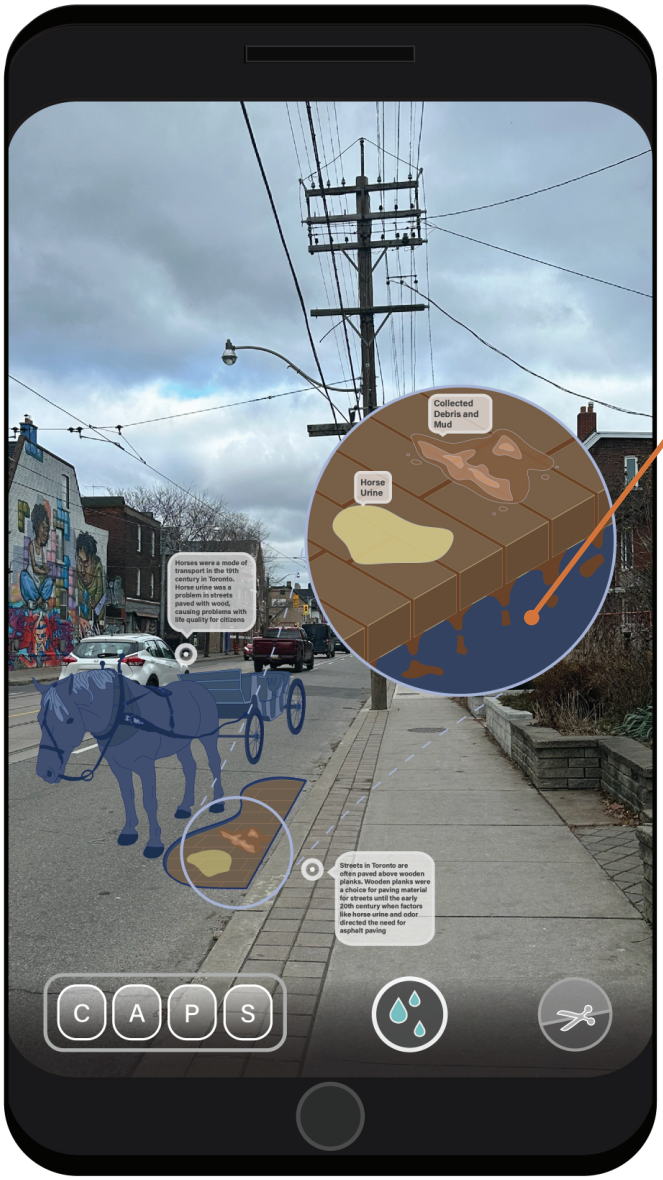
Fig. 4.2.5 Revealing the buried paving material, wood
image by author, 2024.



As shown in Fg. 4.2.4, selecting one of the blue planes reveals one of the past storylines about why our current roads and street fabric is covered in non-porous materials like asphalt and concrete.

Streets before the early 20th century were paved with brick and wood. These materials were porous, allowing rainwater to soak into the ground and not disturb the natural water cycle. However, issues like mud buildup from dust, debris, and water called for a change of material for the city. The cyclist lobby also contributed to Toronto's decision to pave roads with asphalt on top of brick.

Fig. 4.2.6 Illustrating the social driver, maintenance and sanitation, introducing asphalt as new material
image by author, 2024.



Pop up view showing in more detail

Fig. 4.2.8 Composition of concrete
image by author, 2024.



As shown in Fig. 4.2.6, wood was also used to pave roads before the 20th century, and it was used as much as bricks. However, the buildup of horse urine on the wood raised issues of sanitation and odor for the public, creating a need for a more engineered material like asphalt and concrete to repel and direct water to sewers.

Starting from Fig. 4.2.7, the users are able to move on with the experience by using the UI buttons to find the detected concrete plane and learn about its material history, composition, and the stories related to it.

Fig. 4.2.8 Composition of concrete
image by author, 2024.



Pressing the UI buttons reveal a pop up menu for each material or city infrastructure. By pressing on the UI buttons on the Menu, the users can open storylines related to the composition and history

Image showing the origins of the material

Fig. 4.2.9 Locating the source of concrete
created by author utilizing image: Thorning, Stephen. 2019. via https://www.wellingtonadvertiser.com/villages-quarry-created-by-elora-white-lime-co/.



As shown in Fig. 4.2.8, we can start revealing information about the concrete pavers' material composition by utilizing UI buttons. By layering such information on the detected planes, we can visually display the ingredients of making concrete, their percentage share, and the paver's thickness.

Moving along, starting from Fig. 4.2.9, we can map out the material history of the concrete, namely the gravel and sand that come from quarries like Elora quarry, by pressing the UI buttons.

Fig. 4.2.11 Storytelling gravel from quarries
image by author, 2024.

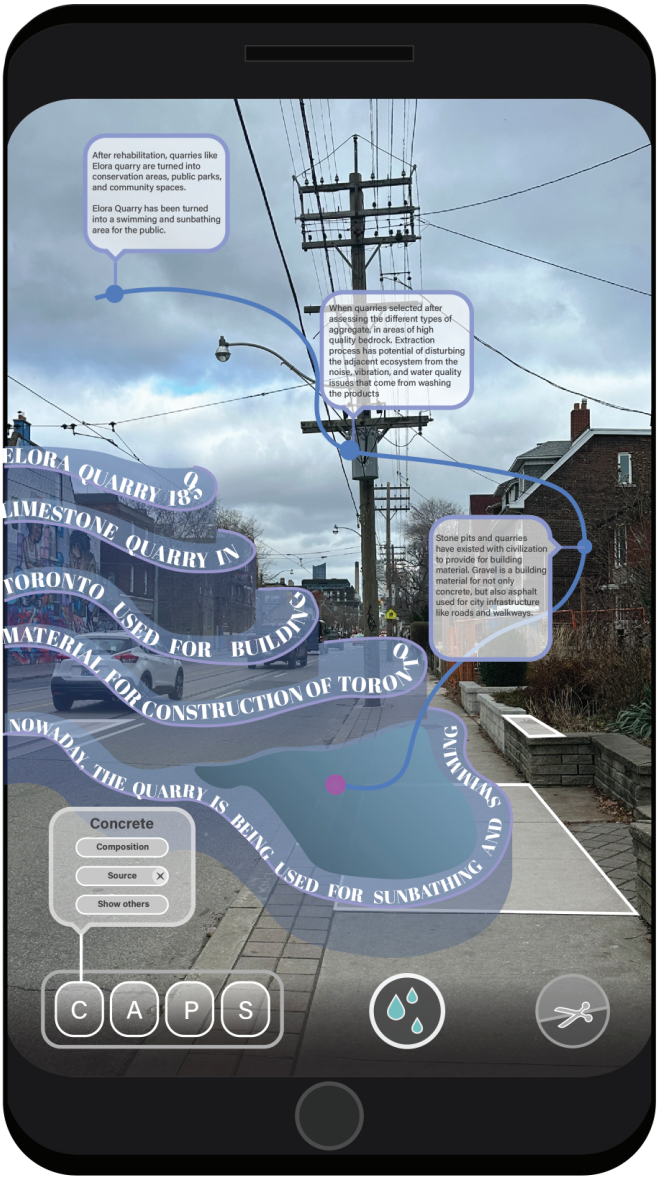
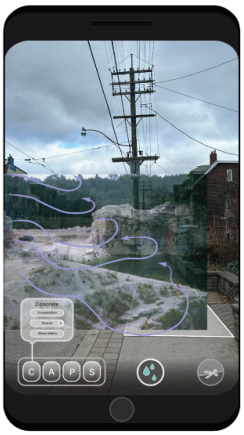


Fig. 4.2.10 Dragging the image to overlay above the environment
created by author utilizing image: Thorning, Stephen. 2019. via https://www.wellingtonadvertiser.com/villages-quarry-created-by-elora-white-lime-co



Going from Fig. 4.2.10 to Fig. 4.2.11, we can visualize an abstract version of Elora quarry on the site to visually tell the history of not only Elora quarry and its current use as a conservation area and swimming location but also general information about quarries.

By creating this in-depth discussion about the whole process in creating our city fabric, like concrete, we can better understand why our cities built a particular method, what technologies were used, and the social drivers or economic drivers that shaped these decisions.

Fig. 4.2.12 Visualizing Concrete's water porosity
image by author, 2024.



By pressing on the water UI button, users can animate how the materials respond to water, and details on their slope

Fig. 4.2.13 Asphalt Composition
image by author, 2024.

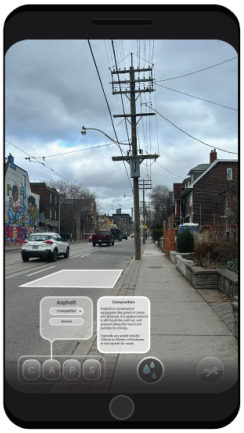


Fig. 4.2.14 Visualizing Asphalt's water porosity
image by author, 2024.



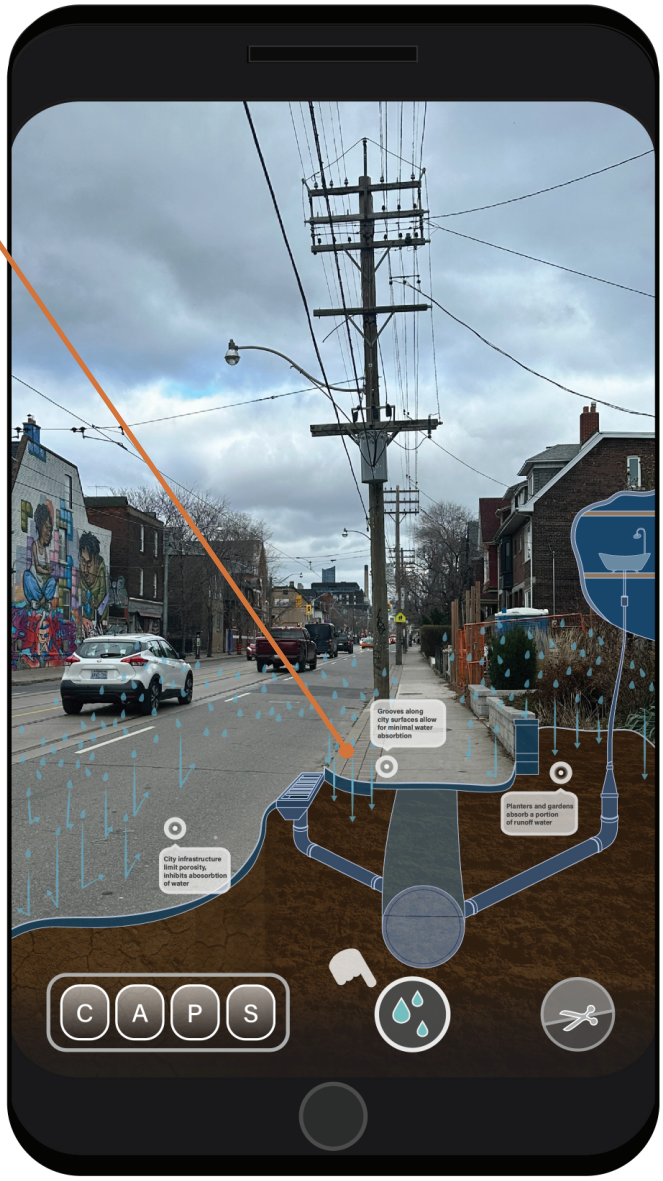
Fig. 4.2.15 F
image by aut



After studying the composition and material history of concrete, we can start to animate how concrete would react to rain and water. Since concrete mostly repels water, we can visualize the slopes of the material and where the water is directed within the roads and streets to track water flow.

A similar process of material study is done with asphalt and the planters in Fig. 4.2.13 to Fig. 4.2.16, along with a study of how each material reacts with water on the surface before moving into what happens beneath the city surface.

Fig. 4.2.18 Animating rain to visualize permeability in the environment image by author, 2024.



By pressing on the water UI button, users can animate how the materials respond to water beyond the surface

Pressing on the section UI button will cut a sectional view of the water system

Fig. 4.2.17 Revealing what lies beneath the ground
image by author, 2024.

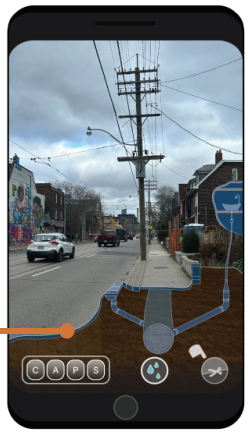


Fig. 4.2.16 Visualizing Planter's water porosity
image by author, 2024.



Planters
thor, 2024.



As shown in Fig. 4.2.17, we can reveal the inner workings of water flow under the surface by pressing the UI button to create a section.

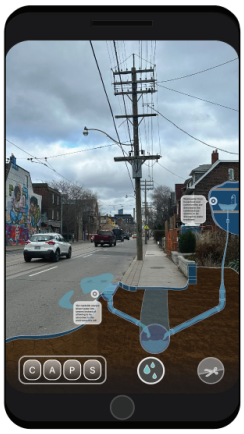
In Fig. 4.2.18, we can animate water throughout the environment by pressing the water UI button. Starting here, we can visualize holistically how the water flows under the ground and how the issues of porosities in materials affect the ground by creating an unequal distribution of rain soaking into the ground.

Fig. 4.2.20 Revealing the wastewater system
image by author, 2024.



Illustrating the progression of Wastewater and Stormwater.

Fig. 4.2.19 Visualizing where the water leads to
image by author, 2024.



Starting with Fig. 4.2.19, the water is collected and drained into the sewers from the streets and the wastewater from the community. In Fig. 4.2.20, the collected water is shown to be carried along to the wastewater treatment facilities.

Users can interact with the UI markers on elements of the AR content to reveal detailed written descriptions.

Fig. 4.2.22 Alterations in the watercycle in the Technocene image by author, 2024.



Showing the altered water cycle of Toronto in the Technocene

Fig. 4.2.21 Visualizing the flow of the water cycle image by author, 2024.



Highlighting the stories of porosity in the city fabric of Toronto can help us point out the unequal distribution of water being let out into the soil, which leads to the disparity in the amount of water being let back into the normal water cycle. Instead, as shown in Fig. 4.2.22, the water cycle in the Technocene bypasses the aquifers, and water is absorbed and filtered by the soil due to the non-porous surfaces. This creates an endless cycle that disturbs the natural water cycle.

The AR experience, designed to tell situated stories relating to porosities in the city fabric of Toronto, explores the criteria of pedagogical and situated urban storytelling. As shown in Figure 4.2.23, this AR experience creates **interest** by engaging the audience to actively **participate** through UI and in the revelation of information and networks hidden in our streets. Handheld devices used in delivering the experience are **familiar** and easy to access. Throughout the experience, **rapport** is initiated by displaying the information with architectural drawing techniques like sections, giving an architectural perspective in thinking about porosity in the Technocene. The **structure** is created for the story by laying out the series of events chronologically. This progression also meets the criteria of containing Technocene subject complexity, laying out the story from the cause of why non-porous materials were chosen due to **social drivers** such as cyclist lobbies to their **technological** material composition and history, and finally, the overall **outcome** in the whole water cycle.

This experience considers the criteria of situated urban storytelling by allowing the users to **time travel** through the building material choices of the past and the present. Material histories also allow users to travel in space to the origin of materials like concrete and gravel quarries. By **layering** information with AR content and unraveling it with the help of UI buttons and gestures, users can actively **participate** in discovering the story of porosity in the streets of Toronto in the Technocene.

	Criteria	Story of Porosity
Pedagogical Story ↓	- Create Interest	UI elements
	- Familiarity	Usage of smart devices, Digital media
	- Structure	Progression from present to past, and the water cycle
	- Rapport	Expressing storyteller's aesthetics through drawing and sections
Situated Urban Story	- Time Travel	UI buttons travelling through time in studying material histories
	- Participation	Create participation by exploring physically and through UI
	- Layering	Layering of digital content on environment
Technocene subject complexity ↑	- Social Driver	Cyclist lobby, transportation, sanitation
	- Technology	Engineered non porous materials, waste water treatment system
	- Outcome	Non porous city, distruption in water cycle

Fig. 4.2.23 Porosity Criteria, assessing if the goals have been met image by author, 2024.

4.3 Story of Flood

This AR experience focuses on visualizing Toronto in cases of extreme flooding in the future, as described in chapter 3.3. Through this AR experience, we can start to imagine the impact of climate change and flooding in Toronto and what Toronto has planned to mitigate flooding in the future. In the Technocene, Toronto has increasingly become prone and vulnerable to flooding due to the old sewer systems and climate change that brings abnormal weather conditions. The story situates itself on Queen Street East, adjacent to the Don River. The present-day floodplain lies a few blocks south of Queen St, making it an appropriate location to imagine the impact of flooding when climate change drives the floodplain incrementally north.

Once the user locates themselves on site, the experience begins with the users using the camera to detect existing planes in the environment to locate where to spawn the water plane. Once the detection is complete, the AR experience is divided into two parts. The first is the visualization of the flood, and the second is the detailed impacts of the flood in Toronto on transportation, the wastewater system, and the community. These stories can be accessed by utilizing UI buttons to generate illustrations and stories of the community relating to the flood. As a result of this experience, the users can visualize in real-time the significance of flooding in the future of the Technocene.

Fig. 4.3.1 Locating planes to apply occlusion shaders image by author, 2024.



UI button showing scanning progress

Point clouds detecting existing planes

Fig. 4.3.2 Plane detection completed image by author, 2024.



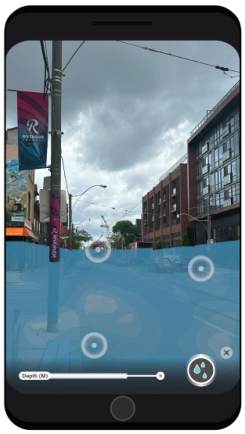
The AR experience begins with detecting the existing planes, such as the buildings and roads. The plane detection utilized raycasting to detect the planes, similar to what is used in Chapter 4.2. There, the detected planes serve as a ground to anchor the floodwater plane. The planes are wrapped in occlusion shaders to occlude the water plane to the wall planes to create a more seamless and curated experience when visualizing the flood in Fig. 4.3.3. In Fig. 4.3.2, the plane detection is complete. The user can press the water UI button to visualize the water plane.

Fig. 4.3.3 Visualizing Queen street in midst of a flood image by author, 2024.



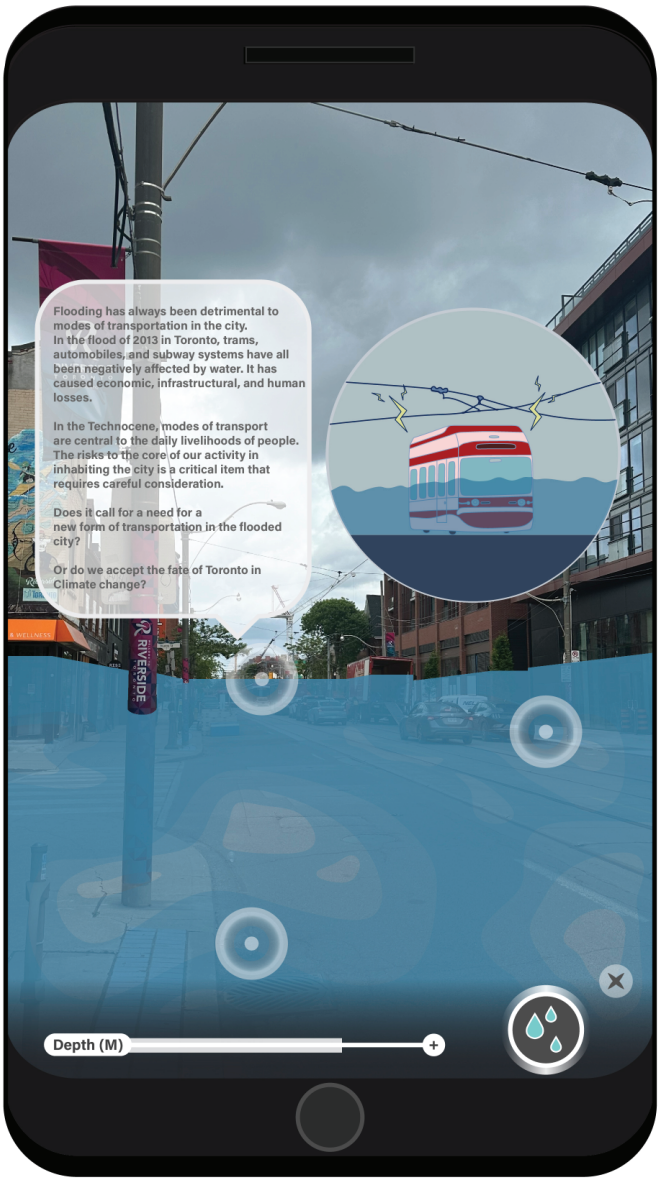
Water depth slider to project into the future flood levels

Fig. 4.3.4 Utilizing the water depth slider to visualize rising flood image by author, 2024.



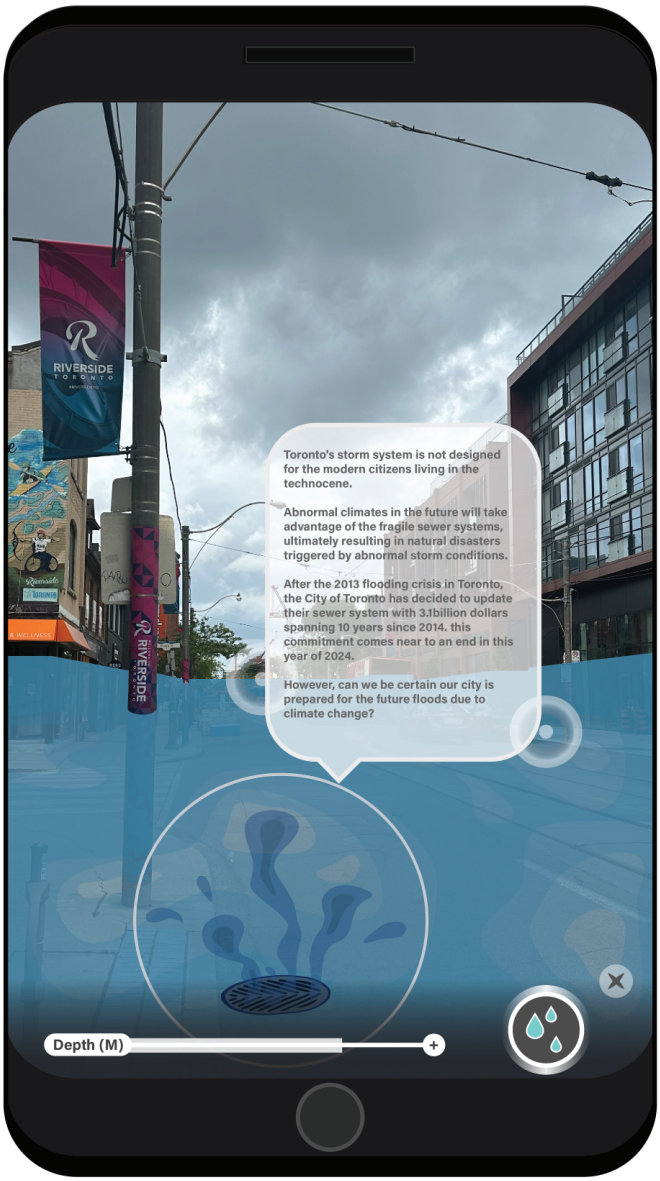
In Fig. 4.3.3, we can see the flood plane spanning Queen St. East. Along with the water visualized, we can fine a water depth slider. This slider can be used for the user to travel through the far future when the flood rates rise higher and higher due to climate change. As shown in Fig. 4.3.4, by sliding the slider to the right, we can start to reveal more detailed stories and facts about the impact of flooding in Toronto.

Fig. 4.3.5 Impact of flooding in public transportation image by author, 2024.



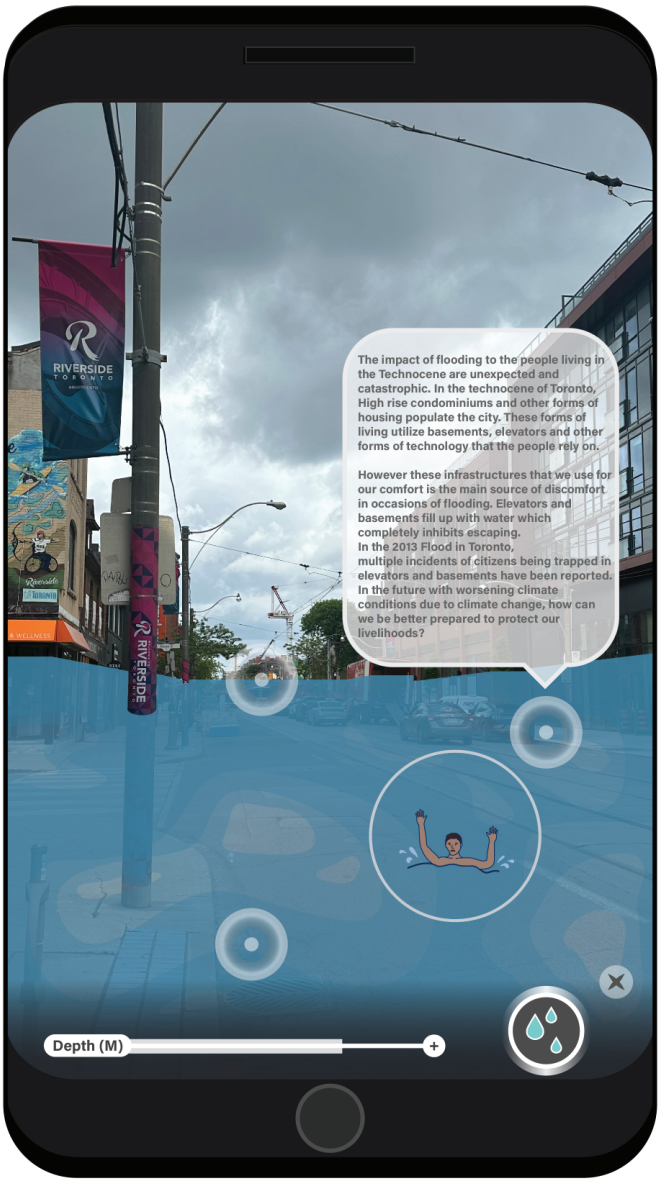
In Fig. 4.3.5 we begin to address more specific impacts of flooding in Toronto. By pressing the UI button above the public transit, we can start revealing some facts and concerns for the future with Toronto's prone to flooding.

Fig. 4.3.6 Impact of flooding to stormwater sewer systems image by author, 2024.



In Fig. 4.3.6 we can press the UI button next to the existing sewer to reveal the City of Toronto's plans for modernizing the sewer system better to accommodate the growing population and buildings in extreme storms.

Fig. 4.3.7 Impact of flooding to the community
image by author, 2024.



In Fig. 4.3.7, we can press the UI button to reveal the impact of flooding on the community, the buildings, and the infrastructure.

This AR experience, which was curated to tell the story of flooding in Toronto, presents a pedagogical and situated urban story by considering the criteria of pedagogical storytelling and situated urban storytelling. As shown in Figure 4.3.8, **interest** is created by promoting active **participation** of the users by physically aiding the discovery of the storyline when walking along Toronto. UI elements like UI buttons and water level sliders also help them become more engaged in the experience. The experience utilizes these water level slides to **travel in time** to Toronto in the future with extreme floods. Through this chronological progression from the present to the future, we can create a **structure** for the story. The experience utilizes handheld smart devices to deploy the experience for **familiarity**. Finally, **rapport** with the users is established by utilizing architectural yet stylistically cartoon-like drawing styles. This digital content is **overlaid** in the environment to create a chance for the users to create direct correlations with the elements in the environment.

Considering the criteria of containing Technocene subject complexity, the story is limited in illustrating the social driver and technology but is successful in delivering the outcome. Climate change is the **social driver** that leads to the failure of the stormwater sewer system. It is briefly mentioned in the story but is more presumed. This story could also have visualized **technological** developments that were used to result in climate change but chose to focus on visualizing the **outcome** of flooding.

	Criteria	Story of Flood
Pedagogical Story	- Create Interest	UI elements
	- Familiarity	Usage of smart devices, Digital media
	- Structure	Chronological progression from present, to future with water
	- Rapport	Expressing storyteller's aesthetics through drawing
Situated Urban Story	- Time Travel	UI slider element allowing for visualizing future water levels
	- Participation	Create participation by exploring physically and through UI
	- Layering	Layering of digital content on environment
Technocene subject complexity	- Social Driver	Climate change, storm water system insufficiency
	- Technology	Technological development accelerating climate change
	- Outcome	Flooding in Toronto

Fig. 4.3.8 Flood Criteria, assessing if the goals have been met image by author, 2024.

4.4 Story of Naturalization

The story of naturalization, as described in chapter 3.4, illustrates Don's Mouth's rich history of human exploitation of the environment due to technology and engineering through a depiction of different timeframes in AR. Being a replacement for the historical Ashbridges Bay Marsh, Don Mouth's story spans the future, the present, and the past, which are drivers of future outcomes. This AR experience is designed to uncover relationships spanning different periods in time to understand Toronto's most significant water body.

This AR experience situates itself in the midst of the Don Mouth revitalization site. The experience begins when the user's location is anchored on the Cherry St South Bridge through GPS locating. When the user is at the geographical location of the don mouth, an interactive timeline UI is generated. In the first timeline, a historical image of Ashbridges Marsh Bay is dragged from the timeline popup to be resized on the screen. When the image is placed on the screen, the digital recreation of the past is generated with interaction points, including history storylines and historical visualizations. The following timeline presents the status quo of the site and its respective histories that have led to the need for a plan for the naturalization of the Don Mouth. The final storyline visualizes post-2024 when the naturalization project comes to an end. A master plan of the project is generated with the user's location, finally triggering a digital creation of the projected future. The interaction points include stories and images of today that indicate signs of naturalization and information on what is expected of the site in the future. Through this progression spanning from the past to the future, users can see the transformation of the bay while connecting it to the social drivers and the technology utilized for the change.

Fig. 4.4.2 Placing the historical image of the Ashbridges Bay Marsh to the present created by author utilizing image: © City of Toronto Archives, Fonds 200, Series 376, File 4, Item 63. 1904

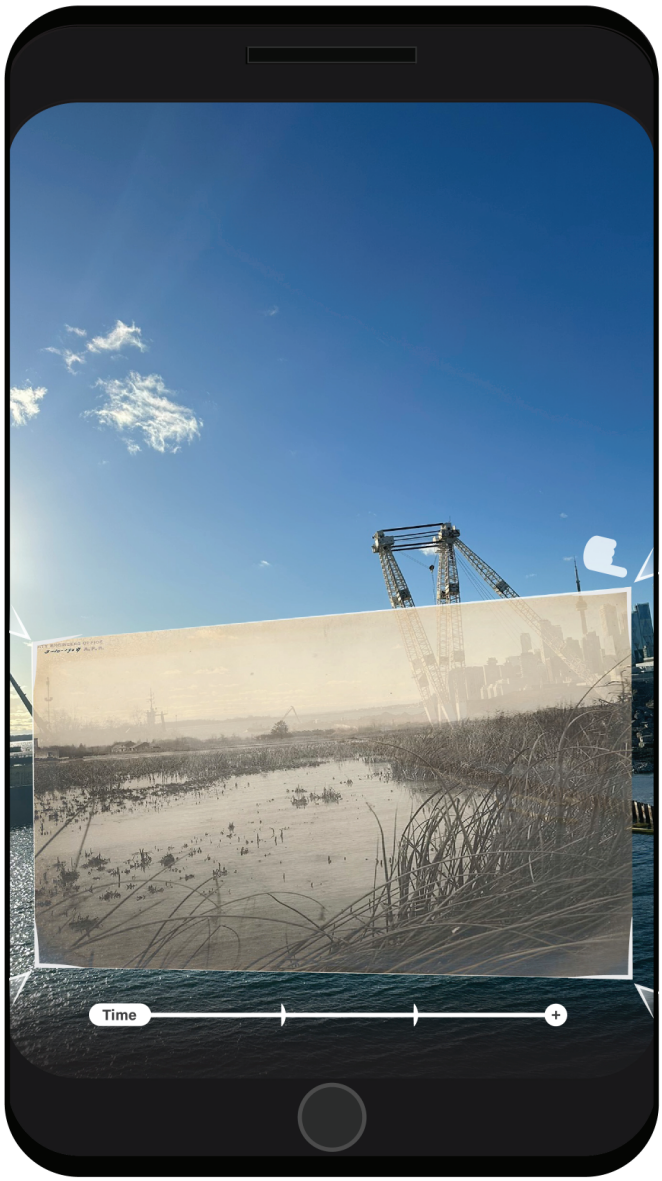


Fig. 4.4.1 Moving along the timeline to access the first time marker, the past created by author utilizing image: © City of Toronto Archives, Fonds 200, Series 376, File 4, Item 63. 1904

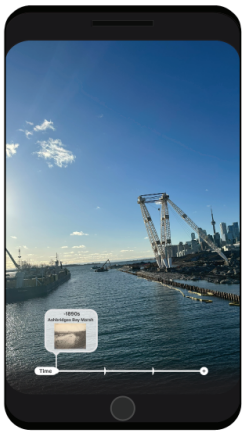
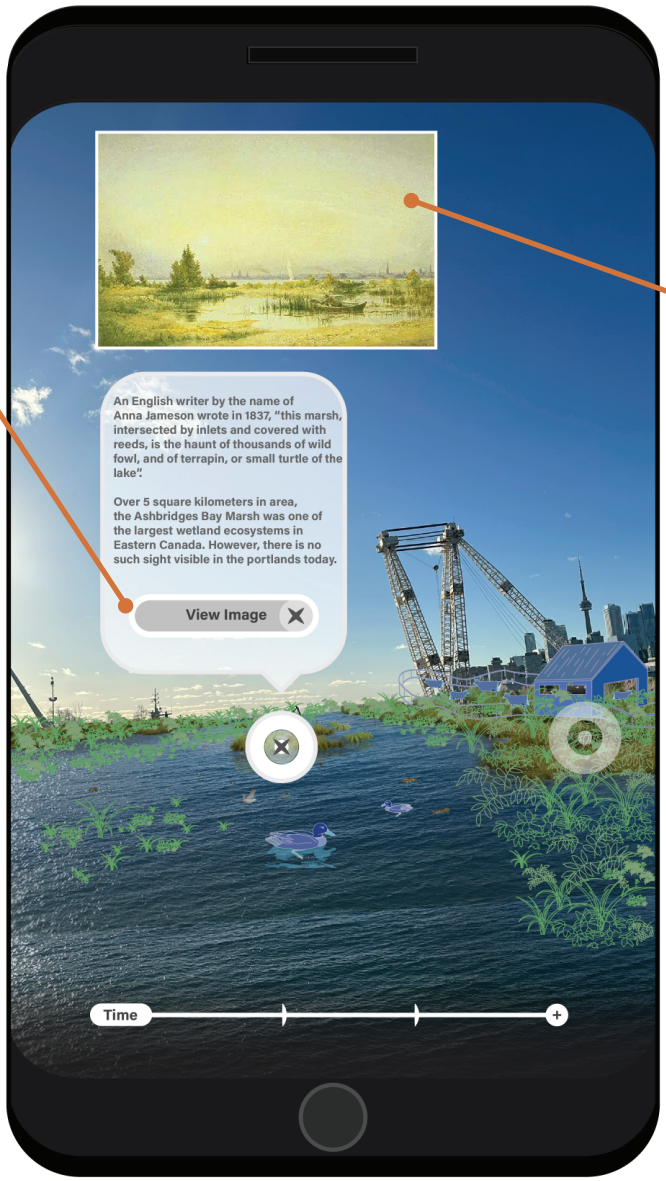


Fig. 4.4.3 Visualizing the Ashbridges Bay Marsh image by author, 2024.



This AR experience utilizes a UI time slider to span through three timelines: the past, the present, and the future. By sliding the slider to the first timeline in Fig. 4.4.1, we can drag the historical image of Ashbridges Bay March into the environment, as shown in Fig. 4.4.2. When the image locks into place, the AR experience will render how the marsh looked in the past, along with UI buttons to reveal information about the marsh's natural state.

Fig. 4.4.5 Marshlands - Visualizing the past using a historical painting created by author utilizing image: © Lucius O'Brien, 1873



UI button to view image

Historical Paintings overlaid on the environment

Fig. 4.4.4 Marshlands stories accessed by pressing on UI button image by author, 2024.



By clicking on the UI buttons in Fig. 4.4.4, we can reveal detailed explanations about how the marsh used to be in the past. We can also press the "view image" UI button in Fig. 4.4.5 to find an image of a painting visualizing the marsh before Toronto was developed.

Fig. 4.4.7 Moving along the timeline to access the second time marker, the present created by author utilizing image: © public domain in Canada, wikimedia commons, Unknown Author, 1900s

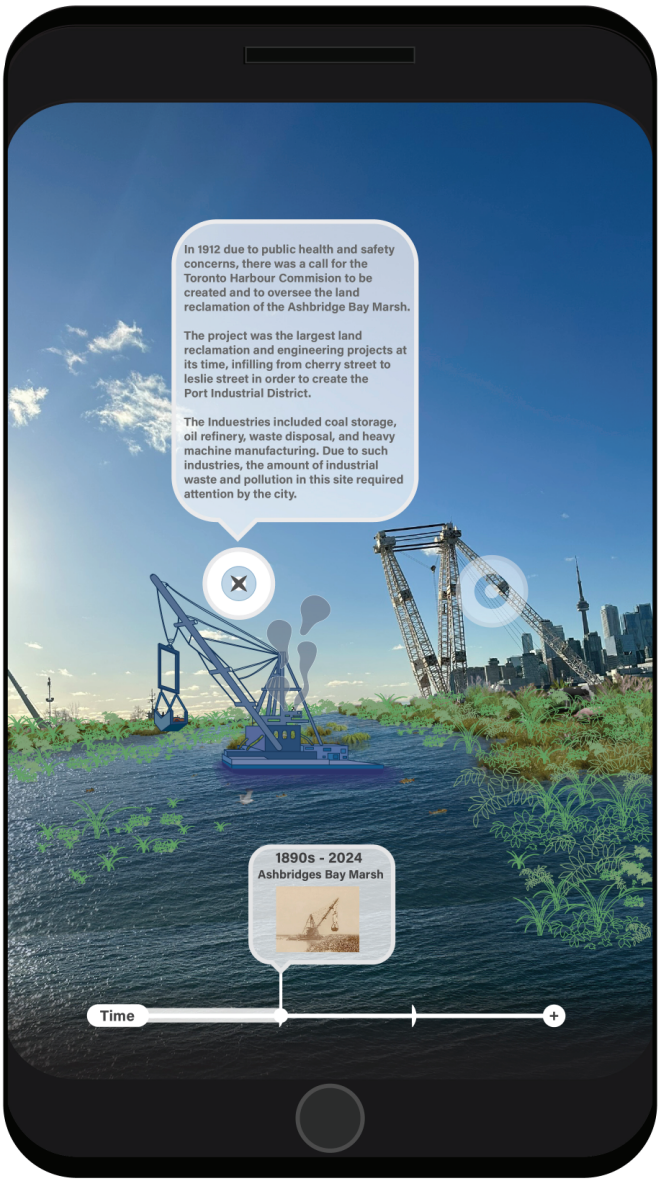


Fig. 4.4.6 Pollutants in the past - Cattle and Settlements image by author, 2024.

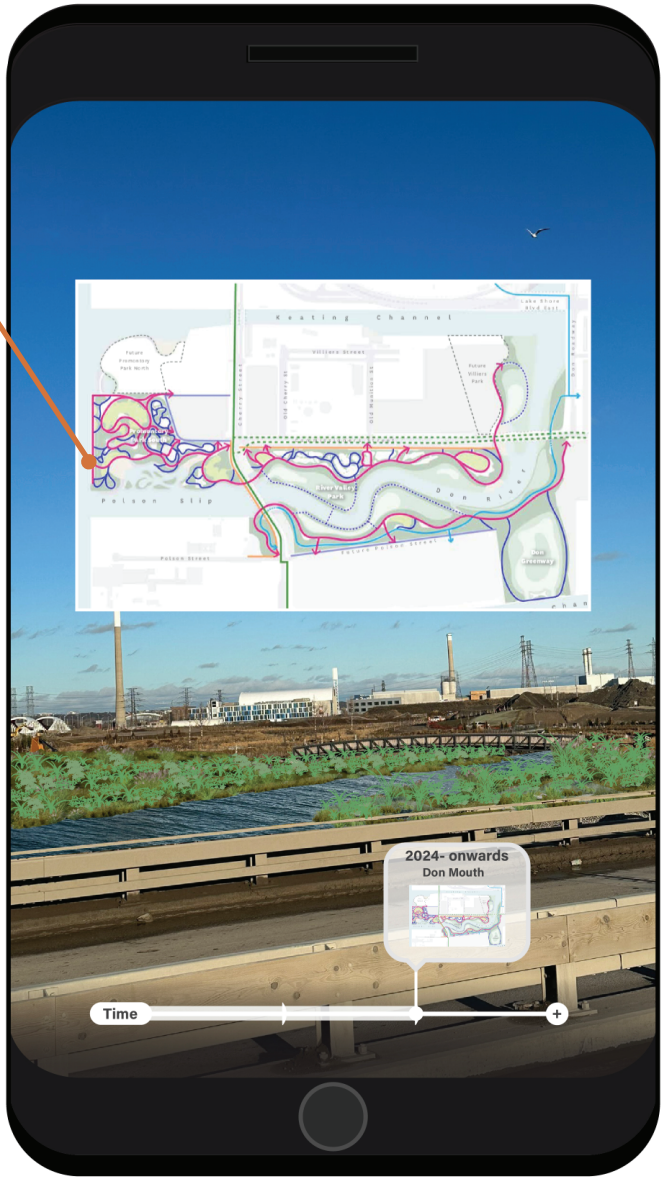


Fig. 4.4.8 Industrial stories accessed by pressing on UI buttons image by author, 2024.



In Fig. 4.4.6, we can press the UI button to start revealing the drivers to the change in the marsh. We can visualize the settlements and cattle raised near the marsh. Their manure and other pollutants were dumped into the marsh, contaminating the environment. In Fig. 4.4.7, we can move the slider to reveal a new time marker, which spans from the industries settling near the marsh to present-day Don mouth. We can see the stories relating to how and why the marsh was transformed to reclaim land for industries and how it got to what we know as the Don Mouth.

Fig. 4.4.10 Don Mouth Revitalization plans shown through future masterplan
image by author, 2024.



Masterplan of the future

Fig. 4.4.9 Moving along the slider to access the third time marker, the future
image by author, 2024.



Starting from Fig. 4.4.9, we move on to the third time marker, the future outlook in Don's mouth. We visualize the plans to revitalize the Don Mouth and restore the ecosystem while providing communal public spaces for the citizens of Toronto. According to the masterplan, we can visualize how the construction site will look.

Fig. 4.4.12 Native Plant seeds stored away under the pollutants image by author, 2024.

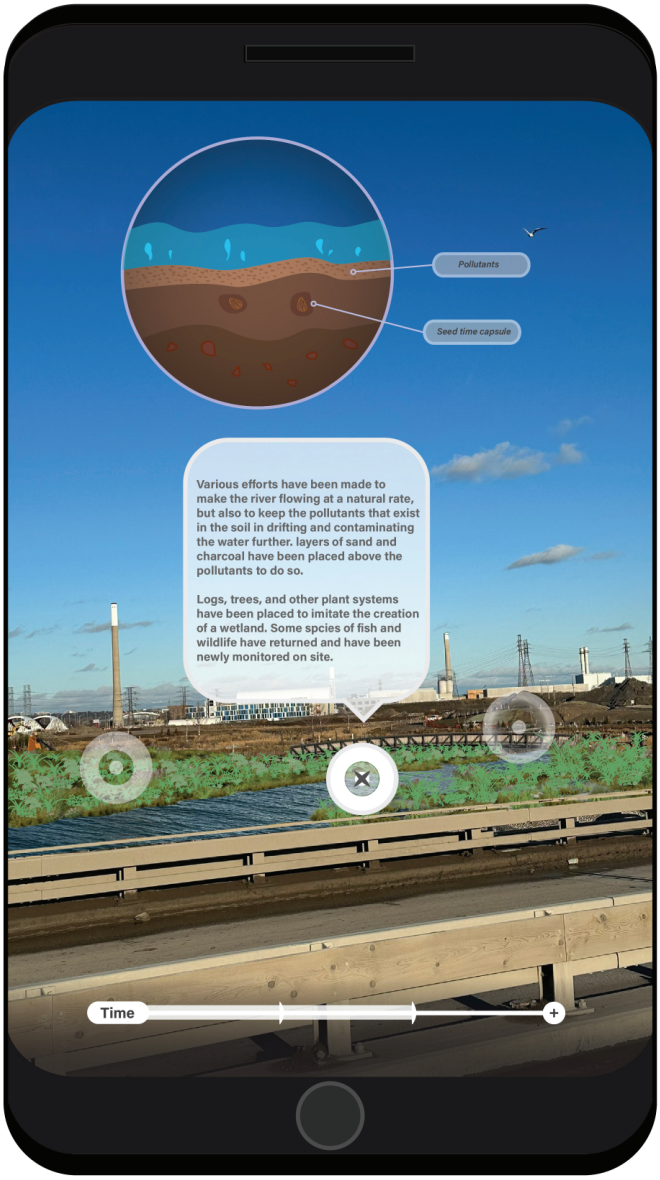
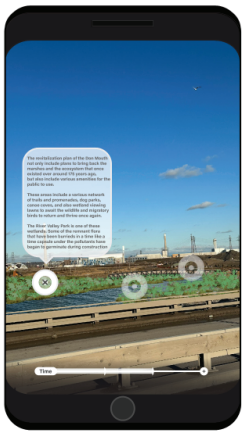
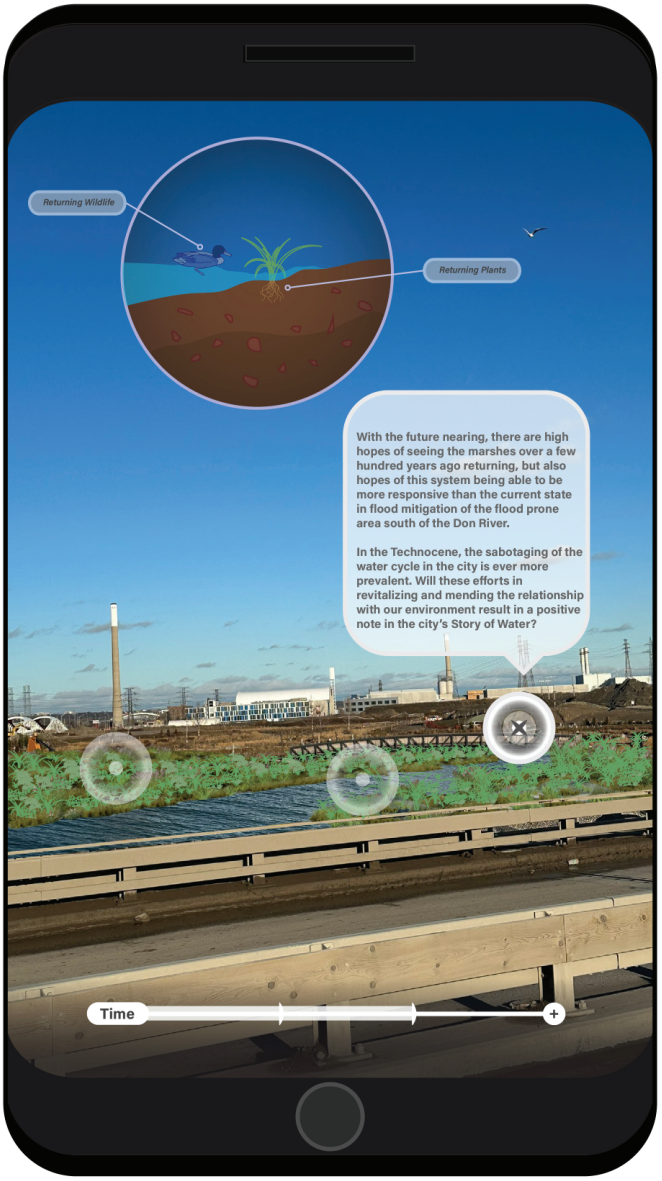


Fig. 4.4.11 Using UI buttons to access stories image by author, 2024.



In Fig. 4.4.12, we can visualize some of the stories about what the pollution has done to the wildlife and how the construction to revitalize the Don Mouth is being planned and proceeded with. By clicking on the UI button, we can reveal text and also a section about the seeds of native plants stored away under the pollutants.

Fig. 4.4.13 Resurgence of native plants following revitalization image by author, 2024.



In Fig. 4.4.13, we see the sequel to section Fig. 4.4.12 about how the native species are returning thanks to the revitalization plans, almost as if the seeds were stored away in time capsules awaiting naturalization.

This AR experience is designed to tell the story of the naturalization in the Don Mouth. It presents a situated story of the Technocene by exploring the criteria of pedagogical storytelling and situated urban storytelling. As shown in Figure 4.4.14, this AR experience utilizes UI elements like buttons and sliders to actively **participate** in physically discovering the story, ultimately creating **interest**. The time slider also meets situated **time travel**, allowing the user to span through the past of the Ashbridges Bay Marsh, the present, and the future of the Don mouth revitalization plan. This chronological **structure** adds stability to the story, along with UI elements that have a flow that guides the users to interact with the experience with specific UI with specific uses. The experience is deployed in a smart device, which is a **familiar** method for the users, and **layers** of information like historical images, paintings, and digital content enhance the understanding of the story. Ultimately, the **rapport** between the storyteller and the user is made by the stylistic choice in the digital content, visualized in an architecturally drawn manner.

Considering the criteria of containing Technocene subject complexity, the story illustrates the **social drivers** that influenced the change of the site, like cattle, settlements, and industries. The story also visualizes how **technology** like construction and land reclamation is used through illustrations. Lastly, it shows how the drivers have induced the **outcome** in the Don Mouth through the layering of the future masterplan and by illustrating the returning wildlife.

	Criteria	Story of Naturalization
Pedagogical Story ↓	- Create Interest	UI elements,
	- Familiarity	Usage of smart devices, Digital media, and artistic choice
	- Structure	Chronological progression from Past, Present, to Future
	- Rapport	Architectural drawing, expressing storyteller's aesthetics
Situated Urban Story	- Time Travel	UI slider element allowing for time travel
	- Participation	Create participation by exploring physically and through UI
	- Layering	Layering of historical images and digital content on environment
↑ *Technocene subject complexity*	- Social Driver	Settlements, Cattle, Industries, need more better environment
	- Technology	Industrial Change, Land reclamation, Construction,
	- Outcome	Creation of Don mouth

Fig. 4.4.14 Naturalization Criteria, assessing if the goals have been met. image by author, 2024.

	Criteria	Story of Lost Rivers	Story of Porosity	Story of Flood	Story of Naturalization
Pedagogical Story	- Create Interest	UI elements, element of discovery on site	UI elements	UI elements	UI elements,
	- Familiarity	Usage of smart devices, Digital media	Usage of smart devices, Digital media	Usage of smart devices, Digital media	Usage of smart devices, Digital media, and artistic choice
	- Structure	Chronological progression from present to the past	Progression from present to past, and the water cycle	Chronological progression from present, to future	Chronological progression from Past, Present, to Future
	- Rapport	Expressing storyteller's aesthetics through drawing	Expressing storyteller's aesthetics through drawing and	Expressing storyteller's aesthetics through drawing	Architectural drawing, expressing storyteller's
Situated Urban Story	- Time Travel	UI slider element allowing for visualizing the past lost river	UI buttons travelling through time in studying material	UI slider element allowing for visualizing future water levels	UI slider element allowing for time travel
	- Participation	Create participation by exploring physically and through UI	Create participation by exploring physically and through UI	Create participation by exploring physically and through UI	Create participation by exploring physically and through UI
	- Layering	Layering of digital content on environment	Layering of digital content on environment	Layering of digital content on environment	Layering of historical images and digital content on environ-
Technocene subject complexity	- Social Driver	Settlements, Open Sewer, Buildable land	Cyclist lobby, transportation, sanitation	Climate change, storm water system insufficiency	Settlements, Cattle, Industries, need more better envi-
	- Technology	Soil relocation, Sewer construction, Water treatment	Engineered non porous materials, waste water treat-	Technological development accelerating climate change	Industrial Change, Land reclamation, Construction,
	- Outcome	Failing sewer system, distruption in ecology	Non porous city, distruption in water cycle	Flooding in Toronto	Creation of Don mouth

Fig. 4.5 Combined Criteria Assessment image by author, 2024

These four AR experiences illustrate different storylines of water in different timelines of past, present, and future to deliver a situated story of the Technocene. As shown in Figure 4.5, all four stories explored the visual storytelling of the Technocene with respect to the criteria in pedagogical storytelling and situated urban storytelling. Guided by this criterion, the stories used UI elements, AR, and digital presentation. However, regarding selecting a storyline to display elements of the Technocene, some things could be improved, specifically with the flood story. The flood story has yet to develop explicit explanations or visuals to show the social drivers and the technology that induced the flood. Instead, this story focuses on visualizing the outcome, the flood. This may be because the focal point in this storyline is a projection into the future. However, when the story is seen more wholistically, with all the storylines in amalgamation, the stories are all linked to one grand story of water in Toronto in the Technocene. Through this methodology, the utilization of AR was evaluated in designing a story to understand and unravel the Technocene.

Chapter 5

Conclusion

This research is investigating the use of augmented reality for storytelling in the Technocene. Augmented reality has potential qualities in unraveling the complex multi-layered framework of the Technocene. To test these qualities, methodologies, and criteria were developed in this thesis to provide opportunities for AR to be a potential method of telling visual stories of the Technocene.

Initially, this thesis started by creating an understanding of the Technocene in general by providing a condensed definition of existing research about its etymology. By doing so, it was clear that the Technocene framework benefited from storytelling to facilitate public understanding. The thesis then researched and reviewed different forms of storytelling, including situated urban storytelling and visual means of storytelling, to begin to set goals and criteria to help design the stories and to help judge the effectiveness of the outcome. In this process, three criteria were set: pedagogical storytelling, situated urban storytelling, and the subject complexity of the Technocene stories. As a result of this process, we decided to utilize augmented reality (AR) as a means of storytelling because of its ability to tell situated urban stories in a participatory manner. Derivatives of these criteria helped review AR technologies and software to create background knowledge in AR and to decide upon the applicable technology and toolkit to test for the design of the AR experiences.

With guidelines from the project criterion, the thesis started to funnel down the story's location and topic. Because the stories needed to be situated in a location rich in technological usage in ecosystemic change, Toronto and its alterations to the water cycle were selected for their abundance in the stories to be told. The sites were then selected based on the progression of the water cycle, from rivers, rain, stormwater, and flooding to the lake. These sites were also selected based on their chronological progression, moving from past events to present to the future. With a concrete foundation on the technicalities and locations, this thesis researched site-specific stories; each site was specific to a time and an element in the water.

After this process, the thesis started to test each technology required to design the stories to grasp the feasibility of creating the AR experience. Unity AR was used to test plane detection, occlusion, UI, and layering of information. Although the testing confirmed the technology's potential to tell situated stories of the Technocene, it was difficult to achieve the quality desired for designing all the sites and stories given the time and the limited level of sophistication in software. These challenges resulted from the lack of experience and resources in learning to code UI elements and digital content to animate the experience. There were limitations in utilizing visual scripting provided within Unity because the AR experience desired in this thesis was site-specific and required special care in aligning and scaling. To further develop this research and AR experience, overcoming these technical issues and growing sophistication in the software can lead to an improved outcome.

As a result of these technical issues, the scope of this thesis shifted its focus to creating more detailed storyboards. We started to design the flow and progression of the stories utilizing UI elements, illustrations, and animations in 2D images. These were created into a filmed AR experience and edited to convey the designed experience. This change in scope greatly facilitated the progression of the thesis and relieved limitations in the design process due to the inability to utilize the AR software. This is where it is possible to draw recommendations for future development for this thesis, to create a more robust background on the AR software, and to entirely transport the experience through AR software. To conclude, the methodologies, research, and project criteria used in this thesis helped the thesis take shape. Based on the requirements, the AR experiences designed to tell situated urban stories of Toronto's water in the Technocene successfully create a deeper understanding of the Technocene framework.

5.1 Future Development

Apart from the future fabrication of the AR application, there are more directions in which the experience can be developed and shifted in terms of its purpose. The stories revolve around the water cycle and the water's direction within the city. However, the fragmentation of the designed experience in specific city sites limits the interpretations of the fluid nature of water flowing within Toronto. To contemplate integrating this nature of water more in the experience, the stories can be designed with more scenes that connect the user between the locations, following the flow of the lost river, the sewers, and the lake. More stories dedicated to explaining the stories of the water will create a more holistic experience.

The direction and the purpose of the experience can also shift when thinking about the future target audience of the experience. This tool was initially designed to introduce the technocene perspective and augmented reality to designers. However, variations of this tool can be more suited for a larger audience. An example would be the flood visualization tool. When developed in sync with the material permeability tool, the flood visualization tool can be shaped into an application that helps users determine the porosity of their immediate surroundings, showing the suspected susceptibility to flood in that surrounding caused by the lack of permeability. In this example, the app would take a more practical approach instead of being a tool made for designers and creative thinkers.

Looking into the future development of this research, contemplations can be made into what role I may participate in the production team. To develop this application, an AR developer, a designer, a scriptwriter, or a UX designer would be needed. In this team, I would be taking a role as a facilitator, drawing the big picture and guiding the direction of the experience based on the team's abilities. This also poses the role of an architect using AR in their workflow, being a facilitator rather than a specialist in the technology.

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