Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
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AR Wetlands Watchers
Water Pollution Simulator

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	06.13.2025	MM	Document creation
1.0	06.25.2025	AM, MMS, NA, YE, MA	Complete draft
2.0	12.05.2025	AM, MMS	Updated to final product deliverables

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1 Problem Statement

In the real world, we observe natural events unfold and sometimes do things outside of what one might predict. In the event of a flood, one would like to be able to accurately predict and visualize such events in order to better serve those in need. Or be able to understand the water run off effects in new development. However, when using only physical models, we are limited to not only the constraints of the built environment but rather more of the effects when simulating. It also limits the location of where said simulation can be as a water source needs to be present. When it comes to these physical models, it can not only be time consuming to create and setup but also require a lot of cleanups and resetting of the model. If there was a way to be able to solve these issues, we could see a major improvement for not only knowing how to better serve others in those events but also educate the public about these situations and making it more accessible and interactive for many to be able to experience anytime.

2 Methodology

Given the known issue at hand when creating these simulations models and running them, there is a better way to address this. To solve this problem, we can create a simpler model or use a modified existing model to be able to function with AR capabilities to simulate such events. Using an AR capable device such as a Smartphone or tablet, we can simply open the application for the compatible AR table-top simulator and by using the device's camera, visualize these events. Within the application, it will have ways to toggle or interact with the model as if you would physically in real life and evoke certain events. Where this would have the same effect if not more in being able to demonstrate and educate others as you would in a physical interaction.

3 Value Proposition

With such capabilities of making these AR simulated events, not only making it easier to be accessible in any setting but also more cost effective in a sense. Where we strongly believe in having this, we will aim to empower communities with an immersive, educational AR experience that brings environmental awareness to life. By turning a simple tabletop into a 3D learning tool, our project solution helps not only businesses but also families understand how their everyday actions affect local water systems as well as extreme situations such as flooding.

4 Development Milestones

- Project Charter first draft - June 2025
- System Requirements Specification - July 2025
- Architectural Design Specification - July 2025
- Demonstration of AR water flow visualization prototype - July 2025
- Demonstration of pollution spread simulation - August 2025
- Detailed Design Specification - September 2025
- Demonstration of user interaction controls (toggle events, triggers) - September 2025
- Demonstration of multi-scenario support (urban, rural, flood simulation) - October 2025
- Demonstration of educational content integration - November 2025
- Final Project Demonstration - December 2025

5 BACKGROUND

Traditional methods of simulating flood events, water runoff, and environmental waterway management rely heavily on physical models and controlled environments. These models, while valuable, suffer from multiple drawbacks. They are often costly to build, limited in the locations where they can be deployed, time-consuming to reset between tests, and are bound by physical constraints that limit dynamic experimentation. Additionally, physical models require significant manual labor, materials, and maintenance, which often makes them impractical for frequent use or wide-scale educational purposes.

There is a growing opportunity to leverage advancements in Augmented Reality (AR) to overcome these limitations. With AR technologies now accessible through widely available consumer devices such as smartphones and tablets, simulations can be made more portable, interactive, and scalable. AR can allow users to visualize complex environmental systems in real time, experiment with different scenarios on demand, and educate diverse audiences without the need for complex physical setups

The AR Wetlands Watchers project is being developed with the aim of empowering communities, municipalities, educators, and businesses by providing a flexible and interactive AR-based tabletop simulation of water systems. Our sponsor is particularly interested in this solution for its potential to enhance public engagement, increase environmental awareness, and support disaster preparedness through interactive educational experiences. This project serves as both a technical exploration and a public outreach tool, fostering better understanding of how human activities influence water systems and how communities can prepare for extreme environmental events such as floods and contamination.

6 RELATED WORK

There are several existing tools and technologies that address water simulation, flood modeling, or educational visualization, but each has significant limitations for the objectives of the AR Wetlands Watchers project.

The U.S. Army Corps of Engineers developed HEC-RAS, a highly regarded river analysis system capable of simulating complex water flow and floodplain scenarios [4]. While extremely powerful, it requires domain expertise and is primarily designed for technical engineering applications, not for public education or interactive AR visualization.

Esri's ArcGIS StoryMaps platform provides interactive web-based storytelling using geographic data [1]. While useful for presenting environmental data, it does not offer real-time physical interaction or immersive AR capabilities that engage non-technical audiences.

SimTable offers a sand-table-based simulation system combining physical models with projected simulations for wildfire and flood planning [5]. However, it involves specialized hardware, large physical space, and high costs, limiting its accessibility for widespread use in classrooms, public outreach, or portable community demonstrations.

FloodSim is a serious game designed to teach policy trade-offs in flood management [2]. Although educational, it is screen-based and lacks real-world spatial interaction or physical engagement with models.

Finally, several AR environmental demos have been created using Microsoft HoloLens and other high-end AR devices [3]. While technologically impressive, these systems often require expensive headsets that are impractical for widespread community deployment, especially in budget-constrained educational settings.

While these existing solutions offer valuable features, they each have significant limitations for our intended use case. Many require expensive specialized hardware, lack true real-time user interaction with physical spaces, or do not provide easily portable, low-cost options for schools, public outreach events, or disaster preparedness training. Our AR Wetlands Watchers project is designed specifically to address these gaps by offering:

- Accessibility through common mobile devices.
- Low-cost implementation using widely available AR platforms.
- Hands-on interaction with simulated environments in real time.
- Customizable educational content for both professionals and public audiences.

By focusing on these strengths, our solution will deliver a unique combination of technical capability and broad accessibility that existing systems do not fully achieve.

7 System Overview

In this project, we propose a high-level system that uses Augmented Reality (AR) to visualize the environmental impact of human behavior on water systems. The goal is to raise awareness about how everyday actions, such as littering, can influence water flow and ultimately affect the quality of the water we consume. The system will simulate water runoff in various environments and demonstrate how pollutants travel through drainage systems into natural water bodies. The AR experience will be presented on a physical roughly 2.0 x 2.0 feet demonstration table, enabling users to interact with a dynamic, visual representation of water flow and pollution spread. Users will interact with the system via a device (Phone, Tablet) above the table. The interface will allow them to see virtual trash on the landscape, simulate rainfall or flooding, and observe how contaminants flow downstream-ultimately making the connection to real-world water sources.

- **AR Display Table:** A physical platform where users interact with the simulation.
- **Water Flow Simulation Engine:** Models the direction and intensity of water movement based on virtual terrain and rainfall.
- **Pollution Propagation Module:** Visualizes how pollutants like trash and chemicals move through water systems.
- **User Interface Layer:** Allows users to interact with the environment by moving their device wherever the animated objects are (e.g., litter, barriers).
- **Educational Overlay:** Displays a sound icon to give real-time information on demand about environmental impact, mitigation strategies.

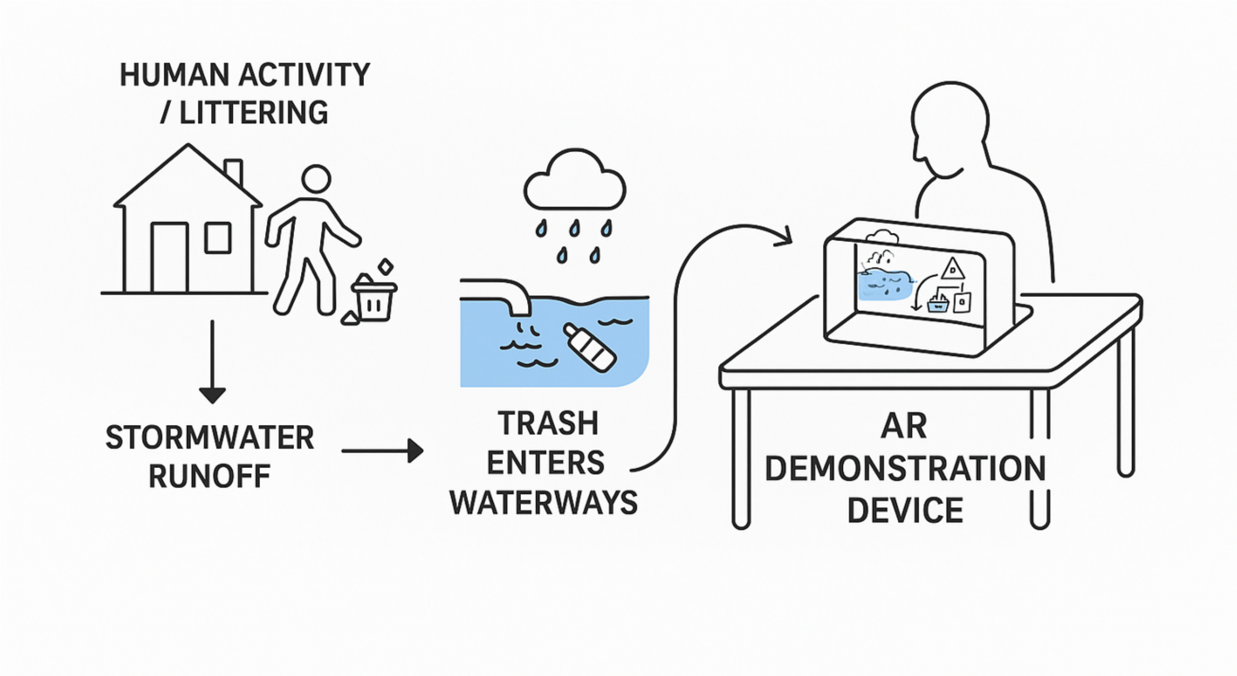

Figure 1: System Overview Diagram

8 Roles & Responsibilities

The stakeholders of this project are the U.S. Army Corps of Engineers, who are supporting the development of an augmented reality experience to raise awareness about water pollution. The designated point of contact with the sponsor is Mauricio Mendoza-Silos, who will communicate directly with the sponsor, Jason Knight, to ensure alignment between project goals and deliverables. The team consists of five members, each contributing to different technical areas of the project. To promote shared leadership and collaboration, the role of Scrum Master will rotate periodically among team members throughout the duration of the project.

- **Yahia Elsaad:** Neighborhood scene design/implementation and animations - Unity
- **Mohamad Nabih Alkhateeb:** Neighborhood scene design/implementation and animations - Unity
- **Mauricio Mendoza-Silos:** Project Structure / Terrain / Water pollution simulation - Unity
- **Adrian Macias:** Mobile App Screens / Contruction Site scene / Educational Narration - Unity
- **Nooraldeen Alsmady:** Factory scene design/implementation and animations - Unity
- **Shawn N Gieser:** Supervisor
- **Jason Knight:** Sponsor - Meeting every 2 weeks to let us know if we are on the right track, and building what the customer wants.

9 Cost Proposal

The budget will primarily support the following key areas:

- **Software Tools and Licenses:** Any software or licenses needed to build, test, or present the AR application.
- **3D Model Assets:** Custom or licensed 3D models (Unity) for trash, terrain, water flow, and pollution visuals.
- **Miscellaneous Expenses:** Additional unforeseen costs such as adapters, cabling, signage, or presentation materials.

At this time, there are no additional funding sources or external sponsors for the project.

9.1 Preliminary Budget

Category	**Estimated Cost (USD)**
Software Tools and Licenses	$150.00
3D Model Assets	$100.00
Miscellaneous Expenses	$75.00
Total Estimated Cost	**$325.00**

Table 1: Estimated Budget for AR Project

9.2 Current & Pending Support

The approximate budget for this project is $800, which will be provided entirely by The University of Texas at Arlington (UTA) CSE Department. This funding is expected to cover all necessary expenses associated with the project. There are no other contributions to the budget.

10 Facilities & Equipment

The main physical requirement for this project is a 2' x 2' tabletop, which will serve as the physical anchor for the AR experience. This board will include all visual markers and illustrations necessary for the AR content to be correctly triggered and aligned. The tabletop, as well as the supporting legs and frame, will be provided by our sponsor, the U.S. Army Corps of Engineers (USACE). As such, no fabrication or woodworking will be required on our part.

For development and collaboration, our team will utilize one of the university-provided Computer Science and Engineering labs at UTA. These labs offer the space and hardware we need for Unity development, 3D modeling, testing AR deployment, and team meetings. Since the AR experience will run on smartphones, our testing environment will also rely on personal mobile devices that support AR frameworks such as ARCore. Any additional testing beyond personal devices will be coordinated through the lab, if necessary.

Most of the software tools we plan to use, including Unity and Blender, are available through free academic licenses. However, one potential equipment consideration is 3D assets. If the available free or open-source 3D models are not suitable for our educational scene, we may need to purchase high-quality models to better represent the animated objects like vehicles, buildings, or landscape features. These models would help enhance the clarity and effectiveness of the AR scenes.

Overall, the project does not require any specialized hardware or sensing systems. All interaction and presentation will be handled through software and mobile AR, minimizing physical dependencies and making this project primarily software-focused in terms of equipment and lab needs.

11 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project:

- The sponsor-provided physical tabletop (2' x 2') and legs will be delivered in a timely manner and meet all necessary dimensional and surface requirements for the AR experience to function as intended.
- Team members will have access to personal smartphones compatible with Android to support development and testing of the AR experience.
- Free or open-source 3D assets will be sufficient for most of the AR scene, and any necessary premium models can be purchased without exceeding the overall project budget.
- Unity and all other required development software will remain free for academic use or otherwise available through the university's licensing agreements.
- Team members will maintain consistent communication and meet sprint deadlines throughout the semester.
- Sponsor feedback will be provided within a reasonable timeframe after any deliverables or design submissions.

12 Constraints

The following list contains key constraints related to the implementation and testing of the project:

- The final prototype must be completed and ready for demonstration by the end of the semester.
- The total development cost, including optional purchases such as 3D models or printing services, must not exceed the project's allocated budget (currently estimated under $800).
- The AR experience must function on standard smartphone hardware without requiring additional equipment (e.g., VR headsets or specialized sensors), which places limitations on performance and graphical complexity.
- Any graphics or animations used in the project must align with the sponsor's expectations and educational objectives, which may limit creative freedom or require design revisions late in the process.
- Not all team members have equal prior experience in Unity or AR development, which may limit how tasks are distributed or completed.
- The project must follow UTA's Senior Design submission timeline, including document deadlines, sprint planning, and milestone reviews.

13 Risks

Risk description	**Probability**	**Loss (days)**	**Exposure (days)**
Delay in sponsor response/decisions	0.25	7	1.75
Learning curve or integration issues with AR tools/platforms	0.40	10	4
Team scheduling conflicts	0.35	9	3.15
Scope creep	0.30	7	2.1
Data loss	0.25	15	3.75

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The project charter initial draft will be delivered at the end of Sprint 1, on June 25th 2025. It will be maintained and updated at the end of each sprint by a different assigned team member. The final version is expected to be delivered in the first week of December 2025.

14.1.2 System Requirements Specification

The first draft of the SRS is scheduled for delivery at the conclusion of Sprint 2, on July 9th 2025. This document will be updated at the end of each sprint or sooner if major requirements are added, removed, or changed based on sponsor feedback or new technical constraints. The SRS is expected to be finalized and submitted during the first week of December 2025.

14.1.3 Architectural Design Specification

We plan to submit the initial version of the ADS by the end of Sprint 3, on July 23rd 2025. This document will only be updated when significant architectural decisions are changed, such as platform shifts, tool replacements, or the addition of major new features. Minor changes will be logged but not formally rewritten unless they impact overall architecture. Delivery of the final ADS is scheduled around the first week of December 2025.

14.1.4 Detailed Design Specification

Delivery of the initial DDS is expected around September 2025, marking the end of Sprint 5. This document will be maintained throughout Senior Design 2 and updated with any significant design changes, module updates, or refinements. The final version of the DDS is planned to be delivered in the first week of December 2025.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added to the product backlog from the SRS during backlog planning sessions held at the end of every sprint. Items will be prioritized by team consensus, and input from product owner. We will use Microsoft Planner to maintain and share the backlog.

14.2.2 Sprint Planning

Sprint plans will be created at the start of each sprint by the team, and led by the presenters of that plan. There will be a total of approximately 8 sprints, depending on any changes in the fall course schedule.

14.2.3 Sprint Goal

The sprint goal will be set collaboratively by the team and approved by the sponsor during regular update meetings, set every other week.

14.2.4 Sprint Backlog

The team will collaboratively decide which backlog items go into the sprint backlog during our planning meetings. The sprint backlog will be maintained and tracked within Microsoft Planner using a Kanban-style board.

14.2.5 Task Breakdown

Tasks will be claimed voluntarily by team members during meetings. Time spent on tasks will be documented in Microsoft Planner as well as through status updates on Teams.

14.2.6 Sprint Burn Down Charts

The burn down charts will be generated by the team's assigned Scrum Master at the end of each sprint. The Scrum Master will gather data from Microsoft Planner and Teams status updates, including the number of work units remaining, reported in hours. These charts track progress over time and help identify whether the team is on pace to complete sprint goals. The burn down chart compares the Remaining Effort against the Baseline Effort:

- **Remaining Effort** is the total number of estimated work units left for all incomplete sprint backlog tasks, updated daily.
- **Baseline Effort** is the projected remaining work calculated at the beginning of the sprint, assuming steady progress each day.

Below is an example burn down chart.

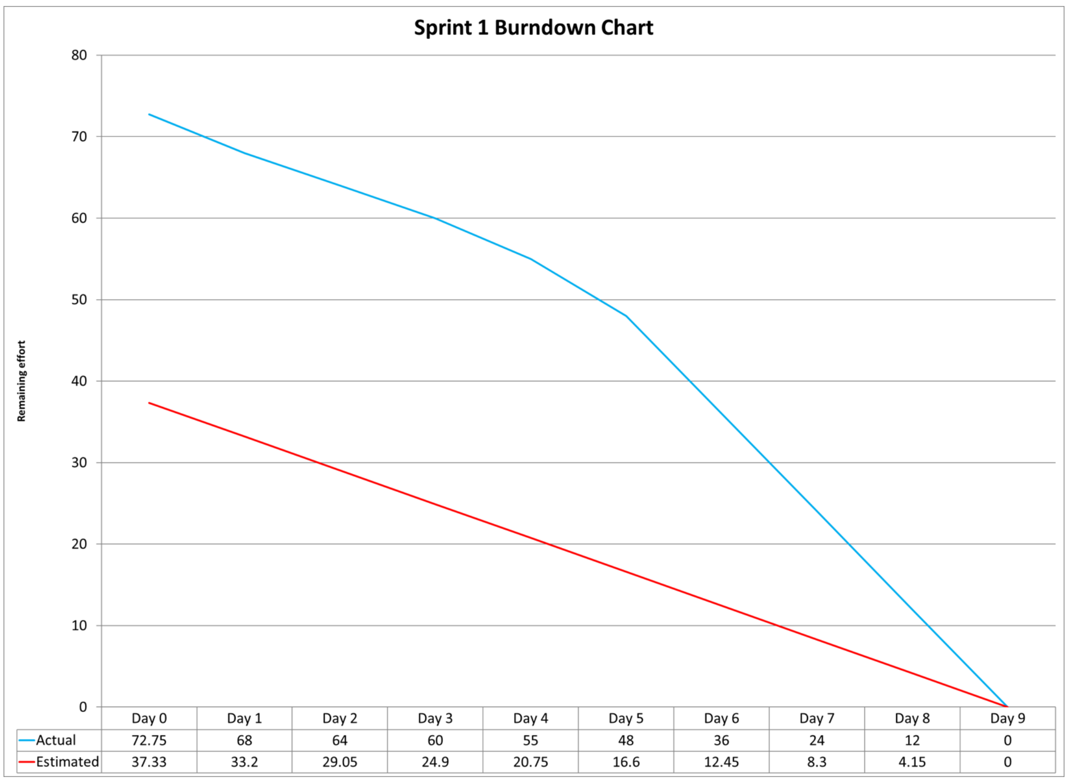

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

The sprint retrospective will take place on Fridays at the end of each sprint. The team will meet and reflect on what went well, what could be improved, and any challenges encountered. Key insights and action items will be documented and shared in our Team project folder. This process will help the team continuously improve collaboration and workflow efficiency throughout the project.

14.2.8 Individual Status Reports

At the end of each sprint, every team member will submit an individual status report summarizing their contributions. The report will include the sprint goal and a breakdown of tasks with estimated and actual hours worked. It will also contain a brief retrospective with actions to start, stop and continue, along with a peer review where team members rate each other's participation, communication, work quality, professionalism, and overall contribution on a scale of 1-5. A team burndown chart showing progress will be included as well.

14.2.9 Engineering Notebooks

Each team member will update their notebook at least once per week, unless big changes are made. A minimum of one full page should be completed each week that they are worked on. The notebooks will be reviewed at the end of each sprint. A designated teammate will serve as a witness to sign off on each entry for accountability. The team as a whole will hold one another responsible by reviewing notebook progress during sprint retrospectives.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will include the AR software, printed table markers, and any supporting materials required for proper operation on smartphones/tablets. The prototype will be demonstrated to the sponsor and other students during the final sprint and will showcase the system's functionality and educational features. A Prototype Acceptance Test (PAT) will be conducted to confirm that the system meets the sponsor's requirements. It is not likely that there will be an off-site demonstration, but if necessary, a Field Acceptance Test (FAT) may also be arranged to confirm performance in the intended use environment. The project will be delivered at the end of the project, along with documentation to support future use.

14.3.2 Project Poster

The project poster will summarize the AR Wetlands system, including its goals, technical approach, and educational impact. It will contain sections such as: Executive Summary, Background, Key Requirements, System Design, Implementation and Test Plan, Results, Conclusions, and References. The final dimensions are still to be determined, but will likely be 4' x 3'. It will be delivered by the conclusion of Senior Design 2, approximately December 5th 2025.

14.3.3 Web Page

The project web page will serve as a public-facing summary of the AR Wetlands Project, highlighting its purpose, features, and key technical details. It will include an overview of the system, authorized sponsor information, team members, project poster, demo video, and links to relevant authorized documentation. It will be delivered at the conclusion of Senior Design 2, around December 3rd 2025, but will be worked on and updated throughout project.

14.3.4 Demo Video

Our demo video will cover system functionality and use, such as startup, how users interact with the AR table, trigger educational content. It will be approximately 3-5 minutes long. B-reel footage of shots of the table and app interface will be included for future video cuts.

14.3.5 Source Code

We will be using Unity and GitHub for version control and maintenance. The sponsor will receive the source file apk at the conclusion of the project directly. Licensing and open source is still to be determined, but will be included in the readme file.

14.3.6 CAD files

While this project does not involve physical mechanical components such as 3D-printed or laser-cut parts, it will make use of 3D digital models to support the augmented reality (AR) experience. These models will visually represent environments and scenarios to the wetlands educational content (e.g., storm drains, houses, construction sites, vehicles, trash bins, people). We anticipate sourcing models from a variety of tools and platforms, including:

- Unity Asset Store
- Other free or licensed online repositories

Where needed, models will be modified or updated using software such as Unity's built-in 3D editing tools.

14.3.7 Installation Scripts

We will provide a signed APK file of the AR Wetlands app along with detailed installation instructions for Android devices. The instructions will cover how to enable installation from trusted sources, install the APK, and configure any required permissions such as camera access for AR functionality. The goal is to ensure that the customer can deploy the app easily and reliably on supported Android smartphones and tablets.

14.3.8 User Manual

A digital user manual and a setup video will be provided at the end of the project.

References

[1] Esri. Arcgis storymaps, 2024.

[2] Serious Games Interactive. Floodsim, 2023.

[3] Microsoft. Hololens environmental ar demonstrations, 2023.

[4] U.S. Army Corps of Engineers. Hec-ras river analysis system, 2024.

[5] SimTable. Wildfire and flood simulation sand table, 2023.