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Final Proposal

Summit Residential Neighbourhood Earthen Channel/Culvert

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List of Abbreviation

HEC-HMS	Hydrologic engineering centre- Hydrologic Modelling System
SENG	Senior engineer
ENG	Project engineer
EIT	Engineer in training
TECH	Lab technician

1.0 Project Understanding

1.1 Project purpose

The earthen channel located in the summit residential neighbourhood along Pullam Rd in flagstaff is experiencing stability and slope issues. During high flows, debris forms within the channel and causes water to overtop the culvert and due to sedimentation issues, which the 24-inch corrugated metal pipe is experiencing, the water exits the culvert rapidly causing erosion and floods the backyard of the homeowners located along South Pullam drive. One of the homeowner's backyard is subjected to movement as their backyard's bottom portion is moving towards the channel. There is an immediate need to assess the channel and design a storm drain.

1.2 Project background

The area of interest is located around a residential neighbourhood along south Pullam drive in the city of Flagstaff, Arizona (see figure 1.1). As shown in figure 1.2, the culvert is located under south Amethyst road which allows water to flow through the culvert under south pullman drive. During the storm, the water overtops the culvert that is located under south Amethyst road and exists the culvert extremely fast causing floods in the backyard of the three houses. years ago, the previous capstone team recommended that a storm drain must be considered.

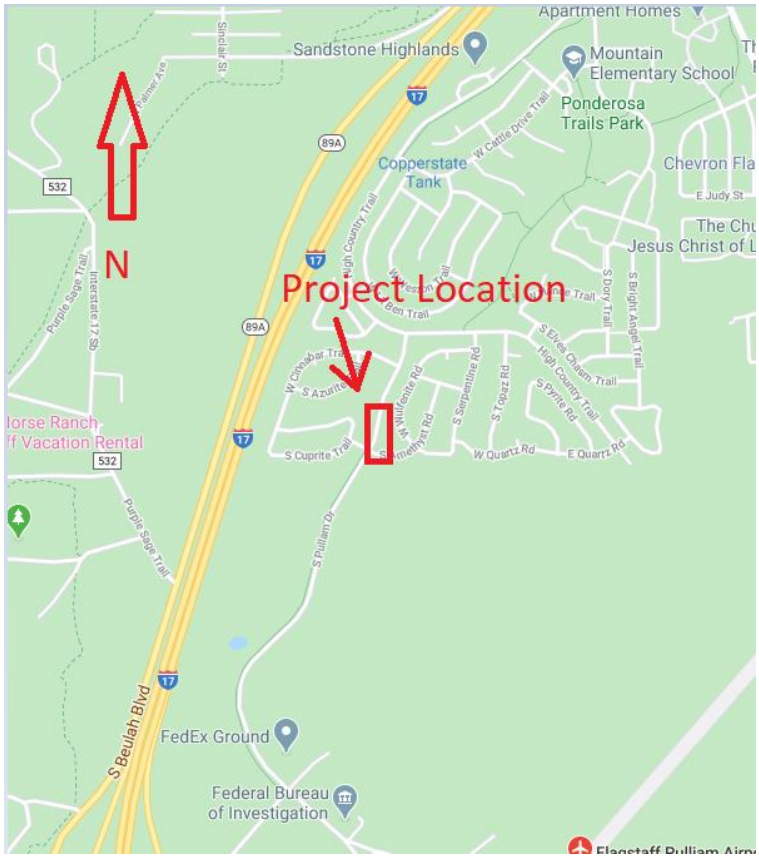

Figure 1. 1:Area of Interest[1].

Figure 1. 2:Aerial View of Project Site.

1.3 Technical considerations

Site investigation must be considered early on to better understand and visualise the current issue of the culvert design and gather an initial understanding of the main issue that the channel is experiencing. A topographic map of the area of interest must be created. In order to create a clear and accurate topographic map of the area, land surveying must be conducted to record every natural and man-made object present in the area to restore the local situation during the drawing process. Survey data such as stations and elevations will be collected throughout the Summit Residential Neighbourhood using Auto Level and Total Station to determine the current slope and height difference between the upstream and the downstream elevations.

Hydrologic Analysis is mandatory and must be conducted before coming up with any storm drain/ culvert design to better understand the current flow regime of the area of interest. The watershed characteristics of the location must be compared to all proposed designs to ensure the efficiency and safety of the project and avoid future failures similar to the current status of the project. Major and sub-basin delineation must be considered to determine the area that contributes to the stormwater runoff. Due to having different surface types, weighted curve number determination must be considered for each sub-basin run-off coefficient that have similar hydrological characteristics. Computer modelling software must be used to create models that simulate those designs to calculate the runoff cycle. HEC-HMS modelling will most likely be used to create those models. Geographic information systems will be used to input historical data into the HEC-HMS modelling software.

It is essential to conduct various types of hydraulic analysis including open channel, culvert, and storm drain design analysis to choose the most efficient design that best suits the topography of the area. Ideally, Culvert Master software will be used to model a culvert with different dimensions and type and input historical stormwater data to calculate the water-runoff volume. Output information will be compared with the required design

criteria of City of Flagstaff Stormwater codes to ensure It meets the design criteria. Storage, discharge, and velocity of the channel must be considered. This could be done using Flow Mater software.

Computer Aided design will be conducted towards the end of the project to document the design process of the chosen design that best suits the characteristics and condition of the area based on the results of the previous analysis discussed above.

1.4 Potential challenges

There are some potential challenges in the implementation of this project. As this project is based in Flagstaff, Arizona, the weather might be an issue during monsoon season, precipitation in the region will increase significantly, which might delay the collection of information. The team will monitor the weather conditions and collect all required data within the right time period to insure all data collected is as accurate as it can be. Furthermore, since the project is located in a residential neighbourhood site visit and any future constructions might be disruptive to the residence therefore, precautions will be considered in regarding working time periods.

1.5 Stakeholders

The main stakeholders of the project are residence living around the affected area where the project is been implemented. Mainly there are three houses that are affected by the flooding and erosion that occurs mostly during monsoon seasons (As shown in figure 1.2). The area is a private property surrounded with residence, but the issue comes from a public construction outcome, including the city of flagstaff, and the HOA. Those are secondary stakeholders as they are not directly affected by the project however its around their land.

2.0 Scope

2.1 **Task 1.0** Site investigation

Site investigation through multiple site visits will be required to get a better understanding on the condition of the area of interest. Those conditions include, surface type, soil types, existing infrastructure and vegetation along the channel. Those conditions will be observed and recorded.

2.1.1 **Task 1.1** Site visit

Site visit to the Summit Residential Neighborhood Channel will be required. Mainly, the field visit will be conducted along South Pullam Drive and South Amethyst Road. Current conditions of the channel will be identified and noted to make sure every natural and man-made feature is considered during the hydrologic analysis.

2.1.2 **Task 1.2** Land survey

Land surveying will be conducted around the channel along South Pullam Drive. Using Total Station and Auto-Level, data will be collected for stations and elevation around the area along with the location of existing natural and man-made features. In addition, survey data will be collected in the channel that runs along South Pullam Drive. The data collected with the Auto Level will be inputted into the cross-section analyzer (NRCS) program to calculate flow rates and water surface elevation. Multiple land survey will be considered to make sure the data collected is adequate.

2.1.3 **Task 1.3** Topographic map

The data collected with the Total Station will be processed in Civil-3D program to create the topographic map. The topographic map is created to identify elevations and other important channel features such as left of bank, right of bank, and thalweg.

2.2 **Task 2.0** Hydrologic analysis

2.2.1 **Task 2.1** Major-basin delineation

The topographic map obtained from task 1.3 will be used to delineate the major basin. High points will be marked on the topographic map. The high points will be connected to determine the area that contributes to the major basin.

2.2.2**Task 2.2** Sub-basin & tc path delineation

Sub-basins will be defined with separate concentration points by splitting the major basin into parts that have similar watershed characteristics. This task is conducted as different areas within the watershed have different drainage rates. This is because of the different soil surfaces and types. The time of concentration path will be drawn in Auto-cad software for each sub-basin using the polyline command. Each time of concentration path will be broken into parts depending on the type of flow I.e. sheet flow, concentrated flow, street gutter flow, and open channel flow.

2.2.3**Task 2.3** Tc calculation

The time of concentration is the duration in which it takes a drop of water to flow from the remote point within a watershed to its concentration/outlet point. This value will be calculated in an excel spreadsheet using the different equations listed in the City of Flagstaff Stormwater Design Manual.

2.2.4 Task 2.4 Weighted curve number development

The weighted curve number is the average of all run off coefficients based on the different surface type. The weighted curve number is required in the rational equation. Using run off coefficients for different surface types, the average by area will be weighted into one weighted curve number coefficient using the method discussed in City of Flagstaff Stormwater Design Manual.

2.2.5 Task 2.5 HEC-HMS model

*2.2.5.1 **Task 2.5.1** Model setup*

Existing data of the channel along South Pullam Drive will be inputted into HEC-HMS to create the model. This model is used to calculate important values such as existing runoff volume of the geographic area, flow rate, and velocity of the channel.

*2.2.5.2 **Task 2.5.2** Unit hydrograph*

Using data obtained from tasks 2.1 and 2.2, a unit hydrograph will be derived that estimates discharge vs time for the drainage area. This will be done using the technical release- 55 curve number in the HEC-HMS software.

*2.2.5.3 **Task 2.5.3** Model optimization*

Review and finalize the model that was created in the previous task. The calculation will be reviewed to make sure they are reasonable and meets the city of flagstaff design criteria associated with runoff volume, flow rate and velocity of the channel.

2.2 **Task 3.0** Hydraulic analysis

2.3.1 **Task 3.1** Existing and proposed design

Many hydraulic modeling software's will be used to assist in determining the current and proposed for open channel design. The software's will achieve that by modeling different storm events. The flows based on hydrology data obtained from the hydrologic task.

*2.3.1.1 **Task 3.1.1** Culvertmaster program*

Culvertmaster is a modelling program used for designing and analysing culverts [2]. The culvertmaster modelling program is used by adding the material and dimensions of the culvert. The modelling program will be used to create the existing and proposed design of the culvert to determine flow runoff of the water.

*2.3.1.2 **Task 3.1.2** Flowmaster model*

Flowmaster is a modeling program used for designing the storm drain. The modeling program will be used to create a proposed design of the storm water drainage design to determine velocity and flow rate of the water.

2.3.2 **Task 3.2** Alternatives designs

The team will provide alternative storm drain design that could be used for the project. These storms drain designs will be developed for the area of interest. The team will provide design plans for each alternative.

2.3.3 **Task 3.3** Final design

Alternative design plans will be created for the final design. The alternatives plans will provide current and proposed storm drain designs. The final storm drain design will be selected based on the technical advisor's recommendation.

*2.3.3.1 **Task 3.3.1** Connecting design through existing CMP*

After selecting the final design, connection of the proposed design to the current design must be considered. This is the connection between the CMP culvert outlet to the final proposed storm drain design.

*2.3.3.2 **Task 3.3.**2 Outlet protection*

If needed, implementation of outlet protection for the culvert will be provided. The purpose of the protection is to protect the culvert from undermining or head cut. The culvert protection will be designed by following the requirements of the City of Flagstaff stormwater Management Design manual[3].

2.4 **Task 4.0** Impacts

2.4.1 **Task 4.1** Social

Impacts towards the stakeholders of the project will be assessed. An evaluation on how the community feels towards the project those include the Summit Residential neighbours, the client, and the property owners along the channel.

2.4.2 **Task 4.2** Environmental

Impacts on how the potential design will affect the environment will be assessed. Those may include the effect the design will have on the wildlife, the natural channels, plants, and vegetation.

2.4.3 **Task 4.3** Economic

Assessing Economic impacts of the project will be conducted. Cost analysis will be conducted in regards to the reduction of the flood insurance rate and the reduction of property damage to the neighbours along the channel.

2.5 **Task 5.0:** Plan Set

2.5.1 **Task 5.1** Cover sheet

In order to show the content of design, team members will make a professional cover sheet, which will include the company name, logo and staff information. The cover sheet will also include contact information of each team member to answer any question if needed.

2.5.2 **Task 5.2** Survey Sheet

A Survey sheet will be created to collect the data and make reasonable design for the situation.

*2.5.2.1 **Task 5.2.1** Topographic Map*

Team members will make the topographic map on AutoCad, to show the channel and the backyards of three house owners.

2.5.3 **Task 5.3** Notes/ Details

The notes and details will record the specific step for each task process, and determine the culvert size of inlet and outlet and material type the culvert, and team members will use the AutoCad to show all design and structure with different elements.

2.5.4 **Task 5.4** Demolition Sheet

In order to make a better design, team members will make the demolition sheet to review locations about backyards and channels and determine their area.

2.5.5 **Task 5.5** Plan sheet

The team will provide a plan sheet for the storm drain design. The plan sheet will be created by using Civil 3D. The plan sheet will provide details of the project site.

2.5.6 **Task 5.6** Plan Profile of Design

In order to get the information about the project, the plan profile is an efficient way to show the information about alignments and boundaries for the channel.

2.6 **Task 6.0:** Deliverables

2.6.1 **Task 6.1** 30% Submission

In the 30% progress, team members will complete the 30% project. In the 30% plan set, the team members will provide the study of the site visit, surveying data, topographic map,

calculation of Run-off, and the watershed delineation. In the PowerPoint, all 30% work will be presented, and 30% report will show the all analysis and progress of 30% work, and team members will make a draft 60% work list. It can ensure the 30% work and 60% work connected well.

2.6.2 **Task 6.2** 60% Submission

In the 60% progress, team members will complete the 60% project. In the 60% plan set, the team members will save all 30% work and do the culvert and channel design, the cross section, the storm drain design, and the project plan. In the 60% presentation, team members will show the deliverables and improvements. And 60% report will present all analysis and progress of 60% work. Team members will make a draft 90% work list. It can ensure the 30% work, 60% work and 90% work connected well.

2.6.3 **Task 6.3** 90% Submission

In the 90% progress, team members will complete the all project. In the 90% plan set, the team members will provide the final design of the project. Redlines and comments received from the 60% submission will be the only revision made to enhance the quality of the project. Due to there is no presentation for 90% work, so all analysis and improvements will show in the final report.

2.6.4 **Task 6.4** Final Submission

The final submission will show the final work and all deliverables, it develops and presents plans and proposals of the existing and proposed design of the storm water drain and culvert including the changes that will be made to the area. In the final presentation, team members will provide all analysis and improvement for this project. And in the final report, team members will fix all mistakes based on the feedback.

2.6.5 **Task 6.5** Website

Team members will create a website providing project description, team information, client information and a link to all project deliverables and PowerPoint. In this way, the observer can access all information and content of this project.

2.7 **Task 7.0:** Project Management

2.7.1 **Task 7.1** Team Meeting

The group members will have a simple discussion after each lesson, which is mainly to summarize the content of each lesson and determine an accurate team meeting time. Usually, the group members will have a formal team meeting on the weekends to discuss the completed steps and make a plan for unfinished steps. Each member can express their opinions at the meeting, after considering all the opinions, the group members will choose the best opinions and implement them in the project.

2.7.2 **Task 7.2** TA Meeting

When the group members encounter technical difficulties and challenges, the technical advisor will give the team the most help, so students need to have at least 4 technical advisor meetings throughout the semester to ensure that the entire project will not cause big mistakes, this is the most effective way to solve the problem.

2.7.3 **Task 7.3** Client Meeting

The purpose of the Client meeting is to ensure that the entire project is in the right direction, so team members need to contact the client at any time and ask the client if they have new requirements for the entire project. For the newly added steps, only the client knows what is required.

2.7.4 **Task 7.4** Grader Meeting

At the end of each step, the team writes a report reflecting the work done and plans for future work. Soon, the team can receive feedback on the entire project, which greatly helps the team to quickly find out what needs to be modified and take corrective action.

2.7.2 **Task 7.5** Schedule Management

In order to record all task schedules, milestones and deliverables, all team members should make the schedule management to ensure the team member completes work on time. There are many steps for each sub-task, all team members can finish the project step by step, it can ensure the correctness of the project.

2.7.3 **Task 7.6** Budget Management

In order to choose the effective method, team members need to consider the cost issue and technical issue, and choose the best design without wasting resources.

2.7.4 **Task 7.7** Personnel Management

In order to solve the problem effectively, the team needs to use the limited human resource for multiple work, in this project, each team member should do different work.

2.8 Exclusion

2.8.1 Geotechnical analysis

Soil analysis is not required as soil data can be obtained from USGS and USDA soil web survey if needed.

2.8.2 Traffic analysis and roadway analysis

Due to time and budget constraints, traffic and roadway analysis will not be conducted.

2.8.3 Construction management

As the purpose of this project is to design a storm drain and not to implement and construct the design, construction management will not be considered.

2.8.4 Floodplain determination

Due to time and budget constraints, floodplain determination will not be conducted. The client can assign a third-party company to be in charge of floodplain determination.

3.0 Project Schedule

This Project is Scheduled to take 115 days. This includes all major tasks: site investigation, hydrologic analysis, hydraulic analysis, impacts, plan set, deliverables, and project management. The deliverables and project managements tasks occur through the whole project, and assist the team to track progress

3.1 Critical Path

The critical path of this project includes the site investigation, hydrologic analysis, HEC-HMS modeling, hydraulic analysis, alternative and final designs. These tasks must be completed as soon as possible and are critical to complete on time in order to make sure the team is on track. This means if any of those tasks takes more than the intended time, this will cause the whole project to be delayed. Throughout the project lifetime, progress will be tracked in Microsoft Project software to make sure the team is on track and maintain the duration of all critical tasks to avoid delays to the project. Gantt Chart Attached in appendix A is created to represent the progression of the team along with scheduling management.

4.0 Staffing Plan

The main purpose of the staffing plan is to provide each staff positions and calculate the cost with regards to each position to help with the project completion.

4.1 Staff titles

The staff required to complete this project are listed below.
Senior engineer (SENG), project engineer (ENG), engineer in training (EIT), and lab technician (TECH).

4.2 List of qualifications.

Every qualification required associated with every project title is listed below.
1- Senior engineer (SENG). Civil or environmental engineering bachelor's degree, professional engineering license, valuable experience in stormwater design, previous management experience, and must be familiar with the city of Flagstaff stormwater design codes.
2- Project engineer (ENG). Civil or environmental engineering bachelor's degree, professional engineering license, valuable experience in stormwater design, familiar with the city of Flagstaff stormwater design codes and must have some management experience.
3- Engineer in training (EIT). Civil or environmental engineering bachelor's degree and must have valuable experience in surveying, HEC-HMS modelling, and AutoCAD software.
4- Lab technician (TECH). Must have previous experience in modelling software such as Culvertmaster, Flowmaster and HEC-HMS and must have previous experience in surveying.

Team qualifications for each team member is listed below.
Abdullah Alrefaei**:** Senior civil engineering student, completed water resources 1 and 2, Geotechnical engineering 1 and 2, Land surveying, and 2 years' experience using Civil 3D and AutoCAD.
Talal AlAmeeri: Senior civil engineering student, completed water resources 1 and 2 and hydraulics Lab, Land surveying, and 3 years' experience with AutoCAD and Civil 3D.
Sarah Ashkanani: Senior civil engineering student, completed Land surveying, 3 years of experience with AutoCAD and Civil 3D, completed water resources, hydraulic and hydrology lab.
Bolun Yang: Senior year civil engineering student, 1-year AutoCAD experience, water resources 1 and 2, Land surveying, Geotechnical Engineering 1, municipal Engineering.

4.3 Estimated Hours.

The table below provides the total time and work for each member of the team to complete the project.

Table 4.3. 1: Work Hours

Task	SENG (hr)	ENG (hr)	EIT (hr)	TECH (hr)	Total Hours
Task 1.0 Site investigation	**3**	**3**	**31**	**31**	**67**
1.1 Site visit	1	1	1	1	3
1.2 Land survey	1	1	20	20	42
1.3 Topographic Map	1	1	10	10	21
Task 2.0 Hydrologic analysis	**4**	**8**	**33**	**33**	**78**
2.1 Watershed delineation	1	2	4	4	10
2.1.1 Time of concentration delineation	1	2	5	5	13
2.1.2 Time of concentration calculation	1	2	9	9	21
2.2 HEC-RAS Modelling	1	2	15	15	33
Task 3.0 Hydraulic analysis	**12**	**15**	**45**	**45**	**117**

3.1 Existing and proposed design	1	1	20	20	21
3.1.1 CulvertMaster programming	1	1	5	5	11
3.1.2 FlowMaster modelling	1	1	5	5	11
3.2 Alternatives Storm Drain	3	4	5	5	17
3.3 Final Design	4	5	5	5	19
3.4 Proposed Outlet protection	2	3	5	5	15
Task 4.0 Impacts	**3**	**6**	**15**	**15**	**39**
4.1 Social	1	2	5	5	13
4.2 Environmental	1	2	5	5	13
4.3 Economic	1	2	5	5	13
Task 5.0: Plan Set	**5**	**4.5**	**20**	**20**	**49.5**
5.1 Cover sheet	0.5	0.5	2	2	5
5.1 Survey sheet	1	0	2	2	4
5.1.1 Topographic map	0.5	1	3	3	7.5
5.2 Notes/ Details	1	1	4	4	10
5.3 Demolition sheet	0.5	0.5	3	3	6.5
5.4 Plan sheet	0.5	0.5	2	2	4.5
5.5 Plan Profile of design	1	1	4	4	10
Task 6.0: Deliverables	**277**	**284**	**287**	**284**	**1132**

6.1 30% Submission	5	6	9	9	29
6.2 60% Submission	7	8	8	8	31
6.3 90% Submission	8	11	11	11	41
6.4 Final Submission	10	10	10	10	40
6.5 Website	3	5	5	2	15
6.6 Memo Binder	30	30	30	30	120
6.7 Team Meeting	140	140	140	140	560
6.8 Technical Advisor	32	32	32	32	128
6.9 Grading Instructor	32	32	32	32	128
7.0 Client	10	10	10	10	40
Total	304	320.5	431	428	1483.5

4.4 Summary table

Table 4.4.2 shows the summary for each staff personnel hours along with a justification in the comment's column.

Table 4.4. 2: summary of Work Hour

Classification	**Hours**	**Comments**
SENG	304	The senior engineer is required to review and supervise the team members and assign them tasks.
ENG	320.5	The engineer is required to perform the survey, Auto-CAD and calculations needed for the completion of the project.
EIT	431	Since the engineer in training is involved in every part of the project, they will have the most hours spent on the project.
TECH	428	Is mostly in charge of software modelling such as HEC-HMS, Culvermaster and Flowmaster software's.
Total	**1482.5**	

5.0 Cost of Engineering services

The table below shows the cost of engineering services required to complete this project. The total cost required to complete this project was calculated to be $57385. A breakdown of this total could be found in table 5.1 Survey equipment which includes renting a Total station and an Auto-level those are listed in the supplies section. The travel section includes a minimum of 8 meetings with the grading instructor, and a minimum of 4 meetings with the technical advisor. The rate for each personnel can be found in table 5.1 below which is calculated as an hourly rate. The Senior engineer is working at a rate of $220 per hour as he has the most experience and is required to review each task and make sure all requirements is met. The project engineer is working at a rate of $150 per hour as he is in charge of most of the major tasks along with spending most of the time working on the existing and proposed design. The engineer in training rate is $80 per hour as he is required to spend at least an hour in every task to gain more experience in every task. Finally, the lab technician is working at a rate of $50 per hour as he is in charge with collecting physical data from the site, along with the surveying portion of the project.

Table 5. 1:Cost of Engineering Services Breakdown

Personnel	**Classification**	**Hours (hr)**	**Rate ($/hr)**	**Cost ($)**
	SENG	84	220	10,560$
	ENG	106.5	150	15,975$
	EIT	217	80	17,360$
	TECH	214	50	10,700$
Travel				
	Meetings	150 Miles	0.60 $/mile	90 $
Supplies				
	Surveying Equipment	30 hours	90$/hr.	2,700$
Total				**57,385$**

Reference

[1] Google Maps, Google, Flagstaff, AZ, 2020. [Online]. [Accessed: 11-Mar- 2020].
[2] Ministry of Transportation, “CulvertMaster,” Ministry of Transportation, 25-Oct-2013. [Online]. Available: http://www.mto.gov.on.ca/english/publications/drainage/software/culvermc.shtml. [Accessed: 12-Mar-2020].
[3] Flagstaff.az.gov. 2020. [online] Available at: <https://www.flagstaff.az.gov/DocumentCenter/View/58133/SWMgmtDesignManual-3-09?bidId=> [Accessed 12 March 2020].

Appendices

Appendix A- Project Schedule Gantt Chart