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TO: Chase McLeod

CC: Dr. Jeffrey Heiderscheidt & Owen Allen

FROM: Smokerise Design Team

DATE: 12/10/2025

SUBJECT: Submission of Penstock Wash Redesign Project Proposal

Project Proposal

The Smokerise Design Team is submitting the attached project proposal for the Penstock Wash Redesign within the Smokerise Neighborhood. The document includes the full project scope, schedule, staffing plan, and estimated cost of engineering services. This proposal outlines the sequence of work required to complete hydrologic and hydraulic analysis, develop and evaluate drainage alternatives, and prepare a preliminary redesign of the Penstock Wash system.

The proposed project schedule begins on January 12, 2026, and concludes on May 5, 2026, for a total of 77 working days. Major deliverables include the 30%, 60%, and 90% design submissions, followed by the final report, plan set, and presentation.

Based on the staffing plan and estimated labor and equipment needs, the total projected cost for completing the engineering services described in the proposal is $90,042. This amount reflects all anticipated hours, technical tasks, and associated support activities necessary to complete the design effort.

Feel free to reach out if you have any questions or concerns.

Sincerely,

Haile Nelson, Briana Pilling, Harth Beaty, & Qixuan Yang
Smokerise Team

Project Proposal
for the
Redesign of Penstock Wash for the Smokerise Neighborhood
DRAFT #7
Revised 12/8/2025

Penstock Wash and Smokerise Neighborhood
Intersection of Snowflake Drive and East Trails End Drive
Flagstaff, AZ 86004
Coconino County, Arizona

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ABBREVIATIONS

Abbreviation	Definition
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AZ	Arizona
CoF	City of Flagstaff
EIT	Engineer in Training
EOPC	Engineer’s Opinion of Probabal Cost
EPA	Environmental Protection Agency
FE	Fundamentals of Engineering
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographical Informational System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HRS	Hours
INT	Intern
MAG	Maricopa Association of Governments
NAU	Northern Arizona University
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PE	Principal Engineer
PrE	Project Engineer
USDA	United States Department of Agriculture
QA	Quality Assurance
QC	Quality Control

1.0 Project Understanding

1.1. Objective

The objective of this project is to evaluate the feasibility of redesigning Penstock Wash to reduce flooding impacts within the Smokerise neighborhood and improve the overall performance of the stormwater system. This will be achieved by quantifying watershed runoff, assessing the capacity of existing conveyance structures, and identifying preliminary design alternatives capable of managing both monsoonal runoff and seasonal snowmelt. The study aims to ensure that proposed improvements comply with City of Flagstaff stormwater management standards and FEMA floodplain requirements while providing a technically sound foundation for subsequent design and construction phases. By focusing on hydrologic and hydraulic performance, structural adequacy, and regulatory compliance, the project objectives support the City's long-term flood control strategy and address the recurring drainage concerns of the Smokerise community.

1.2. Background

The project is located within the East side of Flagstaff, AZ. The area North of Living Christ Lutheran Church signifies the beginning of where Penstock Wash will be redesigned as it flows under Highway 78 and into East Trails End Drive. The end of the redesign area will be signified as the Railhead and Test Drive roundabout.

Figure 1-1 shows the general location of the project in Arizona.

Figure 1-1: Project Location Map

Figure 1-2 shows the general Flagstaff area in relation to the project.

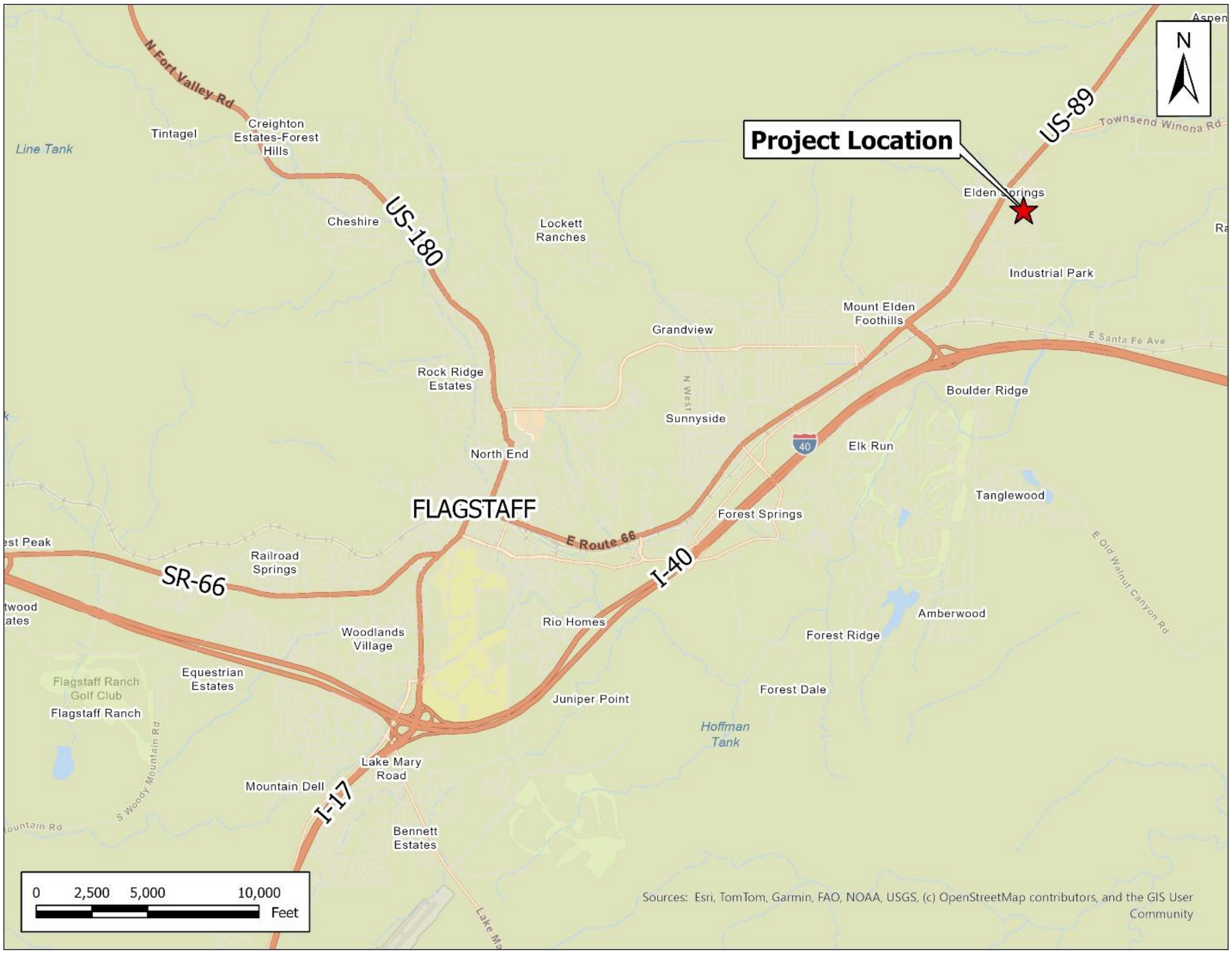

Figure 1-2: Vicinity Map

Figure 1-3 shows the specific project location, with the Smokerise neighborhood highlighted.

Figure 1-3: Site Map

Penstock Wash flows directly into the Smokerise Neighborhood on the east side of Flagstaff, AZ. The Smokerise area currently experiences frequent flooding from surface runoff. The City of Flagstaff seeks to improve the existing stormwater infrastructure within and surrounding the neighborhood to safely convey stormwater to the Rio de Flag river system. Successful completion of this redesign will help the city control flooding along Penstock Wash and protect nearby residential areas.

After exiting a two-culvert system near East Trails End Drive, flow continues through an overgrown natural channel and an adjacent asphalt area before reaching a FEMA-designated floodplain channel. This floodplain channel ultimately drains into a detention basin, which then outlets to the Rio de Flag. Figure 1-3 illustrates the overall site layout, including Penstock Wash, the culvert locations, overgrown channel segments, the FEMA floodplain, and the direction of outflow toward the Rio de Flag.

In addition to infrastructure limitations, regional climate conditions contribute significantly to flooding within the Smokerise Neighborhood. According to NOAA, Flagstaff receives roughly 21 inches of annual precipitation, much of it during intense summer monsoon storms [1]. These short-duration, high-intensity events generate rapid runoff that often exceeds the capacity of small culverts and natural channels. Winter snowfall and subsequent snowmelt further increase runoff volumes, while freeze–thaw cycles can create ice blockages in culverts and channels, reducing conveyance capacity at critical times.

1.3. Technical Considerations

The technical aspects of this project will follow a design process that begins with data collection and field evaluation, continues with hydrologic and hydraulic analysis, and concludes with storm drain, culvert, and channel design.

A site visit will be completed to document existing conditions and locate key drainage features. Access may be limited by vegetation, obstructions, or wet ground. These issues will be addressed through additional visits to dry conditions and by using remote data sources. Early site evaluation will improve the accuracy of subsequent analyses.

ArcGIS will be used to create preliminary maps before surveying data is collected. This information will be used to guide fieldwork, survey planning, and early hydrologic analysis.
Surveying will provide topographic and site condition data, verified with City of Flagstaff and FEMA records. This information will define watershed boundaries, channel alignments, and elevations. Reliable survey data is critical for accurate flow calculations and infrastructure sizing.
Hydrologic analysis will define watershed runoff and establish design flows for 10- and 100-year storm events. This step determines how stormwater volumes are to be managed. Incorrect estimates could lead to undersized infrastructure and flooding or oversized systems and higher costs.

Hydraulic analysis will evaluate the capacity of culverts, channels, and storm drains. Results will be checked for compliance with the CoF and FEMA standards. This step will guide the sizing and layout of drainage infrastructure and reduce flood risks.
Storm drain and culvert design will improve conveyance in the Smokerise neighborhood. Proper design will reduce flooding, improve roadway safety, and limit long-term maintenance. Poor design could increase costs and impact residents.

Open channel design will address stability, erosion control, and long-term maintenance. Stable geometry and appropriate lining or vegetation will reduce erosion and protect water quality. Neglecting these factors could result in channel failure and increased maintenance.
AutoCAD drafting will be used to produce maps, figures, and layouts for the evaluation of design alternatives. Accurate drawings will support technical review and clearly convey design intent for construction.

1.4. Potential Challenges

The Penstock Wash redesign may encounter several challenges throughout the project process that fall outside the direct control of the project team. These external factors, if not anticipated, have the potential to affect data collection schedules, coordination efforts, and overall project delivery.

Unpredictable weather conditions may interfere with fieldwork scheduling, particularly for site surveying and visual inspections. Snow cover, heavy rainfall, or saturated ground conditions may temporarily limit access or compromise safety, leading to delays in data collection. To minimize these risks, field activities will be planned with weather trends in mind, and backup timeframes will be built into the project schedule to accommodate possible disruptions.

Equipment availability is dependent on coordination with other classes and projects; this limited access to equipment may require schedule adjustments. Additionally, unforeseen equipment failures, such as battery power loss in surveying devices, can interrupt planned field activities. To address this, secondary equipment and backup power sources will be made available to the team when surveying, and tasks will be prioritized when equipment is fully operational.

Site access is another important consideration. Portions of the project area lie within or adjacent to private property, which presents limitations on where and how data can be collected. To ensure property rights are respected, the project team will utilize existing records provided by the City of Flagstaff wherever possible. Additionally, non-invasive methods, such as aerial imagery provided by the city and desktop mapping, will be employed to gather necessary data without disturbing private landowners. This approach avoids potential conflicts while maintaining data accuracy.

By anticipating these potential challenges and building flexibility into the schedule and approach, the project team aims to reduce the impact of external factors and maintain project flow.

1.5. Stakeholders

The City of Flagstaff is the primary stakeholder, responsible for overseeing stormwater management and the long-term implementation of improvements. The residents of the Smokerise neighborhood are directly affected by flooding and will benefit from enhanced stormwater infrastructure. Northern Arizona University (NAU) serves as a stakeholder through its student design team, which is conducting the feasibility study and preparing the proposal. The Arizona Department of Environmental Quality (ADEQ) also has an interest in the project, as Penstock Wash ultimately discharges into the Rio de Flag River system. FEMA is a stakeholder as well; the wash is located within a designated FEMA floodplain, since floodplain management and regulatory compliance would be integral to the project. Additionally, the project area impacts local traffic circulation, as Trails End Drive connects to the North Dodge Avenue roundabout and Highway 78. Therefore, residents and commuters who travel through or around the Smokerise neighborhood represent another stakeholder group, with concerns primarily related to mobility and safety.

2.0 Scope of Services

The project scope is organized into a series of tasks that are built logically from data gathering through final design. Each task description outlines the specific work to be completed, explains the reasoning and engineering purpose behind it, and identifies relevant standards, requirements, and regulations that will guide the analysis. The overall goal is to develop a technically sound and regulatory-compliant redesign of the Penstock Wash drainage system that reduces flooding risks in the Smokerise neighborhood while enhancing long-term watershed stability and sustainability.

2.1. Task 1: Due Diligence

The purpose of this task is to establish a comprehensive understanding of existing site conditions and available data before conducting any modeling or design work. Performing due diligence ensures that subsequent hydrologic and hydraulic analyses are based on accurate, verified information. All work under this task will be completed in accordance with the City of Flagstaff Stormwater Design Manual [2], the FEMA Floodplain Management Regulations [3], and applicable NRCS (Natural Resources Conservation Service) [4] Technical Releases TR-55 and TR-20.

2.1.1. Task 1.1 Identify Existing Issues

The team will summarize known flooding problems, culvert deficiencies, and erosion concerns within the Smokerise neighborhood. This effort includes reviewing past drainage complaints, flood records, and known maintenance issues reported by the City of Flagstaff Stormwater Division. The purpose of this subtask is to define the scope of hydraulic and hydrologic deficiencies that must be addressed in later tasks. Understanding these existing conditions is essential to ensure that proposed improvements directly target the most critical drainage concerns and align with community priorities.

2.1.2. Task 1.2 Records Review

The team will compile and evaluate available reference materials, including City of Flagstaff drainage and infrastructure records, previous design studies, and applicable stormwater design criteria. This subtask ensures the team uses the most recent and authoritative data sources. Reviewing these documents allows the project team to confirm the existing floodplain boundaries, drainage basins, and structural characteristics of the current conveyance system. Compliance with FEMA mapping standards and CoF design guidelines ensures consistency with regional floodplain management policies and regulatory expectations.

2.1.3. Task 1.3 Research Existing Topographic Data

Available topographic data will be collected and analyzed to establish the base mapping and control for all hydrologic and hydraulic modeling. Data sources will include City of Flagstaff GIS layers, county LiDAR datasets, and existing survey control points verified through field reconnaissance. The topographic data will be used to delineate drainage boundaries, define channel geometry, and establish ground elevations for model calibration. This information provides the geometric foundation for accurate watershed modeling and design analysis. The work will follow standard practices defined in USGS mapping protocols and NRCS watershed delineation procedures**.**

2.2. Task 2: Site Investigation

This task involves a comprehensive field investigation and survey to document existing site and drainage conditions within the Smokerise neighborhood. The information collected during this phase provides the physical foundation for accurate hydrologic and hydraulic modelling. Observations will include both engineered structures (such as culverts and storm drains) and natural drainage features (such as open channels, vegetation, and ground surfaces).

2.2.1. Task 2.1 Document Existing Conditions

A detailed field visit will be conducted to observe and record the existing hydraulic and geomorphic characteristics of the project area. The investigation will include documenting culvert dimensions, erosion and sediment accumulation, vegetation density, and flow obstructions. Additional data, such as ground-cover types, impervious-surface areas, and drainage connectivity, will be recorded since these directly influence runoff generation and infiltration capacity.

2.2.2. Task 2.2: Surveying

Surveying will be performed at the same time as the existing conditions field visit. The team will gather information on channel geometry to create a topographic map.

2.2.3. Task 2.3 Data Analysis.

Following data collection, the field and survey information will be processed and integrated into ArcGIS Pro and other analytical tools to produce a detailed topographic map. This map will delineate watershed boundaries, identify drainage divides, locate existing structures, and define channel alignments and slopes. The resulting topographic base map will serve as the geometric foundation for all hydrologic and hydraulic analyses.

2.3. Task 3: Hydrologic Analysis

This task quantifies watershed runoff for design storm events to establish reliable inflow conditions for hydraulic modeling of the Penstock Wash system. Hydrologic analysis defines how rainfall is converted into runoff within the watershed, providing design discharges for culverts and open channels. The analysis ensures that the proposed improvements are properly sized to manage stormwater in compliance with regulatory and engineering design standards.

All hydrologic analyses will follow the procedures outlined in the NRCS Technical Release 55 (TR-55): Urban Hydrology for Small Watersheds, the FEMA Floodplain Management

Regulations (44 CFR Part 60), and the City of Flagstaff Stormwater Design Manual. Rainfall data and design intensities will be obtained from NOAA Atlas 14 Precipitation Frequency Estimates for Coconino County, AZ.

2.3.1. <u>Task 3.1 Watershed Delineation.</u>

Drainage boundaries will be delineated using ArcGIS Pro and available LiDAR-based topographic data. The analysis will define sub-basins, drainage divides, and flow paths contributing to each culvert or channel segment. Field-verified elevation data collected during the site investigation will be integrated to ensure the geometric accuracy of delineated areas. Proper watershed delineation is critical to determine the contributing area, land-cover characteristics, and flow routing that directly affect runoff volume and peak discharge.

2.3.2. <u>Task 3.2 Time of Concentration.</u>

The time of concentration (Tc)—the time required for runoff from the hydraulically most distant point of the watershed to reach the outlet—will be determined using NRCS TR-55 methods. Flow segments will be classified into sheet flow, shallow-concentrated flow, and channel flow, and their travel times will be computed using established NRCS equations and Manning's roughness values. Determining Tc is essential for developing accurate hydrographs and ensuring that storm runoff design reflects the actual response time of the watershed.

2.3.3. <u>Task 3.3 Design Storm Modeling.</u>

Hydrologic simulations will be performed using HEC-HMS in conjunction with NRCS TR-55 methodologies to compute runoff hydrographs and 10-year and 100-year peak discharges. The model will incorporate precipitation frequency data from NOAA Atlas 14, land-use parameters from the City of Flagstaff GIS database, and soil characteristics from USDA NRCS Web Soil Survey datasets. The results will define design flows for each sub-basin and provide input hydrographs for subsequent hydraulic analysis.

2.4. <u>Task 4: Hydraulic Analysis – Existing</u>

Assess the performance of the existing Penstock Wash drainage system by developing a hydraulic model, simulating the design of storm events, and evaluating the capacity of existing culverts and open channels. The purpose is to identify deficiencies that contribute to flooding, erosion, or non-compliance with City of Flagstaff and FEMA criteria.

2.4.1. <u>Task 4.1 Culvert Analysis</u>

Each existing culvert will be evaluated for hydraulic capacity and structural adequacy under 10-year and 100-year storm events. The analysis will determine headwater-to-diameter (HW/D) ratios, assess inlet and outlet control conditions, and calculate flow capacity using both energy balance and orifice/weir equations. Results will be compared with City of Flagstaff stormwater design standards to verify compliance with minimum freeboard and non-overtopping requirements. This subtask ensures that the capacity limitations and potential backwater effects of existing culverts are fully understood.

2.4.2. Task 4.2 Channel Analysis

The open-channel system will be analyzed for hydraulic performance and stability using the HEC-RAS model. Flow depth, velocity, and freeboard will be computed for both the 10-year and 100-year storm events. Manning's roughness coefficients will be assigned based on field conditions, including vegetation density and channel lining type. The goal of this subtask is to determine whether the existing channel provides sufficient conveyance capacity while maintaining long-term stability and minimizing sediment transport or scouring.

2.4.3. Task 4.3 Deficiency Identification.

Based on the modeling results, this subtask will summarize all areas where the existing system fails to meet regulatory or design performance standards. Locations of overtopping, insufficient capacity, high flow velocities, or erosion-prone reaches will be identified and documented. The findings will include a comparison of modeled water-surface elevations with FEMA-mapped floodplain elevations to verify consistency. The final summary will highlight deficiencies that contribute to flooding or non-compliance, forming the technical basis for developing design alternatives in the next task.

2.5. Task 5: Alternatives Developments & Screening

This task focuses on developing and comparing conceptual improvement alternatives to address the deficiencies identified in the existing Penstock Wash drainage system. The goal is to identify a preferred solution that improves flood control performance while maintaining constructability, minimizing cost, and complying with all applicable regulations. Screening will consider hydraulic efficiency, cost-effectiveness, maintainability, environmental impact, and regulatory compliance. No detailed design is performed in this phase; rather, the analysis provides a rational, standards-based framework for selecting the most appropriate design alternative to advance into final design.

All work under this task will follow guidance from the City of Flagstaff Stormwater Design Manual, FEMA Floodplain Management Regulations (44 CFR Part 60), FHWA HEC-26 Culvert Hydraulics Design Guidelines, and the NRCS TR-55 Urban Hydrology for Small Watersheds for evaluating performance metrics and runoff control efficiency.

2.5.1. Task 5.1 Identify Constraints and Criteria.

To ensure a fair and consistent evaluation of improvement concepts, the selection of alternatives will follow a structured framework that defines specific criteria, assigns weighting factors, and establishes constraints. The evaluation criteria represent the major aspects of design performance and feasibility. These criteria include cost, hydraulic performance, maintenance requirements, constructability, regulatory compliance, and environmental or social considerations. Cost reflects both construction and long-term maintenance expenses, while hydraulic performance measures the ability of each alternative to reduce flooding, improve conveyance, and meet required flow capacities. Maintenance requirements consider the expected frequency and effort needed for future upkeep. Constructability evaluates whether the alternative can be efficiently built within existing site conditions and schedule limitations. Regulatory compliance ensures that each alternative conforms to City of Flagstaff stormwater design standards and FEMA floodplain regulations. Environmental and social considerations address how each design minimizes environmental impacts and supports community resilience.

Each criterion will be assigned a weighting factor that reflects its relative importance in meeting project objectives, with the total weightings summing to 100 percent. In addition, constraints such as project budget, site boundaries, existing infrastructure, environmental protection zones, and course-level resource limitations will define the boundaries within which all alternatives must remain feasible. This framework will be used to score each option within a decision matrix, allowing the project team to select the alternative that best balances technical performance, cost-effectiveness, and sustainability.

2.5.2. <u>Task 5.2 Develop Alternatives</u>

Using the criteria and constraints identified above, the project team will develop conceptual improvement alternatives to enhance the hydraulic performance and resilience of the Penstock Wash system. Potential concepts may include culvert upsizing or replacement, installation of detention or attenuation basins, channel stabilization using riprap or vegetative lining, and channel realignment to optimize flow efficiency.

Each alternative will be analyzed for its strengths, weaknesses, and performance relative to the established evaluation criteria. Hydrologic and hydraulic simulations using HEC-HMS and HEC-RAS will be conducted at a conceptual level to estimate flow capacity, water-surface elevations, and flood reduction benefits. Each option's regulatory compliance and constructability will also be assessed according to the City of Flagstaff and FEMA requirements. The results will allow the project team to compare feasible concepts in a measurable, data-driven manner.

2.5.3. <u>Task 5.3 Select Best Alternative</u>

All conceptual alternatives will be evaluated using a decision matrix that scores each option based on the weighted evaluation criteria. Quantitative metrics—such as cost, flow capacity, and maintenance effort—will be combined with qualitative factors, such as constructability and environmental compatibility, to generate an overall performance score.

The alternative achieving the highest total score while demonstrating compliance with City of Flagstaff Stormwater Design Standards, FEMA floodplain regulations, and accepted engineering practices will be selected as the preferred alternative. The chosen concept will represent the most balanced solution in terms of technical performance, regulatory compliance, sustainability, and community impact. This preferred alternative will be further refined and advanced into a detailed design under Task 6.

2.6. Task 6: Final Design

This task develops the final academic-level design package for the selected improvement alternative. The purpose is to verify hydraulic performance, finalize geometric parameters, and prepare deliverables that clearly communicate design intent. All design activities will comply with the City of Flagstaff Stormwater Design Manual, FEMA Floodplain Management Standards (44 CFR Part 60), FHWA Hydraulic Design of Highway Culverts (HDS-5), and NRCS TR-55 methodologies to ensure consistency with accepted civil engineering practice.

2.6.1. Task 6.1 Final Hydraulic Design.

The final hydraulic design will include detailed modeling and sizing of the selected alternative under the 10-year and 100-year design storm events. This subtask will confirm that the redesigned system provides adequate capacity, maintains freeboard, and achieves efficient flow conveyance along Penstock Wash. The channel design will finalize geometry, lining type, slope, and stabilization features, with flow velocities and shear stresses analyzed to verify compliance with erosion control and stability standards. Appropriate lining materials or vegetation will be selected to improve long-term durability and reduce maintenance needs. The culvert design will establish final size, shape, inlet and outlet configuration, and headwater elevation, and hydraulic grade lines will be checked for compliance with City of Flagstaff stormwater requirements to ensure that flows are conveyed safely without overtopping or excessive energy loss.

2.6.2. Task 6.2 Plan Set Creation

Plan set creation will include the preparation of construction-level drawings such as plan sheets, profiles, sections, and typical details that communicate design intent. Figures will illustrate both channel and culvert improvements, showing all relevant geometric and material specifications. These drawings will be developed in accordance with standard engineering drafting conventions and the City of Flagstaff plan requirements.

2.6.2.1. Task 6.2.1 Cover Sheet and Existing Site Plan

The cover sheet will include the team logo, project information, legend, and scale. The existing site plan will include current structures, channels, features, and surroundings for the 30% deliverable.

2.6.2.2. <u>Task 6.2.2 Proposed Site Plan</u>

The proposed site plan will include new designs or changes to existing structures, channels, features, and surroundings for the 60% deliverable.

2.6.2.3. <u>Task 6.2.3 Detailed Design Drawings</u>

Detailed design drawings will differ depending on the final design chosen and will include material specifications, dimensions, elevations, and construction information for the 90% deliverable.

2.6.3. <u>Task 6.3 Construction Cost Estimate.</u>

A preliminary Engineer's Opinion of Probable Construction Cost (EOPC) will be developed based on proposed materials, design quantities, and current regional unit prices. The cost estimate will provide a planning-level assessment of expected project costs, support evaluation of financial feasibility, and aid the City of Flagstaff in future budgeting and implementation decisions.

2.7. <u>Task 7: Impacts Analysis</u>

This task evaluates the broader implications of the proposed Penstock Wash redesign to ensure a balanced and responsible engineering solution. The analysis will consider economic, environmental, regulatory, and community factors that influence the project's overall sustainability and feasibility. From an economic perspective, the analysis will summarize the probable construction cost and anticipated maintenance requirements associated with the proposed improvements. Local and community impacts will address issues of neighborhood access, public safety, and operational functionality during and after implementation. The study will also consider environmental and global implications, such as the project's contribution to long-term watershed resilience, reduction of flood risk, and alignment with sustainability goals established by the City of Flagstaff. By integrating these interrelated factors, the project analysis will demonstrate that the proposed design not only meets technical and regulatory standards but also supports environmental protection and enhances the quality of life for residents within the Smokerise neighborhood.

2.8. <u>Task 8: Deliverables</u>

This task defines the major project milestones used to track progress and obtain structured feedback. Each submission represents an administrative checkpoint rather than a separate design phase. At every stage, the team will provide updated analyses, construction plans appropriate to that level of completion, and presentation materials to communicate results clearly to the client and instructor.

2.8.1. <u>Task 8.1 30% Deliverables.</u>

The submission will include an initial report and presentation summarizing baseline data, the confirmed project scope, and the setup of preliminary hydrologic and hydraulic models. Preliminary construction plans showing existing drainage features and proposed study limits will also be provided to support early review and guidance. The 30 percent design report will document the completion of Task 1 (Site Investigation) and Task 2 (Hydrologic Analysis) subtasks. It will include existing conditions documentation, watershed delineation, precipitation data, and preliminary HEC-HMS setup. These results will serve as the foundation for later hydraulic modeling. Using the information developed in Task 8.1.1, the team will prepare an initial presentation summarizing the project objectives, baseline data, and preliminary model configuration to demonstrate design progress and receive early review comments. The 30 percent plans will show existing drainage infrastructure and study limits. Drawings will include existing topographic surveys, culvert locations, and preliminary drainage features.

2.8.2. <u>Task 8.2 60% Deliverables.</u>

The hydrologic analysis, existing hydraulic analysis, and alternatives screening will be complete. The team will submit an updated report that summarizes analytical results and identifies the preferred alternative, along with refined concept-level construction drawings and a presentation prepared for client feedback. The 60 percent design report will expand upon the previous submittal. It will document the full hydrologic and existing hydraulic analysis, alternatives screening, and selection of the preferred concept. This presentation will communicate the evaluation process and findings from the hydrologic and hydraulic modeling, emphasizing the rationale for selecting the preferred design alternative. The 60 percent plan set will include refined layouts for channels and culverts developed through Tasks 4.1 to 4.3 and 5.2 to 5.3. Sheets will show existing and proposed drainage alignments, conceptual profiles, and cross-sections based on updated hydraulic results.

2.8.3. <u>Task 8.3 90% Deliverables.</u>

The 90 percent submittal will consist of a draft final report, near-final plans, and a draft project website. At this stage, all technical analyses—including Task 7 (Impacts Analysis)—will be complete, leaving only editorial and formatting adjustments before the final version. The draft final report will compile the completed hydrologic, hydraulic, and design results from Tasks 3 through 6, plus environmental, societal, and economic impact discussions from Task 7. It will serve as the comprehensive design document for internal and external review. This presentation will compare existing versus proposed drainage conditions and summarize all design outcomes for pre-final feedback. The 90 percent plans will include plan views, profiles, and detailed sections from Task 6 (Final Design)**,** covering final hydraulic layout, proposed site plan, detailed drawings (6.2.3), and cost estimate (6.3). A draft project website will summarize the report findings and integrate maps, graphics, and downloadable documents for review.

2.8.4. **Task 8.4 Final Deliverables.**

The final deliverable will demonstrate a fully developed and professionally presented design package, incorporating all review comments from the 90 percent submittal. The final report will include final revisions and polished content reflecting all accepted client and instructor feedback. The final presentation will summarize project objectives, design evolution, and final recommendations, highlighting the proposed improvements to the existing drainage network. The final plans will complete the Task 6 plan-set creation (6.2) with all edits, QA/QC corrections, and annotations required for submission. The final website will include the updated final report, drawings, figures, and visuals summarizing project outcomes and serving as a public-facing record of the completed design.

2.9. **Task 9: Project Management**

This task provides overall control of project schedule, staffing, budget, and quality assurance to ensure timely and efficient completion of all deliverables. The management framework focuses on tracking progress, balancing workloads, controlling resources, and maintaining coordination among all project participants.

2.9.1. **Task 9.1 Schedule Management.**

The project schedule will be maintained and regularly updated in Microsoft Project to monitor task progress, dependencies, and milestones. Any deviations from the original plan will be addressed promptly to ensure that the project is completed on time and aligned with academic deadlines.

2.9.2. **Task 9.2 Resource and Budget Management.**

Staffing and resource allocation will be managed to balance workloads and maintain productivity. Budget control will include monitoring of materials and other project-related expenses to ensure that all activities remain within the established limits.

2.9.3. **Task 9.3 Meetings and Quality Assurance.**

Regular meetings will be held with the project team, client, teaching assistant, and grading instructor to maintain effective communication and coordination. Internal quality assurance and peer reviews will be performed throughout the semester to verify technical accuracy, ensure document consistency, and confirm compliance with City of Flagstaff and course requirements.

2.10. Exclusions

Project boundaries that will not be performed due to course limitations, resources, or licensure restrictions.

2.10.1. Geotechnical Investigation.

No drilling, subsurface sampling, or laboratory soil testing will be performed.

2.10.2. Land or Right-of-Way Acquisition.

The team will not pursue property acquisition or easements.

2.10.3. Community Outreach.

Public engagement and community meetings are outside the scope.

2.10.4. Environmental Permitting.

No preparation of NEPA documentation or Section 404 permit applications will be included.

2.10.5. Construction Ready review.

No PE-stamped, construction-ready documents will be produced; deliverables remain at the student-design level.

2.10.6. Construction Phase.

Bidding, contractor coordination, and construction oversight are excluded.

2.10.7. FEMA paperwork.

Preparation and submission of FEMA compliance paperwork will not be performed.

3.0 <u>Schedule</u>

The project schedule defines the planned sequence and duration of engineering, analysis, and design tasks necessary for the successful completion of the Penstock Wash Project. Developed in Microsoft Project, the schedule establishes the baseline for tracking progress, coordinating tasks among team members, and managing all submittals. The project start date is January 12th, and the projected end date is May 5th, 2026. The total duration is 77 working days. A complete Gantt chart is provided in Appendix A**.**

3.1. <u>Schedule Overview</u>

Each major task and subtask have a defined start and finish date to maintain a continuous and efficient workflow. The project progresses through the following sequence of major tasks: due diligence, site investigation, hydrologic and hydraulic analyses, alternatives development, final design preparation, and impact evaluation. Project milestones serve as checkpoints for tracking progress and confirming completion of major deliverables, with the 30 percent submittal scheduled for February 10, 2026, the 60 percent submittal for March 24, 2026, the 90 percent submittal for April 23, 2026, and the final deliverable for May 5, 2026. The workflow follows the logical dependencies outlined in the Gantt chart: due diligence establishes baseline site conditions and collects existing data, while site investigation begins shortly after under a start-to-start relationship to allow limited overlap. Hydrologic and hydraulic analyses run concurrently to improve efficiency and maintain modeling consistency between runoff and conveyance systems. After these analyses are complete, alternative development begins using their results to guide design decisions. The final design phase refines the selected alternative into detailed modeling, plan preparation, and cost estimation, while impact evaluation and documentation occur concurrently to prepare for the final submittals and client review. A series of major design deliverables serves as key schedule milestones for evaluating progress. The 30 percent submittal is scheduled for February 10, 2026, followed by the 60 percent submittal for March 24, 2026. The 90 percent deliverable is planned for April 23, 2026, and the final deliverable for May 5, 2026. These milestones provide structured checkpoints for internal review, client coordination, and confirmation of ongoing task completion.

3.2. <u>Critical Path</u>

The critical path for the Penstock Wash Project follows the sequence of due diligence, site investigation, hydrologic and hydraulic analyses of existing conditions, alternatives development, final design, impacts analysis, and final deliverable preparation. Because these activities have zero or minimal float, maintaining progress along this sequence is crucial for timely completion. Float is incorporated into the project only on weekends and during Spring Break (Appendix A), designated as nonworking periods. Schedule control measures include overlapping compatible tasks where possible, monitoring task interdependencies, and reallocating resources as needed to preserve schedule integrity and avoid delays. Additional float is available on weekends and during Spring Break, allowing the team to work as necessary to recover any lost time.

Maintaining momentum along the critical path ensures the project remains aligned with milestone deadlines and overall schedule objectives.

4.0 <u>Staffing Plan</u>

The staffing plan for the Smokerise Neighborhood Penstock Wash Redesign Project outlines the project team's organizational structure and distribution of responsibilities. The plan ensures that all technical, analytical, drafting, and administrative tasks are completed efficiently in accordance with engineering standards.

4.1. <u>Staffing Positions</u>

The positions identified for this project include the Principal Engineer (PE), Project Engineer (PrE), Engineer in Training (EIT), and Intern (INT). Each position represents a distinct role within the project and collectively covers all phases of work. Table 4-1 shows the estimated hour breakdown for each role within the project.

Principal Engineer (PE) — The PE functions as the most senior technical authority on the project. This role typically requires a bachelor's or master's degree in civil engineering, a Professional Engineer (PE) license, and more than 5–10 years of experience in stormwater, hydrology, or hydraulic design. The PE provides oversight on methodology, confirms compliance with applicable design standards, performs high-level quality assurance reviews, and validates final engineering decisions and deliverables.

Project Engineer (PrE) — The Project Engineer performs the majority of technical analysis and design development. Typical qualifications include a bachelor's degree in civil engineering and 2–5 years of experience in hydrologic and hydraulic modeling, GIS analysis, and design software such as HEC-HMS, HEC-RAS, and AutoCAD Civil 3D. The PrE refines conceptual alternatives, conducts detailed modeling, prepares engineering figures, and coordinates closely with both senior and junior staff.

Engineer in Training (EIT) — The EIT supports the Project Engineer by completing calculations, developing preliminary models, assisting with plan production, and verifying technical data. This role generally requires a bachelor's degree in civil engineering and successful completion of the Fundamentals of Engineering (FE) exam. EITs typically have 0–2 years of professional experience and contribute extensively to analysis, drafting, and documentation under the guidance of senior team members.

Intern (INT) — The Intern provides foundational support across technical and administrative tasks. This role is typically filled by a sophomore–senior undergraduate engineering student with coursework in hydrology, hydraulics, surveying, and GIS. Responsibilities include data organization, field documentation, assisting with basic modeling tasks, preparing figures, and supporting deliverable development. The INT position offers exposure to professional workflow while contributing meaningfully to project execution.

Table 4-1: Staffing Plan

Task	PE (hrs)	PrE (hrs)	EIT (hrs)	INT (hrs)	Total (hrs)
Task 1: Due Diligence (Total hrs)	**0**	**9**	**18**	**30**	**57**
1.1 Identify Existing Issues		3	6	5	14
1.2 Records Review		3	6	10	19
1.3 Research Existing Topo		3	6	15	24
Task 2: Site Investigation (Total hrs)	**0**	**12**	**24**	**13**	**49**
2.1 Document Existing Conditions		4	8	4	16
2.2 Surveying		4	8	4	16
2.3 Data Analysis and Mapping		4	8	5	17
Task 3: Hydrologic Analysis (Total hrs)	**7**	**17**	**25**	**9**	**58**
3.1 Watershed Delineation	2	7	15	3	27
3.2 Time of Concentration (Tc) Analysis	3	5	5	3	16
3.3 Design Storm Modeling (HEC-HMS)	2	5	5	3	15
Task 4: Hydraulic Analysis - Existing (Total hrs)	**7**	**21**	**35**	**12**	**75**
4.1 Culvert Analysis	2	7	10	4	23
4.2 Channel Analysis	3	7	15	4	29
4.3 Deficiency Identification	2	7	10	4	23
Task 5: Alternatives Development (Total hrs)	**6**	**15**	**20**	**9**	**50**
5.1 Identify Constraints and Criteria	2	5	10	3	20
5.2 Develop Conceptual Alternatives	2	5	5	3	15
5.3 Select Best Alternative	2	5	5	3	15
Task 6: Final Design (Total hrs)	**15**	**28**	**45**	**15**	**103**
6.1 Final Hydraulic Design	5	8	10	3	26
6.2 Plan Set Creation (Total hrs)	7	15	30	9	61
6.2.1 Cover Sheet & Existing Site Plan	2	5	10	3	20
6.2.2 Proposed Site Plan	2	5	10	3	20
6.2.3 Detailed Design Drawings	3	5	10	3	21
6.3 Construction Cost Estimate (EOPC)	3	5	5	3	16
Task 7: Impacts Analysis (Total hrs)		**7**	**4**	**4**	**15**
Task 8: Deliverables (Total hrs)	**8**	**32**	**40**	**20**	**100**
8.1 30% Deliverable	2	8	10	5	25
8.2 60% Deliverable	2	8	10	5	25
8.3 90% Deliverable	2	8	10	5	25
8.4 Final Deliverable	2	8	10	5	25
Task 9: Project Management (Total hrs)	**20**	**44**	**20**	**20**	**104**
9.1 Schedule Management		12			12
9.2 Resource & Budget Management		12			12
9.3 Meetings & Quality Assurance	20	20	20	20	80
Total hours	**63**	**185**	**231**	**132**	**611**

4.1.1. Principal Engineer

The Principal Engineer serves as the senior technical authority responsible for ensuring that all design methods, analyses, and decisions conform to accepted civil engineering standards. This position requires advanced knowledge of stormwater management, hydrologic and hydraulic modeling, and familiarity with FEMA and City of Flagstaff design requirements. The PE provides technical direction, oversees quality assurance, reviews model outputs, and verifies all final calculations, figures, and drawings before submission.

4.1.2. Project Engineer

The Project Engineer performs the core hydrologic and hydraulic analyses that form the technical foundation of the project design. This position requires proficiency with modeling software such as HEC-HMS and HEC-RAS, as well as the ability to interpret survey data, GIS information, and topographic mapping. The PrE develops and refines design alternatives, performs hydraulic capacity checks on culverts and channels, and supports the preparation of final design drawings and documentation in collaboration with other team members.

4.1.3. Engineer-in-Training

The Engineer-in-Training supports the Project Engineer in completing technical analyses and design development. This role requires a solid understanding of hydrologic and hydraulic principles and a working knowledge of software such as ArcGIS, AutoCAD, and Civil 3D. The EIT assists with the preparation of models, figures, and calculations, and contributes to the development of alternative drainage solutions for the Smokerise neighborhood. Although EITs do not approve final designs, they actively participate in creating designs, verifying data, and exploring feasible engineering solutions under the supervision of senior team members.

4.1.4. Intern

The Intern provides general project support and assists both technical and administrative personnel throughout the project lifecycle. This entry-level position is designed to offer exposure to multiple aspects of civil and environmental engineering, including data management, modeling support, and report development. The INT contributes to compiling references, verifying documentation, assisting with quality assurance checks, and preparing supporting materials for project deliverables.

5.0 **Cost of Engineering Services**

This section presents the estimated cost of engineering services required to complete the Penstock Wash redesign for the Smokerise Neighborhood. The total cost is based on the staffing plan described in Section 4.0 and reflects the labor hours, equipment use, expendable materials, and reimbursable expenses necessary to perform hydrologic, hydraulic, and design tasks. The estimate follows conventional cost-development practices used in professional consulting engineering.

5.1. **Billing Rate Development**

The billing rates applied to each staff position were derived by combining the direct pay rate with benefits, overhead, and profit. These indirect costs are represented by an overhead multiplier applied to the base pay rate, followed by a profit margin that yields the final billable rate charged to a client. The U.S. Bureau of Labor Statistics reports that the mean hourly wage for civil engineers in 2023 was $48.64. [5] The IEEE-USA Consultants Fee Survey further notes a median billing rate of $180 per hour for senior technical professionals. [6] Table 5-2 shows the estimated total billing rate for each role within the project.

Table 5-2: Cost Estimate

Cost Estimate			
Personnel	**Hours**	**Billing Rate ($/hr)**	**Total**
Principal Engineer (PE)	63	270	$17,010
Project Engineer (PrE)	185	186	$34,410
Engineer-in-Training (EIT)	231	138	$31,878
Intern (INT)	132	42	$5,544
Personnel Subtotal			$88,842
Equipment	**Days**	**$/day**	**Total**
Surveying	2	100	$200
Computer Lab	10	100	$1,000
Equipment Subtotal			$1,200
Project Total			**$90,042**

5.2. **Labor Cost**

Labor costs were computed by multiplying the number of hours assigned to each position in the staffing plan by the corresponding billing rate. The resulting total represents the professional effort required to complete all hydrologic and hydraulic analyses, field verification, drafting, and documentation associated with the Penstock Wash redesign.

5.3. **Additional Project Costs**

Labor represents the majority of the project cost; several other expenses contribute to the total estimate. Software use, including AutoCAD Civil 3D, ArcGIS Pro, and HEC modeling tools, is accounted for under the computer lab rental at $100/day. Equipment costs are limited to the short-term use of survey and data collection tools such as total stations and GPS receivers for site assessments. We will have two days of surveying at one hundred dollars per day, totaling two hundred dollars spent on surveying equipment. No subcontractor services or travel expenses are anticipated for this design effort, as all technical and administrative work will be performed locally by the Smokerise Team. These additional items ensure that the overall estimate accurately represents the full cost of providing professional design services for the project.

5.4. **Total Project Cost**

The total project cost, calculated including labor and supplies, is $90,042.

6.0 Conclusion

This report outlines the planned approach for evaluating and redesigning the Penstock Wash drainage system within the Smokerise Neighborhood. It defines the project objectives, documents existing conditions, and describes the methods that will be used to complete the hydrologic and hydraulic analyses required for the redesign. The scope of work, schedule, staffing plan, and estimated cost of services provide a clear framework for how the project will be executed from initial data collection through final design submittals.

The tasks presented in this proposal establish the steps needed to identify deficiencies in the current drainage system, develop and screen alternatives, and prepare a preliminary design that complies with City of Flagstaff and FEMA standards. This document serves as the basis for carrying out the project work during the upcoming design phase and provides the structure needed to complete all required analyses and deliverables in an organized and efficient manner.

7.0 References

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[3] "FEMA," U.S. Department of Homeland Security, [Online]. Available: https://www.fema.gov/floodplain-management.

[4] "Natural Resources Conservation Service," U.S. Department of Agriculuture, [Online]. Available: https://www.nrcs.usda.gov/.

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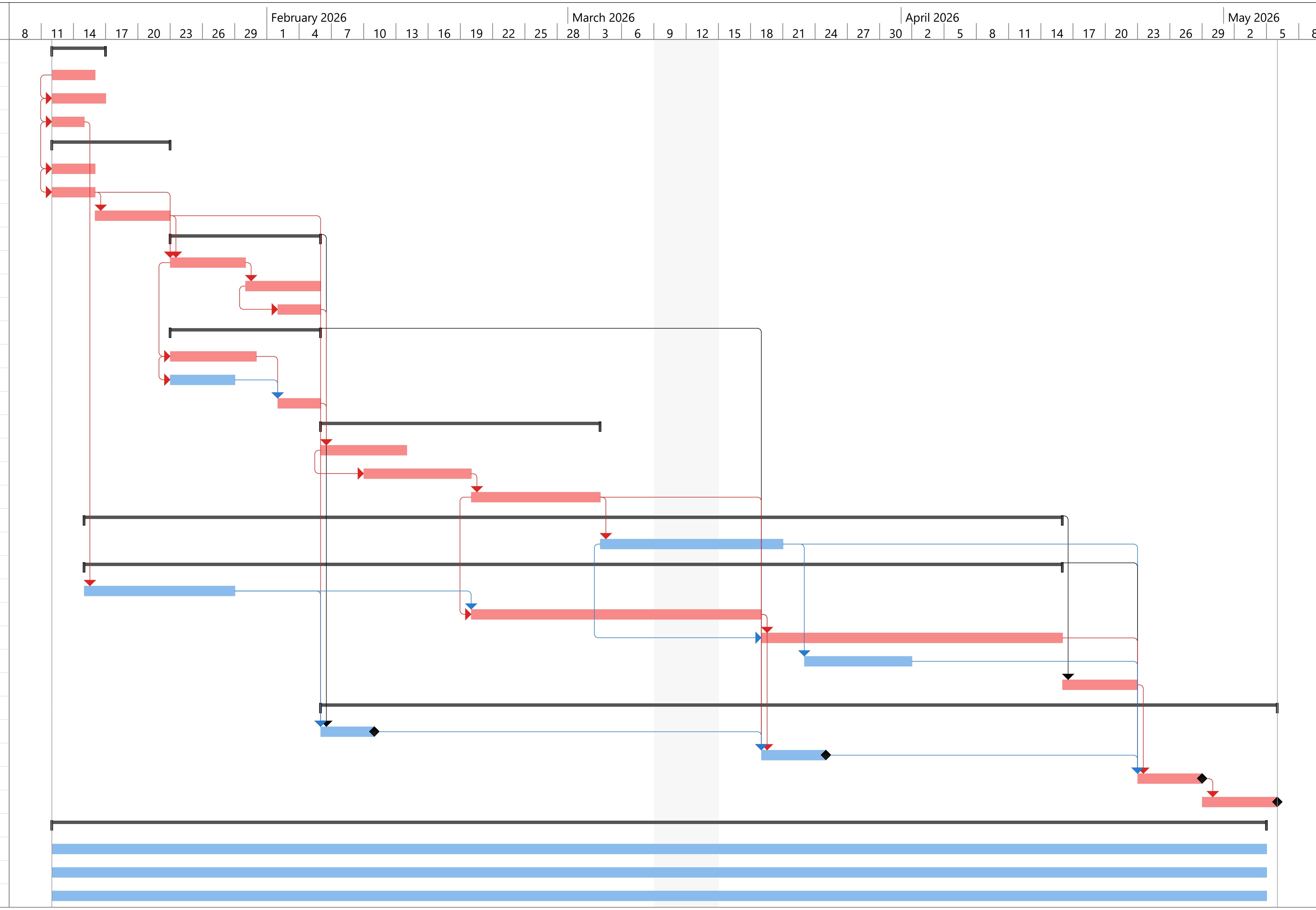
Appendices

Appendix A: Gantt Chart

ID	Task Mode	Task Name
1		**Task 1: Due Diligence**
2		1.1 Identify Existing Issues
3		1.2 Records Review
4		1.3 Research Existing Topo
5		**Task 2: Site Investigation**
6		2.1 Document Existing Conditions
7		2.2 Surveying
8		2.3 Data Analysis and Mapping
9		**Task 3: Hydrologic Analysis**
10		3.1 Watershed Delineation
11		3.2 Time of Concentration (Tc) Analysis
12		3.3 Design Storm Modeling (HEC-HMS)
13		**Task 4: Hydraulic Analysis - Existing**
14		4.1 Culvert Analysis
15		4.2 Channel Analysis
16		4.3 Deficiency Identification
17		**Task 5: Alternatives Development**
18		5.1 Identify Constraints and Criteria
19		5.2 Develop Conceptual Alternatives
20		5.3 Select Best Alternative
21		**Task 6: Final Design**
22		6.1 Final Hydraulic Design
23		**6.2 Plan Set Creation**
24		6.2.1 Cover Sheet & Existing Site Plan
25		6.2.2 Proposed Site Plan
26		6.2.3 Detailed Design Drawings
27		6.3 Construction Cost Estimate (EOPC)
28		Task 7: Impacts Analysis
29		**Task 8: Deliverables**
30		8.1 30% Deliverable
31		8.2 60% Deliverable
32		8.3 90% Deliverable
33		8.4 Final Deliverable
34		**Task 9: Project Management**
35		9.1 Schedule Management
36		9.2 Resource & Budget Management
37		9.3 Meetings & Quality Assurance



Project: Penstock Wash Project
Date: Thu 11/13/25

Task	Inactive Task	Manual Summary Rollup	External Milestone	Manual Progress			
Split	Inactive Milestone	Manual Summary	Deadline				
Milestone	Inactive Summary	Start-only	Critical				
Summary	Manual Task	Finish-only	Critical Split				
Project Summary	Duration-only	External Tasks	Progress				