RANGE REGIONAL AIRPORT STORMWATER MANAGEMENT ALTERNATIVES

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VERSION 1.0

DRAFT

Prepared by RS&H for the
Chisholm Hibbing Airport Authority

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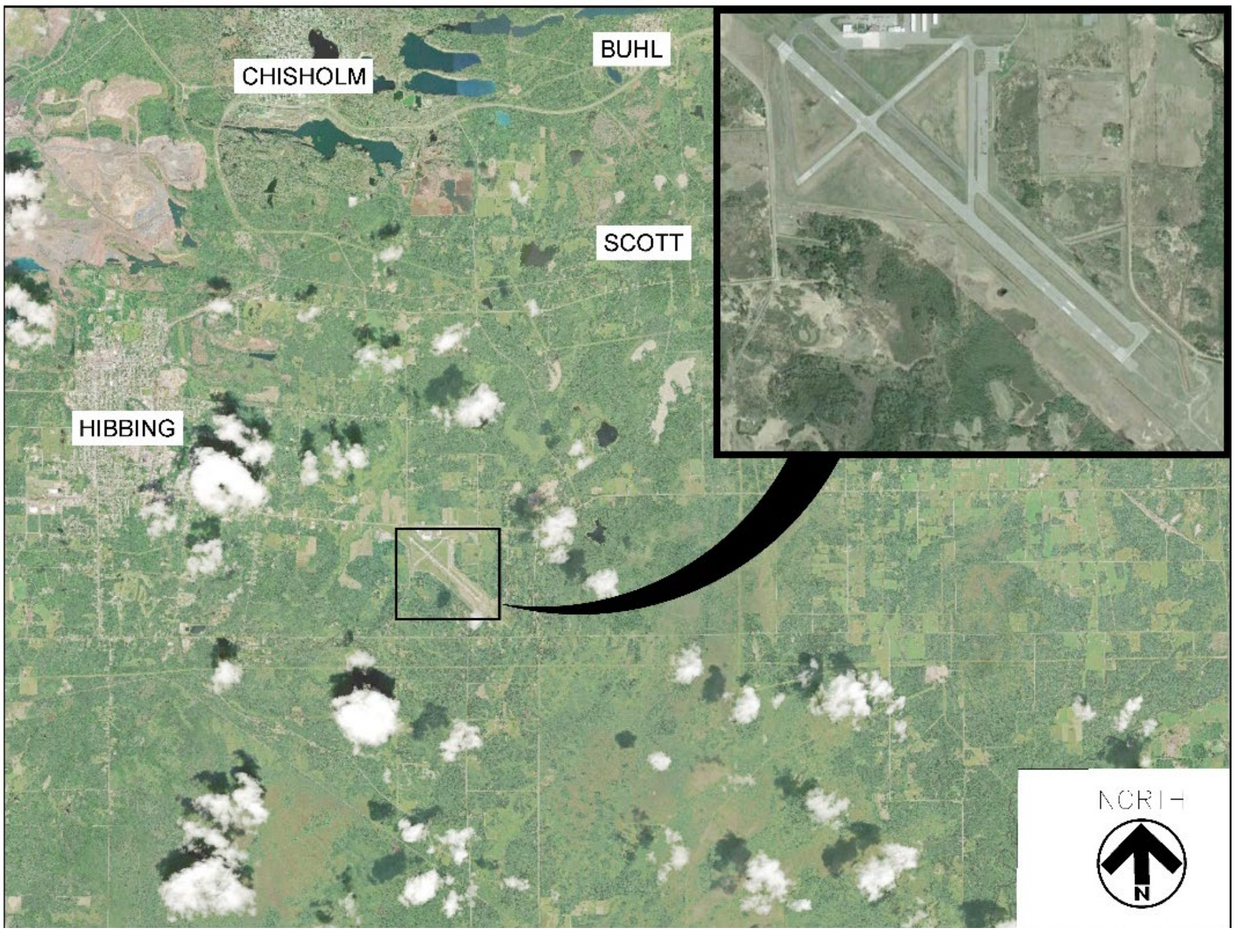
1.1 INTRODUCTION

The Chisholm-Hibbing Airport Authority (CHAA) owns and operates Range Regional Airport (HIB) located at 11038 Highway 37. Hibbing, Minnesota (See **Figure 1**). HIB is located in northern Minnesota within St. Louis County and the city of Hibbing. The property lies within Township 57N Range 20W, and Sections 26 and 36. The Airport's location is approximately 70 miles from the city of Duluth, 200 miles from the city of Minneapolis, and 120 miles from International Falls, along the US-Canada border. HIB is a part of the Duluth, MN-WI Metropolitan Statistical Area, that includes the Carlton County, Minnesota; St. Louis County, Minnesota; and Douglas County, Wisconsin. The airport covers approximately 1,382 acres, with two (2) runways and three (3) taxiways as part of the airfield.

FIGURE 1
AIRPORT VICINITY MAP



Source: RS&H, 2022

The primary objective of this report is to identify stormwater management triggers that may require new facilities and to develop alternatives for managing stormwater runoff that incorporates future development. These stormwater alternatives will be evaluated with respect to a range of factors, including ability to meet regulatory requirements, ease of construction, and probable construction costs. A preferred stormwater alternative will be identified as a part of this investigation.

1.2 REGULATORY BACKGROUND

The Airport must comply with applicable federal, state, and local permit programs administered by various agencies. The following section provide an overview of applicable permits and requirements.

1.2.1 Federal/State Level

The Clean Water Act (CWA) establishes the laws for developing regulation regarding stormwater runoff from municipalities, construction sites, and industrial sites. The regulations are enforced through the National Pollutant Discharge Elimination System (NPDES) permit program. The State of Minnesota is delegated authority by U.S. Environmental Protection Agency (EPA) with administering its own permit system for compliance with the NPDES permit program requirements. The result is The Minnesota Pollution Control Agency (MPCA).

1.2.2 State Level

To maintain the quality of water resources in Minnesota, MPCA issues permits to construction site owners and operators to prevent stormwater pollution during and after construction. Site owners and any construction operators must sign off on a NPDES/State Disposal System (SDS) General Stormwater Permit for Construction Activity (MN R100001), also referred to as the Construction Stormwater General Permit. An MN R10001 permit is required if the following conditions are met:

- The proposed construction activity results in land disturbance of equal to or greater than one acre, or,
- The proposed construction activity is part of a common plan of development or sale that disturbs greater than one acre, or,
- The proposed construction activity impacts less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources.

In this context, construction activity does not include a disturbance to the land of less than five (5) acres for the purpose or routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility.

As part of this permit application, the owner and operator must create a Stormwater Pollution Prevention Plan (SWPPP) that explains how they will control stormwater. If a SWPPP already exists for the project site, updates must be made to the SWPPP to account for any construction that changes the site areas, outfalls, etc. Since a SWPPP already exists for this project site, it is necessary that the SWPPP be updated to account for construction changes. RS&H has been tasked to update the SWPPP as part of the Runway Safety Area (RSA) grading project.

1.2.3 Municipal Level

The municipal separate storm sewer system (MS4) stormwater program is designed to reduce the amount of sediment and pollution that enters surface and grown water from storm sewer systems. The airport is located within the city of Hibbing MS4.

1.3 DESIGN CRITERIA

To comply with stormwater guidelines as set forth by the permits and regulatory bodies described in **Section 1.2**, RS&H developed a summary of design criteria relevant to the drainage infrastructure at HIB. These criteria are summarized below:

FAA AC 150/5320-5D *Airport Drainage Design* (8/15/2013)

- Hydrology
  - Design storm frequency for conveyance system is a 5-year storm event with no encroachment of runoff on taxiway and runway pavements
  - Minimum time of concentration of 5 minutes
  - Hydrologic analysis using the Rational Method
  - Manning's equation for concrete pipe of 0.011 to 0.15
  - Minimum full flow pipe velocity of 3 feet per second
- Culverts
  - Entrance loss of 0.5 for headwalls and end section conforming to slope

FAA Advisory Circular 150/5200-33C *Hazardous Wildlife Attractants On or Near Airports* (2/21/2020)

- Stormwater detention ponds should be designed, engineered, constructed, and maintained for a maximum 48–hour detention period after the design storm and remain completely dry between events

Minnesota Stormwater Manual

- Where a project's ultimate development replaces vegetation and/or other pervious surfaces with one (1) or more acres of cumulative impervious surface, the project must be designed so that the water quality volume of one (1) inch of runoff from the new impervious surfaces created by the project is retained on site (i.e., infiltration or other volume reduction practices) and not discharged to a surface water

City of Hibbing

- A project that changes land use and/or runoff conditions will be required to maintain the existing peak flow rates and hydrologic conditions for the 2-year,10-year, and 100-year rainfall events

National Oceanic and Atmospheric Administration, *Precipitation Frequency Data Server (PFDS)*

- Intensity Duration Frequency (IDF) Curves for the 2-year, 10-year, and 100-year rainfall events

1.4 EXISTING CONDITIONS

RS&H collected data from multiple sources and used the data to develop an understanding of the existing conditions and future development within the study area. Sources and types of data are discussed in the following sections.

1.4.1 Site Conditions

The airport property encompasses approximately 1,383 acres bounded by Highway 37 to the north, Runway 13 to the west, Runway 22 to the east, and taxiway on the south. Perimeter roads that border the airport include South Dublin Rd and South Hughes Rd.

1.4.1.1 Soils

The Natural Resources Conversation Service (NRCS) maps for St Louis County, Minnesota indicated the airport contains the following soils:

- Urban land-McQuade-Buhl complex soils - hydrologic group C/D (B63B)
- McQuade-Fayal, depression complex - hydrologic group C/D (B33A)
- McQuade-Buhl complex - hydrologic group C/D (B27A)
- Hibbing Loam - hydrologic group C/D (B31D)
- Meehan Loamy Sand - hydrologic group A/D (B39A)
- Mooseline-Turpela Complex (B48A) - hydrologic group C/D
- Wurstsmith-Meehan Complex (B58B) - hydrologic group A
- Rifle Soils, Hibbing Catena (B67A) - hydrologic group A/D
- Roscommon, depressional - Roscommon complex (B68A) - hydrologic group A/D
- Barber-Wabuse Complex (B72A) - hydrologic group A/D
- Spooner-Buhl-Littleswan Complex (B73A) - hydrologic group C/D
- Kapla, depressional-Wabuse complex (B74A) - hydrologic group A/D
- Cathro muck (B108A) - hydrologic group A/D

Refer to **Figure 2** for a soil map. The majority of the soils located on site are Urban land-McQuade-Buhl complex soils - hydrologic group C/D (B63B). The soils located in areas where the stormwater alternatives propose a detention pond are McQuade-Fayal, depression complex - hydrologic group C/D (B33A), Mooseline-Turpela Complex (B48A) - hydrologic group C/D, and Wurstsmith-Meehan Complex (B58B) - hydrologic group A.

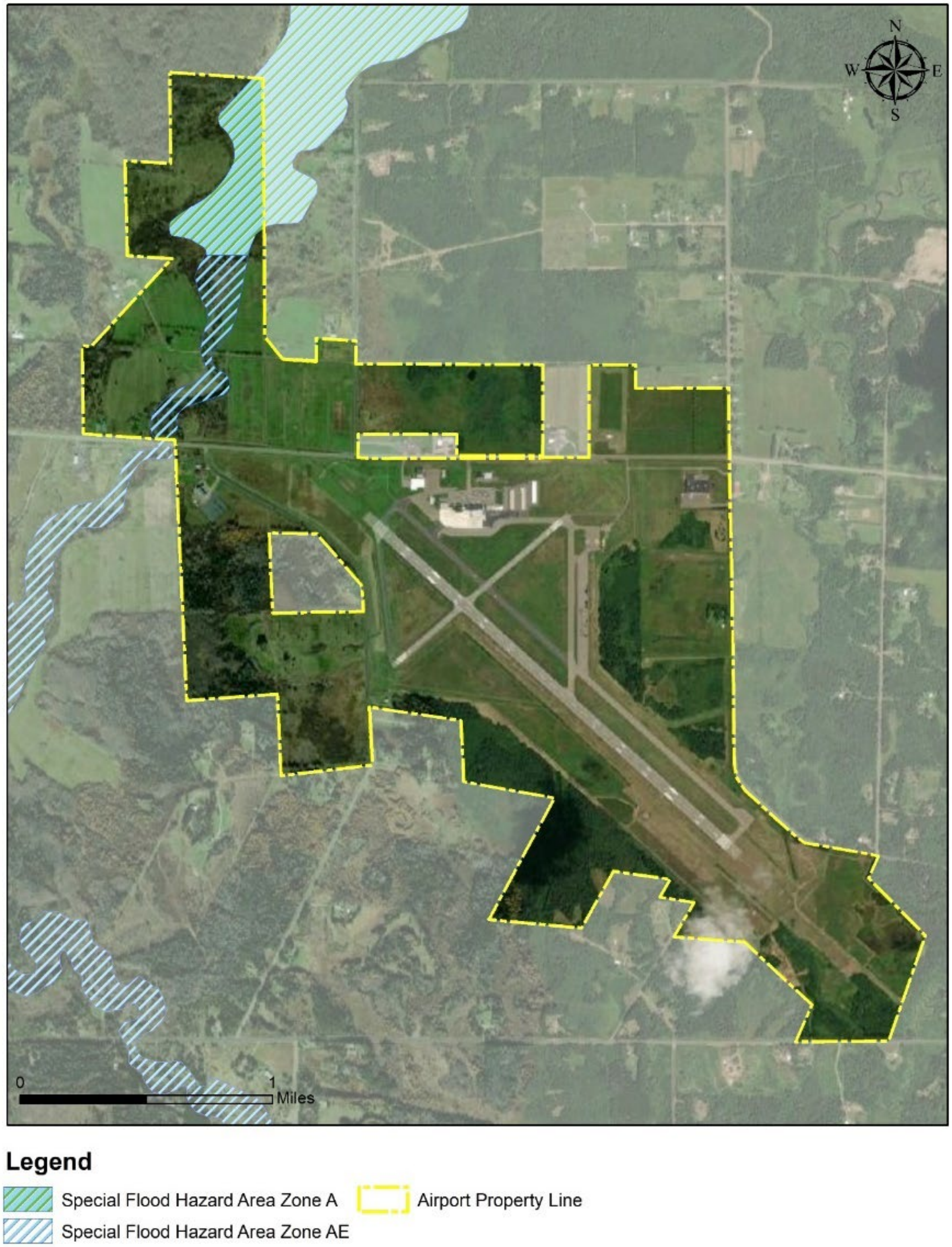
FIGURE 2
SITE SOILS MAP

Source: National Resources Conservation Service, Web Soil Survey, 2021

1.4.1.2 Floodplains

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) number 2705770070A, the airport is located within the city of Hibbing, Minnesota and lies in floodplain zone AE of Barber Creek. An AE flood zone is an area that presents a 1 percent annual change of flooding. See **Figure 3** for location of nearby floodplains.

FIGURE 3
FLOODPLAIN MAP

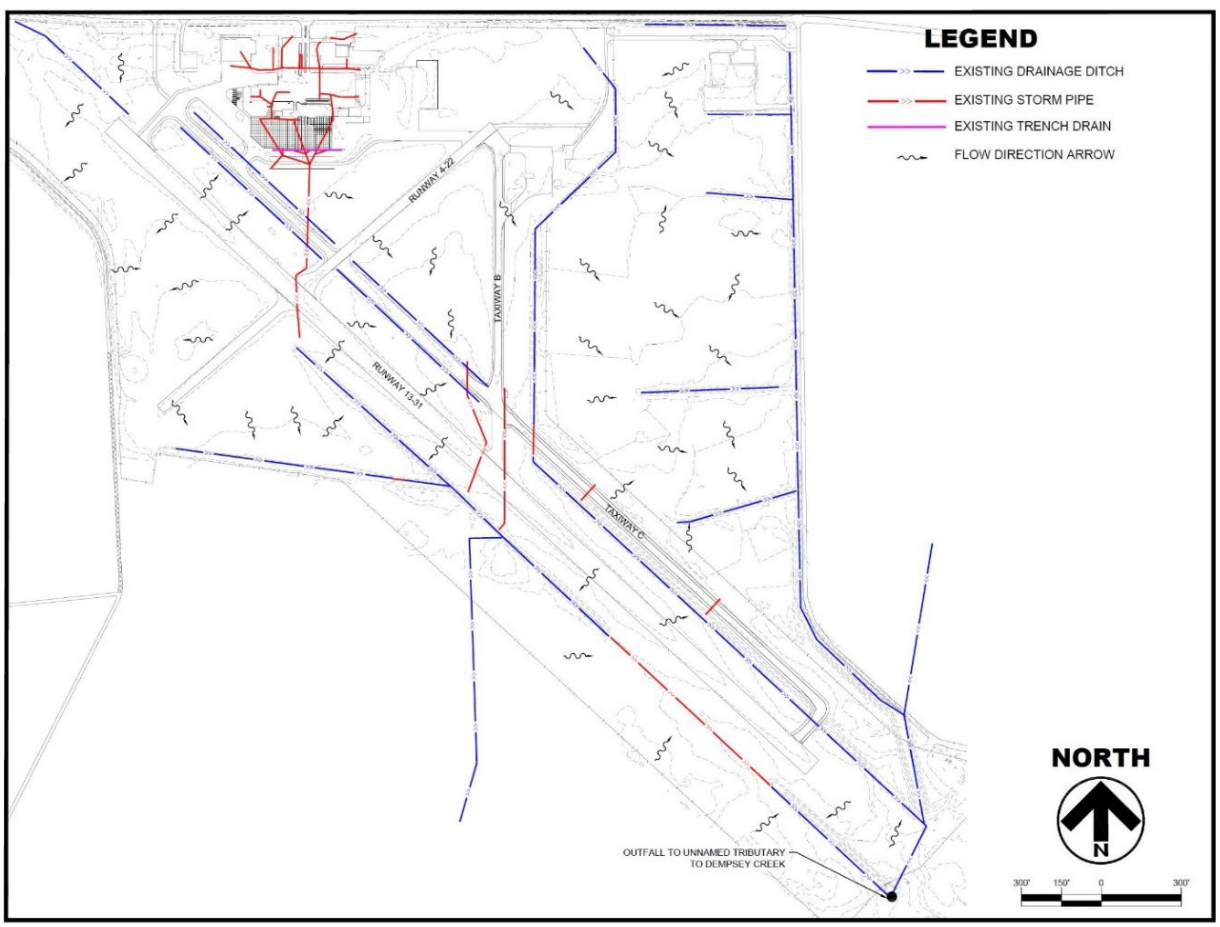


Source: FEMA Flood Insurance Maps; Prepared by RS&H, 2022

1.4.2 Airport Drainage

Information regarding airport drainage was collected through existing as-built information and field observation. The existing stormwater conveyance system begins in the northern portion of the airport near Highway 37. Stormwater runoff from the landside portion of the airport generally flows to inlets located at low points in the terminal parking and hangar area. Runoff is conveyed south by reinforced concrete pipe (RCP) and connects to the storm sewer system that serves the airport apron. The storm sewer system then continues to the south towards the airfield where runoff is conveyed through a water quality unit that outfalls to a 21-inch corrugated metal pipe (CMP). This pipe then collects additional runoff from the infield and runway safety area and flows under Taxiway C and Runway 13-31 before it ultimately outfalls to a drainage ditch on the south side of Runway 13-31. This ditch eventually connects to Dempsey Creek. Runoff from other areas in the airfield, namely the grassed areas between Runway 13-31, Taxiway C, and Taxiway B, generally sheet flows to ditches located parallel to airfield pavements before eventually reaching Dempsey Creek. The area that contributes to this single outfall point to Dempsey Creek is approximately 528 acres, with 94 acres of that area being impervious surfaces.
See **Figure 4** for an existing conditions drainage map.

FIGURE 4
EXISTING CONDITIONS DRAINAGE MAP



Source: RS&H, 2021

1.5 FUTURE CONDITIONS

1.5.1 Site Conditions

RS&H developed two comprehensive airport development layout alternatives as part of Range Regional Airport Master Plan. Following analysis of these layout alternatives, RS&H will recommend one of the layout alternatives, referred to as the preferred comprehensive layout alternative, based on potential for long-term development flexibility and better fulfillment of airport goals and objectives that were identified during the airport stakeholder visioning. The preferred comprehensive layout alternative is defined by the following improvements and shown at the conclusion of 2022 Master Plan **Chapter 3, Airport Development Alternatives**:

- The airfield intersections for the Taxiway A/Runway 22/Taxiway B/Taxiway B-1 area are corrected and under a new arrangement where the Taxiway B/B-1 intersection becomes the north end of a future taxiway parallel to Runway 4-22.
- After the taxiway is realigned, all future aprons, taxiways, and taxilanes will then be aligned to match the orientation of the two-runway system, resulting in safe, efficient, and organized facility development on newly available developable acreage adjacent to the airfield.
- In preparation for the ultimate removal and replacement of existing Taxiway B, the taxiway connection to the Runway 22 threshold is reconfigured to establish a new orientation that accommodates a future taxiway north of the existing Taxiway C paralleling Runway 4-22.
- The placement of the new FBO, transient apron, and FBO fuel farm are strategically located to allow use of the existing taxiway system, while positioning for the later reconfiguration of airfield taxiways. With the construction of new FBO facilities on the east side of the Airport, the terminal and air carrier apron are able to expand for increased service.
- The MnDNR remains at its current site and is connected to the new realigned taxiway near the north end of Taxiway B and Taxiway B-1, therefore allowing it the ability to expand in a manner that is consistent with future airfield and facility development plans.
- The single row of nested T-hangars forecast as needed to meet facility requirements over the planning period is constructed east of Taxiway B in an orientation consistent with future facility plans while still providing simple access to existing Taxiway B. As demand grows, the plan provides flexibility to add more nested T-hangars buildings to the east and west, depending on the timing of replacing Taxiway B, until the T-hangar area reaches full buildout.
- All further general aviation development on the east side of the airfield is planned to orient hangars parallel to the Taxiway C and the future parallel taxiway of Runway 4-22. The conceptual layout shows new conventional/corporate hangars in the south, but the design is flexible enough to accommodate different sizes and styles of hangars as demand dictates.
- All development on the east side of the airport relies on roadway access to S. Hughes Road. These roadways be incorporated to the ultimate road network of the preferred comprehensive layout.

1.5.2 Airport Drainage

The preferred comprehensive layout alternative is expected to impact existing drainage patterns and site flows due to the increase in impervious area and the proposed construction of new facilities in existing drainage elements There is an addition of approximately 78.56 acres of impervious surfaces associated with the redevelopment of the airfield and supporting facilities. To meet regulatory requirements for retention and flow control, as outlined in **Section 1.3**, future stormwater management facilities must be able to provide storage of runoff prior to entering Dempsey Creek and also provide enough attenuation where the post-development runoff rate will not exceed the pre-development runoff rate per city standards.

To aid in the analysis of the future conditions at HIB, RS&H performed preliminary calculations for the impervious area and peak flow at the site outfall associated with the preferred comprehensive layout alternative. These calculations were completed using the rational method and were utilized as the basis for the development of the stormwater alternatives that are explored in **Section 1.6. Table 1** provides a summary of both the existing and future conditions and some results of preliminary calculations. These calculations assumed a time of concentration of 30 minutes for the existing project area and a time of concentration of 15 minutes for the ultimate project area as a conservative measure to be used for sizing any flow control or detention ponds.

TABLE 1
PREDEVELOPMENT VS POST-DEVELOPMENT CONDITIONS

	Condition		Δ
	Existing	Future	
Impervious Area (ac)	93.49	172.05	78.56
Pervious Area (ac)	444.15	365.60	-78.56
Total Area (ac)	537.64	537.64	0
Q, 2-year (cfs)	410.90	716.32	305.48
Q,10-year (cfs)	617.40	1069.20	451.84
Q, 100-year (cfs)	952.20	1651.20	699.07

Source: RS&H Analysis, 2022

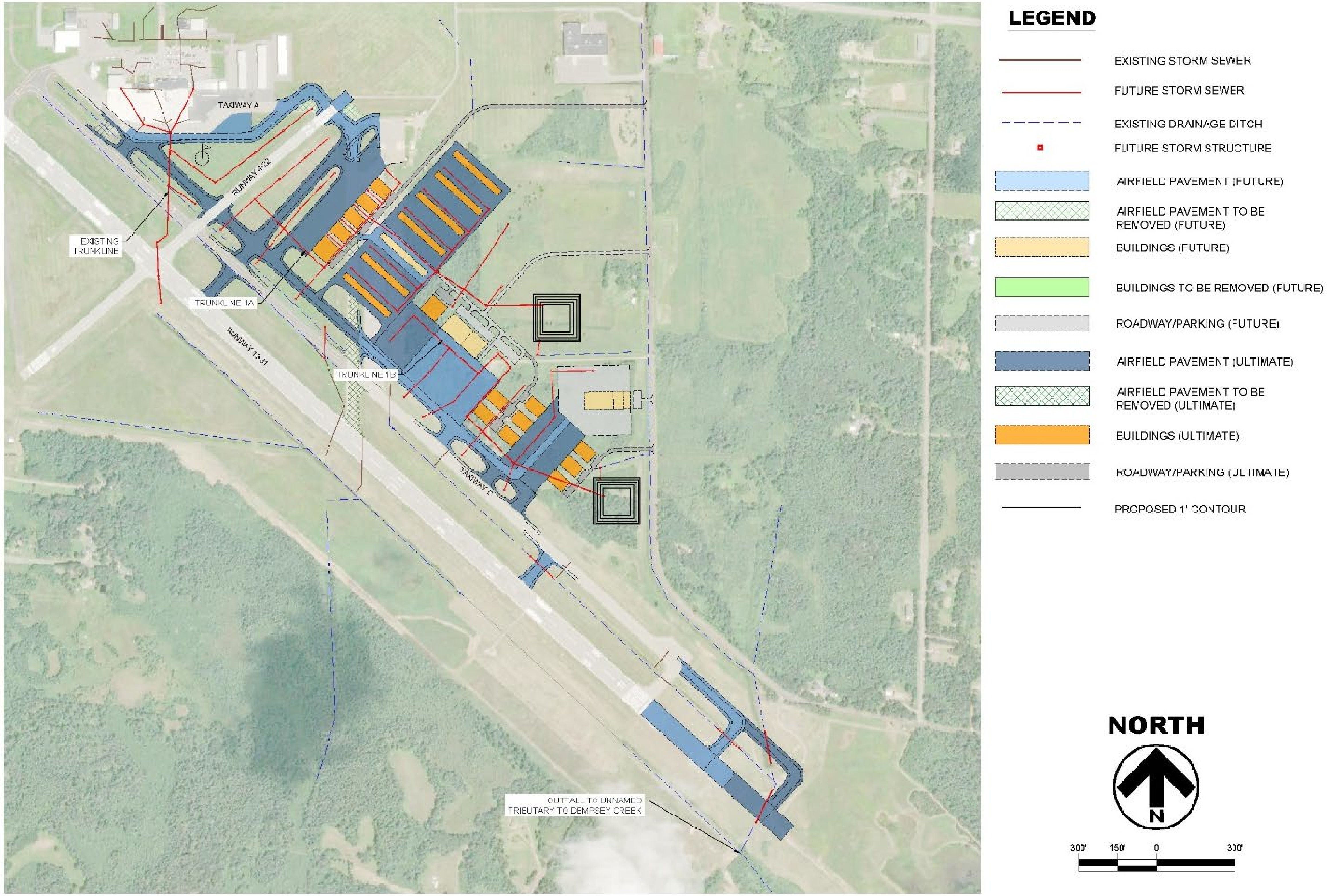
1.6 PROPOSED DRAINAGE ALTERNATIVES

The proposed facilities will require updates to the existing drainage infrastructure to account for the addition of 78.56 acres impervious area associated with the ultimate preferred comprehensive layout alternative. Additionally, airport staff has observed significant flooding on the landside portion of the airport, indicating that the conveyance system serving the landside area and general aviation apron is undersized. RS&H identified necessary improvements for the Airport based on the analysis of the existing drainage system deficiencies and the expected adverse impacts from future airport runoff. These improvements will aid the Airport in meeting the applicable design and regulatory requirements and improve the overall efficiency of the system. The recommended improvements are outlined in the following sections along with a Preliminary Opinion of Probable Cost (POPC) for each stormwater alternative.

1.6.1 Stormwater Alternative 1

Stormwater Alternative 1 alleviates the flooding observed on the landside portion of the airport while also utilizing the existing drainage patterns to the extent possible. This alternative improves overall capacity of the existing system by increasing the size of the pipes that run from the GA apron area to the drainage ditch to the south of Runway 13-31. A new trunkline will be installed and will collect runoff from the infield areas created through the addition of the future parallel taxiway to both runways, the future hangars that lie to the Southeast of Runway 4-22, and the future T-hangars. This trunkline will convey this runoff to a ditch to the East of the proposed future development. The storm pipes serving the future FBO facility, fuel farm, and future hangars on the far southeast side of the airport will outfall to a ditch located to the east of these facilities. All drainage ditches being used as outfalls in this alternative, convey runoff to the major drainage ditch that runs parallel to S Hughes Road. To meet state and local regulations, stormwater detention ponds are proposed at the end of the two proposed trunklines. These detention ponds will capture runoff from the future paved areas to decrease peak flow and provide treatment. An overview of Stormwater Alternative 1 is provided as **Figure 5**. A more detailed exhibit for Stormwater Alternative 1 is provided as part of **Attachment 2**.

FIGURE 5
STORMWATER ALTERNATIVE 1

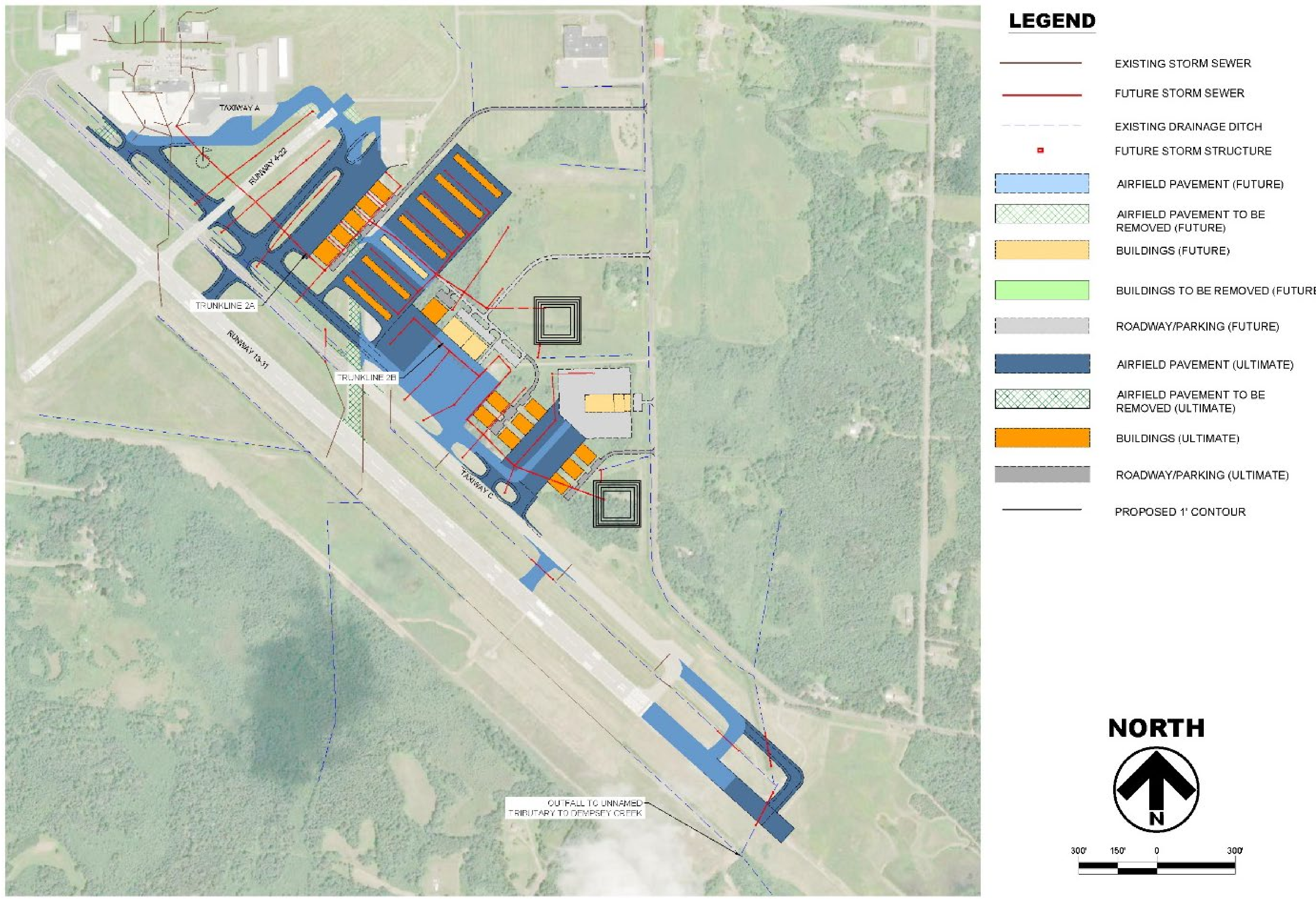


Note: Scale bar graphically represented.
Source: RS&H Analysis, 2022

1.6.2 Stormwater Alternative 2

Stormwater Alternative 2 alleviates the flooding observed on the landside portion of the airport by the addition of new storm pipe that divides the flow from the landside area into two separate drainage ditches. Similar to Stormwater Alternative 1, a new trunkline will be installed and will collect runoff from the infield areas created through the addition of the future parallel taxiway to both runways, the future hangars Southeast of Runway 4-22, and the future T-hangars. However, a portion the existing landside storm sewer system will be re-routed to a proposed trunkline along rather than utilizing the existing storm sewer pipes that outfall to the drainage ditch that runs parallel to Runway 13-31. This new trunkline will convey runoff to a ditch east of the proposed future development. The storm pipes serving the future FBO facility, fuel farm, and future hangars on the far southeast side of the airport will outfall to a ditch located to the east of the FBO facility, fuel farm, and future hangars. All drainage ditches being used as outfalls in this alternative convey runoff to the major drainage ditch that runs parallel to S Hughes Road. To meet state and local regulations, stormwater detention ponds are proposed at the end of the two proposed trunklines. These detention ponds will capture runoff from the future paved areas to decrease peak flow and provide treatment. An overview of Stormwater Alternative 2 is provided as **Figure 6.**

FIGURE 6
STORMWATER ALTERNATIVE 2

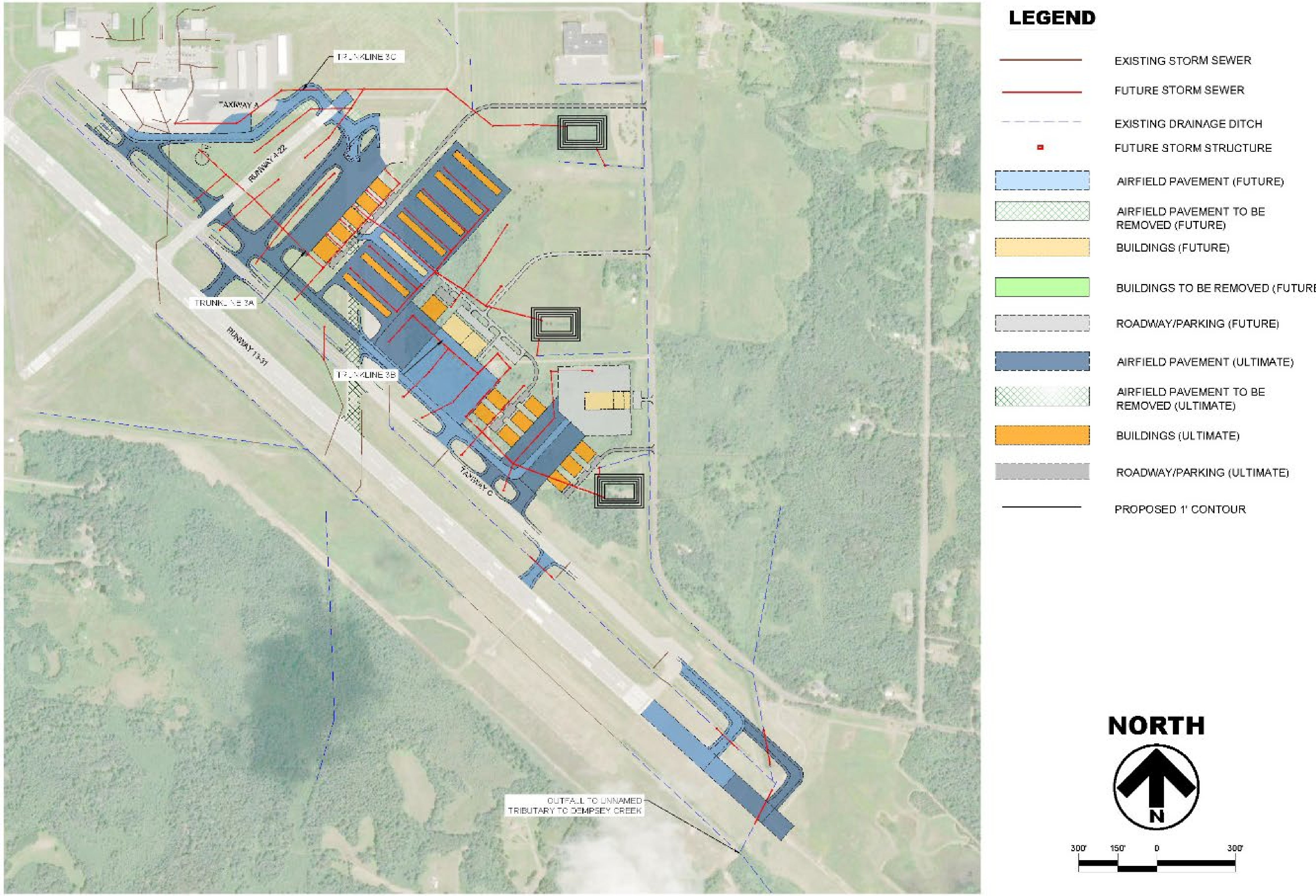


Note: Scale bar graphically represented.
Source: RS&H Analysis, 2022

1.6.3 Stormwater Alternative 3

Stormwater Alternative 3 follows a similar approach to Stormwater Alternative 2, where runoff from the landside portion for airport will be directed into two separate drainage ditches. The major difference between Stormwater Alternative 2 and Stormwater Alternative 3 is that runoff from the landside portion of the airport will be directed to a separate drainage ditch than the runoff the future hangars that lie to the Southeast of Runway 4-22, and the future T-hangars. The purpose of this, as opposed to utilizing a single trunk line, is to provide opportunity for future expansion on the north side of the airfield that is currently not being developed as part of the 2022 Airport Master Plan. In addition to this, a third stormwater detention pond is proposed on the northeast side of the airport property to attenuate runoff from the additional trunkline. An overview of Stormwater Alternative 3 is provided as **Figure 7**.

FIGURE 7
STORMWATER ALTERNATIVE 3



Note: Scale bar graphically represented.
Source: RS&H Analysis, 2022

1.7 STORMWATER ALTERNATIVES ANALYSIS

Based on discussions with HIB staff and industry best practices, the stormwater alternatives were analyzed using the following criteria:

- Ability to meet regulations
- Preliminary opinion of probable construction costs
- Ease of Construction

The stormwater alternative concepts identified are compatible with the airfield, landside operations, and the ground transportation system. Additionally, RS&H has developed future calculations for the proposed stormwater alternatives which includes required conveyance and treatment sizing as well as evaluation of use of existing conveyances in future conditions where applicable. Generally, all capacity calculations performed utilized Manning's Equation to get a baseline of where existing storm infrastructure needed to be upsized and what pipe and ditch dimensions are required to accommodate proposed future development. All calculations for site hydrology utilized the rational method. The following assumptions were made in these calculations:

- A 10-year 24-hour design storm was assumed
- Drainage subbasin delineations were assumed based on typical site grading patterns
- Time of concentrations for each subbasin were assumed based on the following characteristics:

TABLE 2
TIME-OF-CONCENTRATION ASSUMPTIONS

Basin Area	Assumed Time of Concentration (min)		
	C = 0.3 to 0.5	C = 0.5 to 0.7	C = 0.7 to 0.9
Less than 1 acre	5	5	5
1 to 2 acres	10	7	5
2 to 5 acres	15	10	7
5 to 7 acres	20	15	10
Greater than 7 acres	25	20	15

Source: RS&H Analysis, 2022

Both the Manning's Equation analysis and the Rational Method analysis provided an idea of how large storm pipes within the major trunklines must be to accommodate future development and meet regulations. Additionally, existing site topography and preliminary pipe slopes were utilized to identify if the utilization of existing outfalls is possible given the proposed storm sewer alignments. Pipe cover was not reviewed as part of this preliminary analysis. Calculations performed as part of this analysis are provided as **Attachment 1.**

1.7.1 Stormwater Alternative 1

1.7.1.1 Facilities and Sizing

1.7.1.1.1 Storm Pipes

Stormwater Alternative 1 does not use any existing storm sewer pipe and instead replaces existing storm pipe in the airfield to provide greater capacity. Based on an analysis of the existing storm sewer system and by field observation, the existing storm sewer system that serves the landside area, the GA apron, and the airfield is undersized and often produces ponding in the airport parking areas as well as in the grassed infield area. Because of this, Stormwater Alternative 1 proposes upsizing the storm pipes located in the airfield to provided additional capacity and alleviate the observed flooding. These proposed storm pipes will follow the alignment of the existing storm pipes but will be, on average, 2-3 times larger than what is currently installed. This proposed storm line will terminate at the existing drainage ditch that runs parallel to Runway 13-31.

Additionally, Stormwater Alternative 1 proposes that storm sewer pipes and inlets are installed where ultimate facilities are indicated in the preferred comprehensive layout alternative. Given that the existing airfield utilizes sheet flow and shallow drainage ditches to convey runoff, it was determined that the amount of impervious area proposed as part of the master plan could not be accommodated by these ditches and would instead need to utilize other means to reach the site outfall. RS&H proposes two reinforced concrete pipe (RCP) trunklines to accommodate this area, one that serves the future hangars that lie to the Southeast of Runway 4-22 and the future T-hangars (referred to as Trunkline 1A), and one that serves the future FBO facility, fuel farm, and future hangars on the East side of the airport property (referred to as Trunkline 1B). Trunkline 1A has a minimum pipe size of 18-inches and a maximum pipe size of 60-inches and terminates at a detention pond prior to entering to an existing drainage ditch. Trunkline 1B has a minimum pipe size of 36-inches and a maximum pipe size of 60-inches and terminates at a detention pond prior to entering the existing drainage ditch located to the southeast of the system.

1.7.1.1.2 Drainage Ditches

Stormwater Alternative 1 utilizes three (3) existing drainage ditches located on the airport property. These drainage ditches all convene on the southeast end of Runway 13-31 before they outfall to an unnamed tributary that feeds into Dempsey Creek. Based on existing contours, the capacity of these three drainage ditches was analyzed. It was determined that the drainage ditch running parallel to the south side of Runway 13-31 is likely currently too high to be used as an outfall for the existing trunkline. It is proposed that this drainage ditch be regraded and deepened slightly to allow for proper outfall and additional capacity. Based on preliminary calculations, RS&H estimates the drainage ditch to the south of Runway 13-31 requires approximately 3,166 cubic yards (CY) of excavation. Since Trunkline 1A and Trunkline 1B outfall to detention ponds prior to entering the existing drainage ditches, it is assumed that the detention ponds will provide enough flow reduction to avoid any capacity problems with the two existing drainage ditches on the west side of the Airport property.

1.7.1.2 Flow Control

The city of Hibbing requires flow control from the project site to maintain help the existing peak flow rates and hydrologic conditions for the 2-year,10-year, and 100-year rainfall events. To meet this requirement, Stormwater Alternative 1 proposes that two detention ponds be built at the downstream end of Trunkline 1A, to the west of S. Hughes Road and east of the future fuel farm, and Trunkline 1B, to the southeast of the future FBO facility. This detention pond will be sized to capture and retain a total of 14.4 acre-ft of excess runoff from the project site that results from the 100-year storm event. Each detention pond has a bottom area of one acre, an outfall pipe will be installed approximately 3.75 feet above the pond bottom to release flows from trunklines to the outfall ditches. A model was not created to evaluate drawdown time of this proposed pond and thus the pond area and dimensions must be further evaluated in future projects to determine if the 48-hour pond drawdown requirement is met. Calculations performed to determine the preliminary dimensions of these detention ponds are provided as **Attachment 1.**

1.7.1.3 Water Quality and Detention

The Minnesota Stormwater Manual requires that the volume of one inch of runoff from the new impervious surfaces created by the project is retained and treated on-site and not discharged to a surface water. It was determined that this amount to a required treatment volume of 5.89 acre-ft. Given the size of the detention ponds described in the previous section, it is expected that this volume of runoff will be infiltrated in the detention ponds and thus no additional water quality measures will be required.

1.7.1.4 Ease of Construction

The majority of Stormwater Alternative 1 can be built concurrently with the CIP identified in the 2022 Airport Master Plan. Based on the future and ultimate preferred comprehensive layouts for the airport, portions of the proposed stormwater system can be incorporated during the construction of the future layout and then easily expanded on as elements form the ultimate layout are constructed. There are a few runs of pipe that cross below existing pavement. These runs are the upsized existing trunkline and the upsizing of a culvert underneath Taxiway C. The upsized existing trunkline is expected to require the demolition of portions of Runway 13-31 and Taxiway C that are not impacted by the CIP projects. This could significantly impact airfield operations and would require the closure of the runway for construction.

1.7.2 Stormwater Alternative 2

1.7.2.1 Facilities and Sizing

1.7.2.1.1 Storm Pipes

Stormwater Alternative 2 utilizes the existing storm sewer pipes that serve the landside portion and the airfield to the extent possible. Based on an analysis of the existing storm sewer system and by field observation, the existing storm sewer system that serves the landside area, the GA apron, and the airfield is undersized and often produces ponding in the airport parking areas as well as in the grassed infield area. Because of this, Stormwater Alternative 2 proposes splitting the existing system to between two outfalls. This will alleviate the flooding problems that the airport currently experiences on the upstream end of the existing storm sewer system. To split the system, a new trunkline (referred to as Trunkline 2A) that ties into the existing system will be installed on the East side of the GA apron. Trunkline 2A will convey runoff to the southeast and collect runoff from the future hangars that lie to the Southeast of Runway 4-22 and the future T-Hangars. Similar to Stormwater Alternative 1, an additional trunkline (referred to as Trunkline 2B) that serves the future FBO facility, fuel farm, and future hangars on the East side of the airport property will be installed. Trunkline 2A has a minimum pipe size of 24-inches maximum pipe size of 60-inches and terminates at a detention pond prior to entering to an existing drainage ditch.

Trunkline 2B has a minimum pipe size of 36-inches and a maximum pipe size of 60-inches and terminates at a detention pond prior to entering the existing drainage ditch located to the southeast of the system.

1.7.2.1.2 Drainage Ditches

Stormwater Alternative 2 utilizes three (3) existing drainage ditches located on the airport property. These drainage ditches all convene on the southeast end of Runway 13-31 before they outfall to an unnamed tributary that feeds into Dempsey Creek. Based on changes to existing flow patterns, it was determined the ditch that runs parallel to the southside Runway 13-31 will have enough capacity to accommodate peak flow. This drainage ditch collects runoff from areas that are minorly impacted by the preferred comprehensive layout alternative and the amount of runoff contributing to this ditch is reduced through the installation of Trunkline 2A. Additionally, since Trunkline 2A and Trunkline 2B outfall to detention ponds prior to entering the existing drainage ditches, it is assumed that the detention ponds will provide enough flow reduction to avoid any capacity problems with the two existing drainage ditches on the west side of the airport property.

1.7.2.2 Flow Control

The city of Hibbing required flow control to maintain help the existing peak flow rates and hydrologic conditions for the 2-year,10-year, and 100-year rainfall events. To meet this requirement, Stormwater Alternative 2 proposes that two detention ponds be built at the downstream end of Trunkline 2A to the west of S. Hughes Road and east of the future fuel farm and Trunkline 2B to the southeast of the future FBO facility. These detention ponds will be sized to capture and retain a total of 14.4 acre-ft of excess runoff from the project site that results from the 100-year storm event. Each detention pond has a bottom are of 1 acre. An outfall pipe will be installed approximately 3.75 feet above each pond bottom to release flows from the trunklines to the outfall ditches. A model was not created to evaluate drawdown time of these proposed detention areas and thus the detention pond areas and dimensions must be further evaluated in future projects to determine if the 48-hour drawdown requirement is met.

1.7.2.3 Water Quality and Detention

The Minnesota Stormwater Manual requires that the volume of one inch of runoff from the new impervious surfaces created by the project is retained and treated on-site and not discharged to a surface water. It was determined that this amount to a required treatment volume of 5.89 acre-ft. Given the size of the detention ponds described in the previous section, it is expected that this volume of runoff will be infiltrated in the detention pond and thus no additional water quality measures will be required.

1.7.2.4 Ease of Construction

The majority of Stormwater Alternative 2 can be built concurrently with the CIP identified in the 2022 Airport Master Plan. Based on the future and ultimate preferred comprehensive layouts for the airport, portions of the proposed stormwater system can be incorporated during the construction of the future layout and then easily expanded on as elements form the ultimate layout are constructed. There is a single culvert that crosses below Taxiway C and a run of 36-inch RCP that crosses below Runway 4-22 that would temporarily disrupt operations of aircraft. The installation of the culvert could be phased such that it is installed following the addition of the future taxiway so taxiing of aircraft can still occur during construction. Additionally, if a closure of runway 4-22 is necessary for the future and ultimate taxiway additions, this pipe could be installed during construction of those projects to prevent any additional closures.

1.7.3 Stormwater Alternative 3

1.7.3.1 Facilities and Sizing

1.7.3.1.1 Storm Pipes

Stormwater Alternative 3 utilizes the existing storm sewer pipes that serve the landside portion and the airfield to the extent possible. Similar to Stormwater Alternative 2, Stormwater Alternative 3 proposes splitting the existing system to between two outfalls to alleviate the flooding problems that the airport currently experiences on the upstream end of the existing storm sewer system. Unlike Stormwater Alternative 2, the new trunkline utilized to split the system (referred to as Trunkline 3C) will route stormwater via pipes to an existing drainage ditch on the northeast side of the airport property. This trunkline will be separate from the trunkline that collects runoff from the future hangars that lie to the southeast of Runway 4-22 and the future T-hangars (referred to as Trunkline 3A). A third trunkline (referred to as Trunkline 3B) that serves the future FBO facility, fuel farm, and future hangars on the east side of the airport property will be installed. Trunkline 3A has a minimum pipe size of 24-inches maximum pipe size of 60-inches and terminates at a detention pond prior to entering to an existing drainage ditch. Trunkline 3B has a minimum pipe size of 36-inches and a maximum pipe size of 60-inches and terminates at a detention pond prior to entering the existing drainage ditch located to the southeast of the system. Trunkline 3C consists of 36-inch pipes and terminates at a detention pond prior the existing drainage ditch on the northeast side of the airport property.

1.7.3.1.2 Drainage Ditches

Stormwater Alternative 3 utilizes four (4) existing drainage ditches located on the airport property. These drainage ditches all convene on the southeast end of Runway 13-31 before they outfall to an unnamed tributary that feeds into Dempsey Creek. Based on changes to existing flow patterns, it was determined the ditch that runs parallel to the southside Runway 13-31 will have enough capacity to accommodate peak flow. This drainage ditch collects runoff from areas that are minorly impacted by the preferred comprehensive layout alternative and the amount of runoff contributing to this ditch is reduced through the installation of Trunkline 3C. Additionally, since all trunklines outfall to detention pond prior to entering the existing drainage ditches, it is assumed that the detention pond will provide enough flow reduction to avoid any capacity problems with the three existing drainage ditches on the west side of the airport property.

1.7.3.2 Flow Control

To meet the City of Hibbing Flow Control requirement, Stormwater Alternative 3 proposes that three (3) detention ponds be built at the downstream end of all of the trunklines. These detention ponds will be sized to capture and retain the excess volume of runoff from the project site that results from the 100-year storm event. Unlike Alternative 1 and Alternative 2, each detention pond is smaller has a bottom area of 0.60 acres. An outfall pipe will be installed approximately 3.8 feet above the pond bottom to release flows from the trunklines to the outfall ditches. The benefit of incorporating three smaller detention areas on the project site is that it leaves room for additional expansion/development on the west side of the airport. A model was not created to evaluate drawdown time of this proposed pond and thus the pond area and dimensions must be further evaluated in future projects to determine if the 48-hour drawdown requirement is met.

1.7.3.3 Water Quality and Detention

The Minnesota Stormwater Manual requires that the volume of one inch of runoff from the new impervious surfaces created by the project is retained and treated on-site and not discharged to a surface water. It was determined that this amount to a required treatment volume of 5.89 acre-ft. Given the size of the detention ponds described in the previous section, it is expected that this volume of runoff will be infiltrated in the detention ponds and thus no additional water quality measures will be required.

1.7.3.4 Ease of Construction

The majority of Stormwater Alternative 3 can be built concurrently with the CIP identified in the 2022 Airport Master Plan. Based on the future and ultimate preferred comprehensive layouts for the airport, portions of the proposed stormwater system can be incorporated during the construction of the future layout and then easily expanded on as elements form the ultimate layout are constructed. There is a single culvert that crosses below Taxiway C as well as a run of 36-inch RCP that crosses below the GA apron and existing Taxiway A that would require some demolition that would temporarily disrupt operations of aircraft. In addition to this, the incorporation of the detention pond that serves Trunkline 3C will likely need to be constructed on the airport property as its own project and not as part of the project identified in the Master Plan, as it is not in the vicinity of many of the proposed developments.

1.8 PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

RS&H developed a POPC for all three of the stormwater alternatives described above. Each POPC is representative of a conceptual, planning level, rough order of magnitude cost estimate. **Table 3** presents the POPC for each stormwater alternative.

TABLE 3
PRELIMINARY OPINION OF PROBABLE COST

Alternative ID	Cost
Alternative 1	$7.3 Million
Alternative 2	$6.3 Million
Alternative 3	$6.9 Million

Source: RS&H Analysis, 2022

1.9 STORMWATER ALTERNATIVES SUMMARY MATRIX

Each of the three presented stormwater alternatives will reduce flooding on the airport property and maintain existing conditions flows. All three stormwater alternatives are implementable solutions that will allow the airport to meet the MPCA general permit requirements. The major differentiating factor that sets stormwater Alternative 2 apart is cost and ease of construction. Out of the three alternatives examined, Stormwater Alternative 2 had the lowest POPC. This is because the alternative aims to reduce the number of proposed trunklines and therefore requires less drainage pipe and drainage structures that were necessary in Alternative 1 and Alternative 3. Additionally, the storm sewer alignment proposed as part of Stormwater Alternative 2 falls within the areas where construction is proposed as part of the preferred comprehensive layout alternative. This allows the alternative to phased with the different CIP projects to avoid additional interruptions to aircraft and tenant operations. **Table 4** shows the evaluation matrix for the stormwater alternatives.

TABLE 4
STORMWATER ALTERNATIVES SUMMARY MATRIX

Evaluation Criteria	Stormwater Alternative ID		
	Alternative 1	Alternative 2	Alternative 3
Ability to Meet Design Requirements			
Preliminary Opinion of Probable Construction Cost			
Impact on Airport Operations			
Ease of Construction			

Source: RS&H Analysis, 2022

1.10 RECOMMENDATIONS

RS&H identified stormwater alternatives for managing stormwater runoff. The proposed options were evaluated based on ability to meet regulations, probable construction costs, ease of construction, and impact on airport operations. Using provided airport data, the options have been evaluated for feasibility and potential locations for implementation have been identified. Based on the evaluation of these stormwater alternatives, RS&H recommends that Stormwater Alternative 2 be implemented to manage stormwater runoff. This alternative has the lowest preliminary opinion of probable construction cost and does not require construction in areas of the airport property that do not already have work proposed as part of the preferred comprehensive layout alternative as identified in the 2022 Airport Master Plan. This allows for greater flexibility during phasing and minimizes the overall impact on airport operations.

RANGE REGIONAL AIRPORT DEICING MANAGEMENT ALTERNATIVES

JANUARY 2022

VERSION 1.0

DRAFT

Prepared by RS&H for the
Chisholm Hibbing Airport Authority

RANGE REGIONAL AIRPORT

CHAA

RS&H

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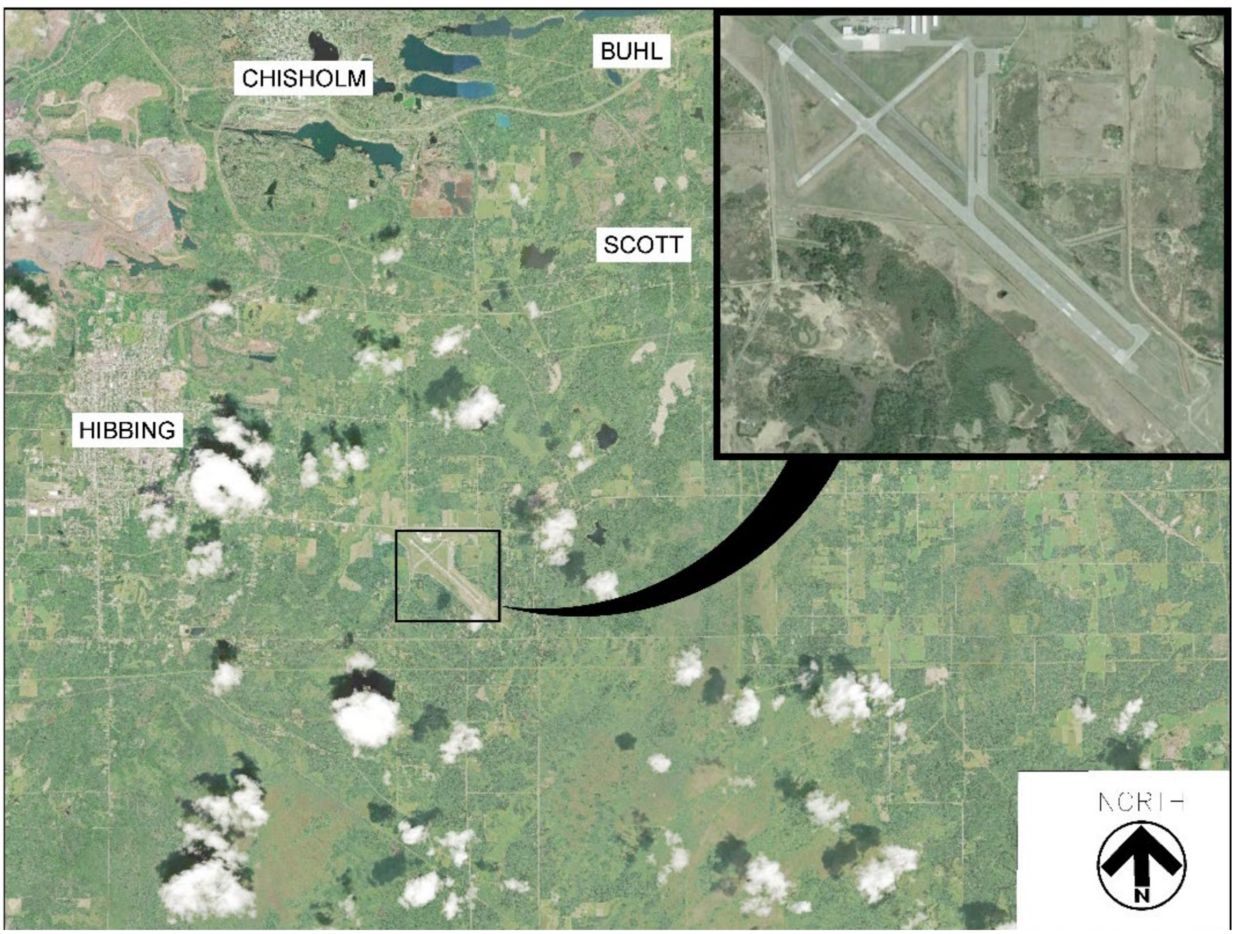
DEICING MANAGEMENT STUDY

1.1 INTRODUCTION

The Chisholm-Hibbing Airport Authority (CHAA) owns and operates Range Regional Airport (HIB) located at 11038 Highway 37. Hibbing, Minnesota (See **Figure 1**). HIB is located in northern Minnesota within St. Louis County and the city of Hibbing. The property lies within Township 57N Range 20W, and Sections 26 and 36. The Airport's location is approximately 70 miles from the city of Duluth, 200 miles from the city of Minneapolis, and 120 miles from International Falls, along the US-Canada border. HIB is a part of the Duluth, MN-WI Metropolitan Statistical Area, that includes the Carlton County, Minnesota; St. Louis County, Minnesota; and Douglas County, Wisconsin. The airport covers approximately 1,382 acres, with two (2) runways and three (3) taxiways as part of the airfield.

FIGURE 1
AIRPORT VICINITY MAP



Source: RS&H, 2022

The primary objective of this report is to identify stormwater management triggers that may require new facilities and to develop alternatives for managing stormwater runoff that incorporates future development. These stormwater alternatives will be evaluated with respect to a range of factors, including ability to meet regulatory requirements, ease of construction, and probable construction costs. A preferred stormwater alternative will be identified as a part of this investigation.

1.2 STORMWATER REGULATION

The Clean Water Act (CWA) establishes the laws for developing regulation regarding stormwater runoff from municipalities, construction sites, and industrial sites. The regulations are enforced through the National Pollutant Discharge Elimination System (NPDES) permit program. The State of Minnesota is delegated authority by U.S. Environmental Protection Agency (EPA) with administering its own permit system for compliance with the NPDES permit program requirements. The result is the Minnesota Pollution Control Agency (MPCA).

In June of 2020, MPCA issued General Permit MNR05000 for Stormwater Discharges Associated with Industrial Activity to the airport. General Permit MNR050000 allows HIB to discharge in accordance with permit requirements, sets effluent limitation, establishes monitoring requirement and inspection requirements, and other conditions set forth in the permit. The receiving water body is an unnamed tributary to Dempsey Creek. **Figure 2** identifies the outfall location per General Permit MNR05000. The specific permit that was granted to the airport is MCPA General Permit ID MNR05386T.

FIGURE 2
AIRPORT OUTFALL MAP

Source: RS&H, 2021

General Permit MNR05000, Permit I.D. MNR05386T identifies the following requirements:

1. Visual monitoring is required quarterly
2. Water quality standards monitoring must be performed
3. Sector-specific benchmark monitoring must be performed

Per the General Permit, a permittee must comply with all permit requirements. A violation of permit requirements may result in civil and/or criminal liability. Part II of the General Permit identifies control measures to be used by the permittee to meet permit requirements. These control measures must be selected, designed, installed, implemented, and maintained in accordance with good engineering hydrologic and pollution practices.

The General Permit provides pollutant benchmark concentrations. The benchmark concentrations are not effluent limitations. A benchmark exceedance is not considered a permit violation per General Permit Part V. When discharge exceeds an applicable benchmark concentration, corrective actives must be taken per General Permit Part V.49.1. Failure to respond to a benchmark exceedance is considered a permit violation.

TABLE 1
BENCHMARK MONITORING CONCENTRATIONS

Parameter	Benchmark Value	Sample Type/Frequency
Total Suspended Soils (TSS)	100 mg/L	Grab sample/Quarterly
Chemical Oxygen Demand (COD)	120 mg/L	Grab sample/Quarterly
5-Day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	25 mg/L	Grab sample/Quarterly
Total Ammonia (as N)	2.8 mg/L	Grab sample/Quarterly

Source: RS&H Analysis, 2021

To maintain compliance with the requirements set forth in General Permit MNR05000, CHAA developed a Stormwater Pollution Prevention Plan (SWPPP) in June of 2010. The SWPPP must be updated anytime there is a change in design, construction, operation, or maintenance at the facility. This plan intends to be updated as part of the RSA Grading Improvement project to be designed in 2022. A copy of the current SWPPP is maintained onsite at HIB.

1.3 PAST DEICING STUDIES

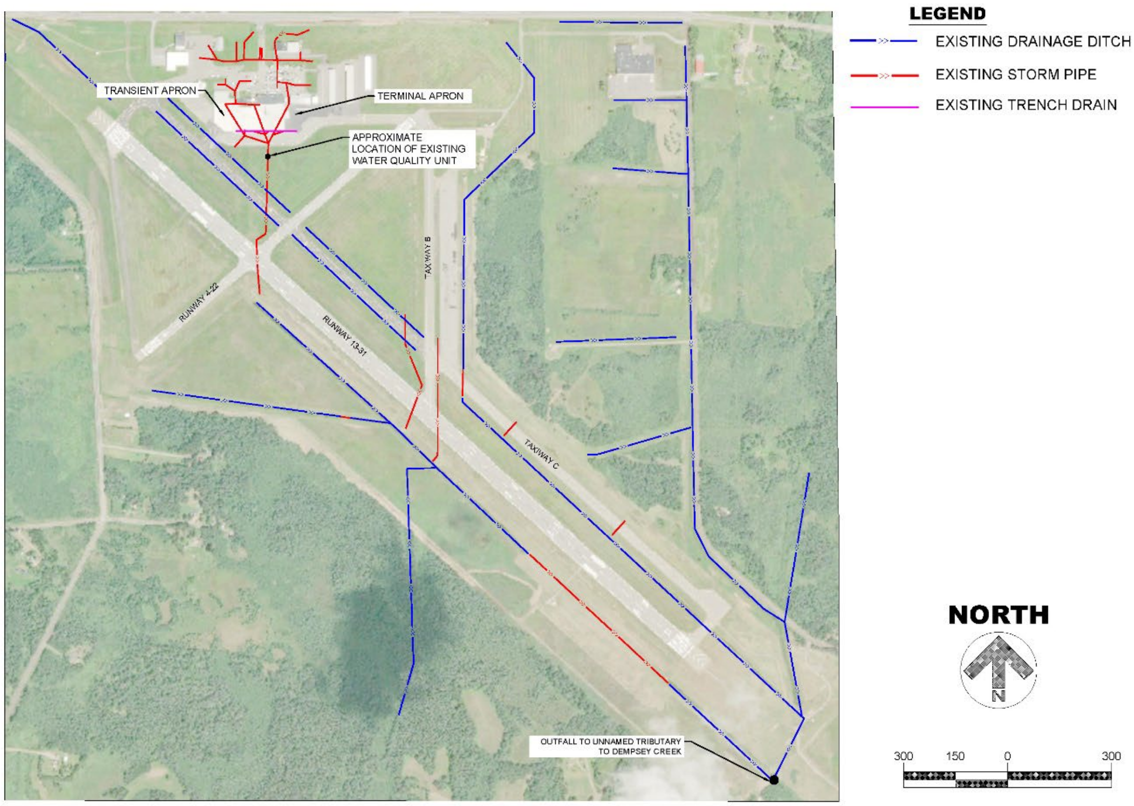
HIB has had no formal deicing studies performed.

1.4 CURRENT DEICE OPERATIONS

Commercial aircraft deicing is performed at the terminal gate and during pushback depending on the ability of the deicing truck to reach the front of the aircraft. Generally, the deicing of general aviation (GA) aircraft occurs where they are parked on the transient apron adjacent to the terminal. Stormwater runoff from this area is captured by a trench drain located on the apron and is conveyed via storm pipe to a water quality unit that outfalls to a 21-inch corrugated metal pipe (CMP). This pipe then collects additional runoff from the infield and runway safety area and flows under Taxiway C and Runway 13-31 before outfalling to a drainage ditch that eventually ties into Dempsey Creek. See **Figure 3** for a map showing the deicing conveyance.

The fixed base operator (FBO) uses Type I and Type IV propylene glycol (PG) for aircraft deicing. The deicing solution used by the airport is composed of a 45:55 water to propylene glycol ratio. CHAA indicated that HIB has glycol usage levels consistent with airport Subsector S-2, which indicates a use of less than 100,000 gallons of glycol-based deicing/anti-icing chemicals on an annual basis. Based on conversations with Airport leadership, yearly use of deicing solution is estimated to be under 1,000 gallons.

FIGURE 3
DEICING CONVEYANCE



Source: RS&H, 2021

The 2010 SWPPP describes stormwater management controls, general inspection procedures and documentation regarding the use and application of deicer fluid. The following is a list of the current best management practices (BMPs) identified in the SWPPP that should be followed by the FBO:

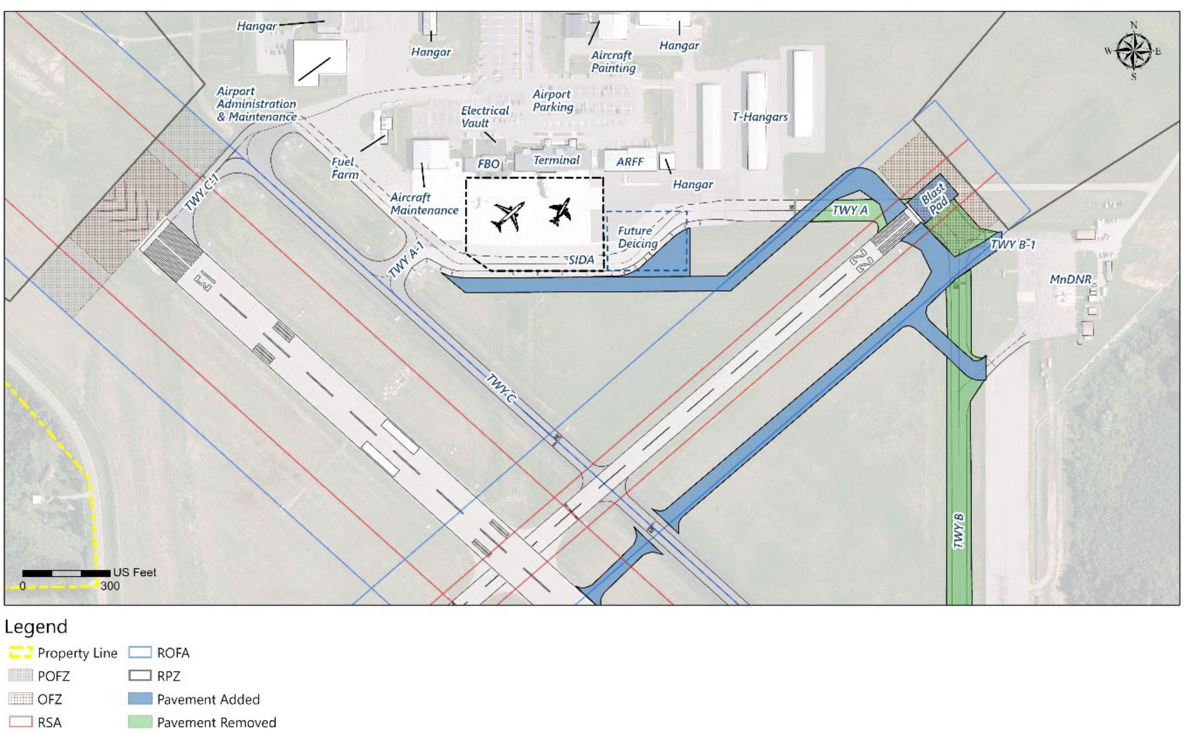
» Perform training for all personnel involved with deicing operations. This includes proper handling of deicing materials and fuels and proper recordkeeping of deicing fluids applied and stored.

- Aircraft operators and their services providers have the responsibility to ensure that the amount of aircraft deicing fluid (ADF) applied is appropriate to ensure flight safety without excess usage.
- Should excess deicing chemical be applied that creates a noticeable pool and/or large amount of green or reddish snow on the ground, it will be collected with shovels and stored in a drum for proper disposal offsite.
- Periodic inspection for deicing equipment is required and the facilities Spill Prevent, Control, and Countermeasure (SPCC) plan must be followed. The preventative maintenance schedule for the deicing equipment will follow manufacturers recommended guidelines and any deficiencies in operation will be corrected promptly.

1.5 FUTURE DEICE OPERATIONS

The 2022 Airport Master Plan preferred development alternative includes a proposed designated deicing area south of the Aircraft Rescue and Fire Fighting (ARFF) facility and east of the terminal apron. Given there is not a designated deicing apron at HIB, maneuvering by aircraft or deicing trucks can pose a safety concern to bypassing GA aircraft along Taxiway A and Taxilane A to/from the T-hangar facilities. The addition of this designated deicing area will alleviate these safety risks. Refer to **Figure 4** for location of proposed deicing facility.

FIGURE 4
AIRPORT PROPOSED DEICING FACILITY



Source: RS&H, 2021

The proposed facility will require capture, storage, and disposal to meet permit requirements. This report evaluates two different capture and disposal options, and a final recommendation is provided.

1.6 PROPOSED ALTERNATIVES

Two options were developed with the goal of reducing discharges of aircraft deicer to the HIB stormwater system. These options were identified based on compatibility with the airfield, landside operations, and preferred conceptual master plan design. The proposed option include:

- Directly connecting deicer into to sanitary sewer
- Connecting deicer into holding tank and disposal of fluid offsite

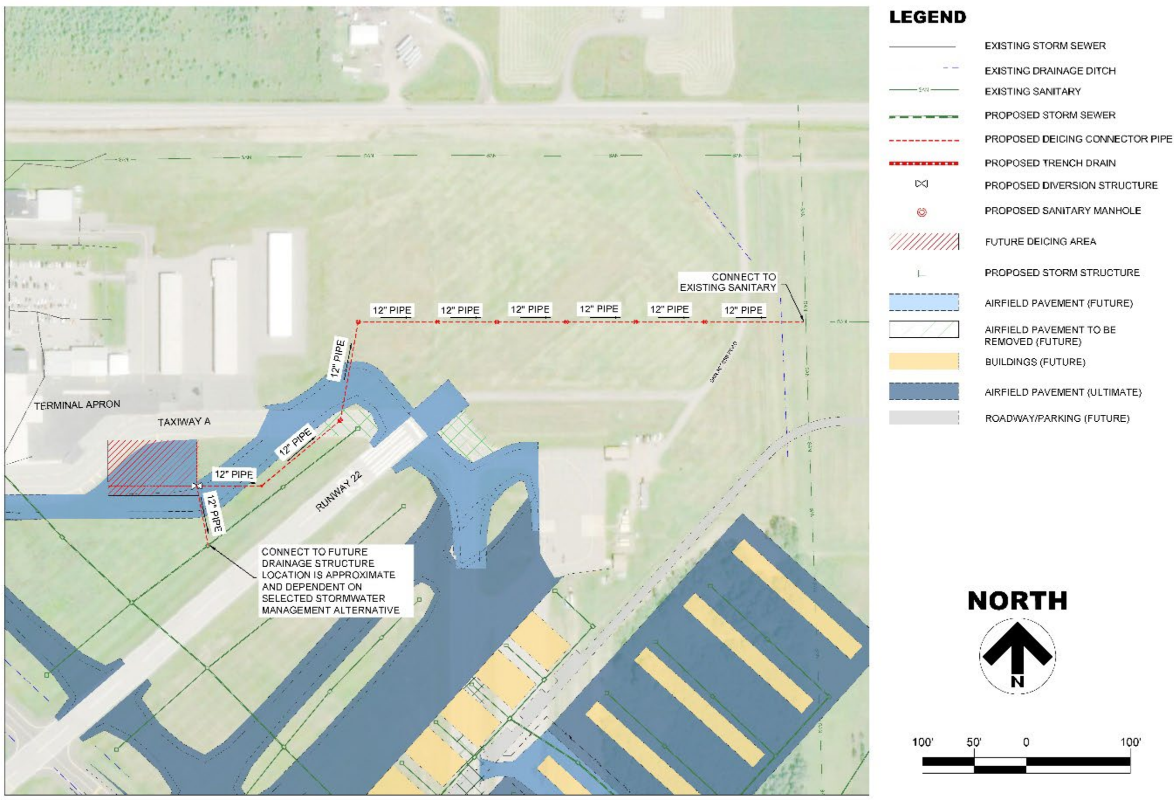
The evaluation and analysis of each alternative can be found in the following sections.

1.6.1 Alternative 1: Conveyance to Sanitary Sewer System

Currently, applied deicer generally sheet flows from the terminal apron and transient apron to a trench drain and is conveyed to a water quality unit prior to entering the stormwater conveyance system. There are no other treatment facilities located on the airport other than this water quality unit. Based on an analysis of the drainage area, the storm sewer system that serves the landside and airside terminal operations is undersized and needs to be upgraded or some of the contributing area needs to be rerouted to a different basin.

The proposed improvements are expected to impact the current treatment that deicer runoff receives, therefore a reconfiguration of the conveyance system for the proposed deicing pad is necessary to ensure permit requirements are met. This can be accomplished by installing trench drains or inlets in the proposed areas of deicer application to capture runoff and route it to an existing sanitary sewer line when deicing operations occur. Based on information provided by the city of Hibbing, there is an existing sanitary sewer line located to the northeast of the airfield that runs parallel to the Department of Natural Resources (DNR) access road. Prior to connecting the existing sanitary sewer, a diversion structure may be installed along the proposed conveyance pipe to ensure that only glycol contaminated water reaches the sanitary sewer. Under non-deicing conditions, the diversion structure would allow runoff to be routed to the storm sewer system that outfalls to Dempsey Creek. Refer to **Figure 5** for a map that outlines this alternative.

FIGURE 5
DEICING ALTERNATIVE 1

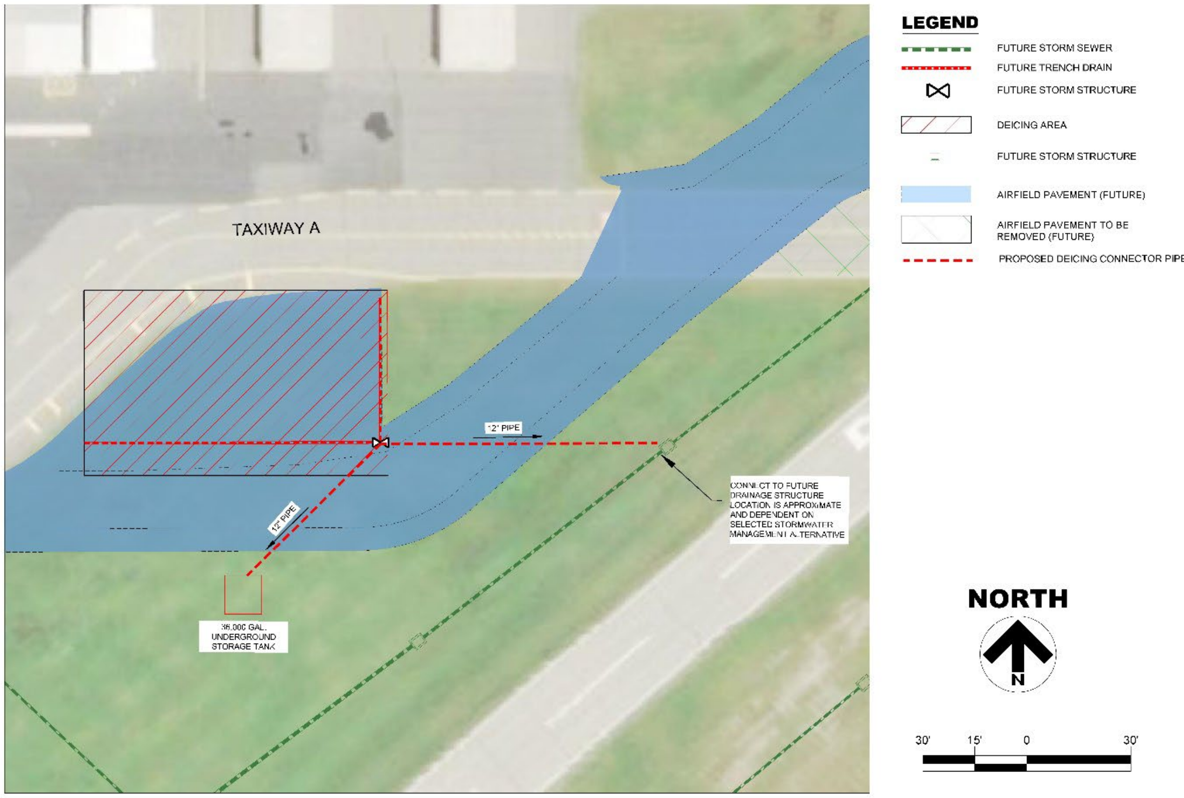


Source: RS&H, 2021

1.6.2 Alternative 2: Underground Holding Tank

Similar to Alternative 1, Alternative 2 includes a reconfiguration of the conveyance system, specifically through installing trench drains, to serve the proposed deicing area. However, instead of conveying runoff from the deicing pad through a diversion structure to an existing sanitary sewer run, Alternative 2 conveys deicing runoff from the proposed deicing area through a diversions structure to an underground holding tank placed within the nearby infield area. Just an in Alternative 1, only glycol contaminated water would be routed to the underground tank. Under non-deicing conditions, the diversion structure would allow runoff to be routed to the storm sewer system that outfalls to Dempsey Creek. Installation of this holding tank will prevent deicer discharges to the stormwater system. The spent deicer would be contained in the tank until the spent fluid can be pumped out and disposed of within the limitations of the permit. Refer to **Figure 6** for a map that outlines this alternative.

FIGURE 6
DEICING ALTERNATIVE 2



Source: RS&H, 2021

1.7 PROPOSED ALTERNATIVES ANALYSIS

Based on discussions with HIB staff and industry best practices, alternatives to reduce discharge of deicers to the stormwater system were developed and analyzed. Criteria utilized for the analyses included ability to meet permit requirements, preliminary capitol and operation costs, impact on airport operations, and impact on tenant/FBO operations.

1.7.1 Alternative 1: Conveyance to Sanitary Sewer System

An improved collection and conveyance system at the proposed deicing apron can reduce discharges of deicer by capturing deicer impacted runoff and routing it to the nearby sanitary sewer system to avoid discharging to Dempsey Creek.

Using HIB topographic data, the direction of sheet flow was determined to configure the system to capture deicer runoff from the application areas. Aircraft-rated trench drains were evaluated for collecting and conveying deicer runoff toward infield areas as seen in **Figure 5**. The trench drains are proposed to empty into a 12-inch PVC pipe. During deicing operations, the trench drains located in the deicing area have the capability to be isolated to direct the runoff to either the stormwater system or the existing sanitary sewer system. A diversion structure will be installed along the 12-inch PVC pipe to assist in the diversion for the glycol mixed runoff to the sanitary sewer located to the northeast of the airfield.

The depth of the existing sanitary sewer line that the proposed 12-inch PVC pipe will connect to is unknown, therefore pipe slopes and ground cover were not able to be evaluated for this alternative. However, based on the proposed layout existing topography, it is expected that the trench drain will not need to be more than 4-feet deep.

This option would have minimal disturbance to FBO operations as minimal pavement would have to be removed to install the trench drains and corresponding conveyance pipes. The connector pipe and diversion structure would be installed in an infield area which would further minimize disturbance to the FBO operations. Anticipated impacts would primarily be to aircraft taxiing operations. It is possible that the proposed deicing alternative could have very minor impacts to tenant operations for a short time if installing the new sanitary sewer line occurs during operating times. Additionally, separate permitting efforts and fees may be required by connecting to the sanitary sewer line. Sewage service at HIB is supplied by the Hibbing Public Utilities Commission (HPUC) and HPUC must grant approval prior to connecting to the existing sanitary sewer line. Additionally, Minnesota law dictates that a Sanitary Sewer Extension Permit from MPCA is required for an extension, addition, or modification, that effects any facility expansion, production increase, or process modification resulting in new or increased discharges of pollutants.

1.7.2 Alternative 2: Underground Holding Tank

Holding tanks were considered for containment of deicer impacted stormwater for eventual disposal either by hauling off site or discharge to a local wastewater treatment plant.

Using HIB topographic data, the direction of sheet flow was determined to configure the system to capture deicer runoff from the application areas. Aircraft-rated trench drains were evaluated for collecting and conveying deicer runoff toward infield areas as seen in **Figure 6**. The trench drains are proposed to empty into a 12-inch PVC pipe. During deicing operations, the trench drains located in the deicing area have the capability to be isolated to direct the runoff to either the stormwater system or to an underground holding tank that has at least a 36,000-gallon capacity. A diversion structure would be installed along the 12-inch PVC pipe to assist in the diversion for the glycol mixed runoff to the holding tank located immediately downstream of the deicing operation area.

The tank size is based on total runoff volumes for a rainfall depth of 1.5 inches. This depth was selected because the MPCA Stormwater manual indicates that this depth is representative of greater than 90% of the annual runoff. The tank size was determined to be 36,000 gallons. The runoff volumes were calculated based on the precipitation depth, as indicated by the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS), the area of the existing deicing pads, and estimate volume of the applied deicer. The calculations are as follows:

Peak Runoff Volume = (Deicing Area) x C x 10-Year Precipitation Depth
C = 0.9
Deicing Area = 0.96 acres
10-Year Precipitation Depth = 1.5 inches * 1 ft/12 inches

Peak Runoff Volume = 0.96 * 0.9 * 1.5 * 1 ft/12 inches = 0.11 acre-ft = 4,705 cf = 35,196 gal

Round up to 36,000 gal to account for deicer fluid

The deicer runoff in the storage tanks would be pumped to a wastewater treatment plant or hauled to a proper disposal facility. Coordination between the FBO and airport (if FBO is ever leased to private entity) would be needed as to how permitting this discharge could be achieved.

This option would have both moderate capital and operating costs due to the requirement of removing deicer from the holding tanks and is based on a conceptual and qualitative estimation of probable cost. This estimation is based on comparative costs for deicing infrastructure improvements from prior industry experience, discussions with the airport, as well as involvement with implementing similar improvements at other airports. The holding tank can be installed in an infield area, which would minimize disruptions to FBO and other airport operations. However, alternate taxiing patterns may be necessary during construction. Also, there could be a fee imposed based on the amount of BOD that the FBO sends to the nearby treatment plant for disposal. The tank option could be implemented in a single construction season and provisions for securing disposal would be needed prior to installation.

1.8 PRELIMINARY OPINION OF PROBABLE COST

RS&H developed a preliminary opinion of probable cost (POPC) for each of the proposed alternatives. The preliminary opinion of probable construction costs is representative of a conceptual, planning level estimate. These costs are not inclusive of anticipated maintenance or permitting costs. **Table 2** presents the total POPC for each alternative.

TABLE 2
PRELIMINARY OPINION OF PROBABLY COST

Alternative	Cost
Alternative 1	$1.1 Million
Alternative 2	$1.7 Million

Source: RS&H, 2021

1.9 ALTERNATIVE SUMMARY MATRIX

Each of the two presented deicer management alternatives will improve the quality of the stormwater runoff from the airport by removing glycol contaminated runoff from the storm conveyance system. Both alternatives are implementable solutions that will allow the airport to meet the MPCA general permit requirements. The major differentiating factors that set Alternative 2 apart is that its easily implementable during one construction season and is expected to minimally impact aircraft operations. Additionally, Alternative 2 will not require a sanitary sewer extension permit. **Table 3** shows the evaluation matrix for the deicer management alternatives.

TABLE 3
DEICING MANAGEMENT ALTERNATIVES EVALUATION MATRIX

Evaluation Criteria	Deicing Alternatives	
	Alternative 1	Alternative 2
Ability to Meet Design Requirements		
Preliminary Opinion of Probable Construction Cost		
Ease of Construction		
Impact on Airport Operations		
Impact on Tenant Operations		

Source: RS&H, 2021

1.10 CONCLUSION

The MPCA permit, General Permit MNR05000 for Stormwater Discharges Associated with Industrial Activity, allows HIB to discharge to one authorized location in accordance with permit requirements, effluent limitations, monitoring requirement, inspection requirements, and other conditions set forth in the permit. The relocation of deicing operations at HIB as part of the master plan development required a re-evaluation of the deicer management BMPs.

RS&H identified alternatives for managing deicer impacted stormwater runoff. The proposed options were evaluated based on impacts on tenant operations as well as capital and operation costs, while helping to maintain compliance with the Airport's MPCA General Permit. Using provided airport data, the options have been evaluated for feasibility and potential locations for implementation have been identified. Based on the evaluation of these alternatives, RS&H recommends that an underground storage tank be implemented to manage deicer impacted stormwater runoff.

ATTACHMENT 1: CALCULATIONS

ALTERNATIVE 1 STORM SEWER DESIGN

This spreadsheet accomplishes a storm sewer design using the rational method. Data is entered in the non-shaded areas only.
This study is preliminary and therefore only major trunklines and laterals were sized. Sizes of pipes not included in this spreadsheet were assumed based on calcuations done for pipes with a simialr contribting area.

Project Name: Existing Trunkline (West Hangars and T-Hangars)

m = 16.529   n = 0.528   Design Storm Event = 10

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	8.57	0.75	6.45	6.45	15.00	15.0	3.96	25.53	0.00	25.53	**36.00**	0.013	0.0015	3.65	25.80	VELOCITY OK	ADEQUATE PIPE CAPACITY	322.00	1347.71	1347.23
2	2	3	3.07	0.81	2.48	8.93	7.00	7.0	5.92	52.84	0.00	52.84	**48.00**	0.013	0.0015	4.43	55.57	VELOCITY OK	ADEQUATE PIPE CAPACITY	214.00	1347.23	1346.91
3	3	4	1.57	0.76	1.19	10.13	5.00	7.8	5.59	56.56	0.00	56.56	**54.00**	0.013	0.0010	3.91	62.12	VELOCITY OK	ADEQUATE PIPE CAPACITY	410.00	1344.13	1343.72
4	4	5	3.27	0.60	1.96	12.09	10.00	9.6	5.02	60.68	0.00	60.68	**54.00**	0.013	0.0010	3.91	62.12	VELOCITY OK	ADEQUATE PIPE CAPACITY	380.00	1343.72	1343.34
5	5	6	1.64	0.51	0.83	12.92	7.00	11.2	4.62	59.69	0.00	59.69	**54.00**	0.013	0.0010	3.91	62.12	VELOCITY OK	ADEQUATE PIPE CAPACITY	98.00	1343.34	1343.24
6	6	Outfall	1.04	0.67	0.69	13.61	7.00	11.6	4.53	61.69	0.00	61.69	**54.00**	0.013	0.0010	3.91	62.12	VELOCITY OK	ADEQUATE PIPE CAPACITY	442.00	1343.24	1342.80

Project Name: Existing Trunkline Lateral 1

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
7	7	8	11.32	0.76	8.57	8.57	15.00	15.0	3.96	33.89	0.00	33.89	**42.00**	0.013	0.0012	3.62	34.82	VELOCITY OK	ADEQUATE PIPE CAPACITY	296.00	1345.96	1345.60
8	8	3	1.59	0.90	1.43	10.00	5.00	16.4	3.78	37.77	0.00	37.77	**42.00**	0.013	0.0015	4.05	38.92	VELOCITY OK	ADEQUATE PIPE CAPACITY	86.00	1345.60	1345.48

Project Name: Existing Trunkline Lateral 2

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
9	10	15	2.27	0.72	1.63	1.63	7.00	7.0	5.92	9.65	0.00	9.65	**24.00**	0.013	0.0019	3.14	9.85	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1346.75	1346.23
10	11	16	2.32	0.66	1.52	3.15	10.00	10.0	4.90	15.43	0.00	15.43	**36.00**	0.013	0.0011	3.06	21.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1346.23	1345.94
11	12	11	3.66	0.67	2.47	5.62	10.00	10.0	4.90	27.53	0.00	27.53	**36.00**	0.013	0.0019	4.11	29.04	VELOCITY OK	ADEQUATE PIPE CAPACITY	384.00	1345.94	1345.21
12	13	17	2.78	0.45	1.25	6.87	15.00	11.6	4.54	31.19	0.00	31.19	**36.00**	0.013	0.0022	4.42	31.25	VELOCITY OK	ADEQUATE PIPE CAPACITY	201.00	1345.21	1344.77
13	13	3	2.27	0.51	1.16	8.03	10.00	12.3	4.39	35.24	0.00	35.24	**36.00**	0.013	0.0028	4.99	35.26	VELOCITY OK	ADEQUATE PIPE CAPACITY	230.00	1344.77	1344.13

Project Name: Trunkline 1A

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	1.59	0.60	0.95	0.95	7	7.0	5.92	5.62	0.00	5.62	18	0.013	0.0030	3.25	5.75	VELOCITY OK	ADEQUATE PIPE CAPACITY	232	1345.67	1344.98
2	2	3	1.75	0.47	0.82	1.77	10	10.0	4.90	8.65	0.00	8.65	24	0.013	0.0019	3.14	9.85	VELOCITY OK	ADEQUATE PIPE CAPACITY	265	1344.98	1344.47
3	3	4	1.95	0.45	0.88	2.64	10	10.0	4.90	12.95	0.00	12.95	30	0.013	0.0026	4.26	20.89	VELOCITY OK	ADEQUATE PIPE CAPACITY	238	1344.47	1343.85
4	4	5	3.08	0.53	1.62	4.26	10	10.0	4.90	20.90	0.00	20.90	30.00	0.013	0.0027	4.30	21.09	VELOCITY OK	ADEQUATE PIPE CAPACITY	316	1343.85	1343.02
5	5	6	4.97	0.68	3.38	7.64	10	10.0	4.90	37.46	0.00	37.46	36.00	0.013	0.0032	5.34	37.69	VELOCITY OK	ADEQUATE PIPE CAPACITY	429	1343.02	1341.64
6	6	7	2.11	0.54	1.14	8.78	10.00	11.3	4.59	40.27	0.00	40.27	42.00	0.013	0.0017	4.31	41.44	VELOCITY OK	ADEQUATE PIPE CAPACITY	207.00	1341.64	1341.29
7	7	8	1.76	0.78	1.37	10.16	5.00	12.1	4.42	44.92	0.00	44.92	42.00	0.013	0.0020	4.68	44.95	VELOCITY OK	ADEQUATE PIPE CAPACITY	154.00	1341.29	1340.98
8	8	9	1.26	0.76	0.95	11.11	5.00	12.7	4.32	48.01	0.00	48.01	48.00	0.013	0.0012	3.96	49.71	VELOCITY OK	ADEQUATE PIPE CAPACITY	150.00	1340.98	1340.80
9	9	10	1.69	0.76	1.28	12.39	5.00	13.3	4.21	52.20	0.00	52.20	48.00	0.013	0.0020	5.11	64.17	VELOCITY OK	ADEQUATE PIPE CAPACITY	234.00	1340.80	1340.34
10	10	11	8.79	0.76	6.65	19.04	15.00	15.0	3.96	75.34	0.00	75.34	54.00	0.013	0.0016	4.94	78.58	VELOCITY OK	ADEQUATE PIPE CAPACITY	160.00	1340.34	1340.08
11	11	12	8.16	0.83	6.79	25.84	15.00	15.0	3.96	102.21	0.00	102.21	54.00	0.013	0.0029	6.66	105.79	VELOCITY OK	ADEQUATE PIPE CAPACITY	264.00	1340.08	1339.31
12	12	13	6.41	0.85	5.41	31.25	10.00	15.7	3.87	120.84	0.00	120.84	60.00	0.013	0.0025	6.63	130.08	VELOCITY OK	ADEQUATE PIPE CAPACITY	254.00	1339.31	1338.68
13	13	14	6.72	0.39	2.65	33.89	25.0	16.3	3.79	128.34	0.00	128.34	60.00	0.013	0.0025	6.63	130.08	VELOCITY OK	ADEQUATE PIPE CAPACITY	214	1338.68	1338.14
14	14	Pond	3.55	0.31	1.09	34.99	15.0	16.8	3.72	130.21	0.00	130.21	60.00	0.013	0.0026	6.76	132.66	VELOCITY OK	ADEQUATE PIPE CAPACITY	436	1338.14	1337.01

Project Name: Trunkline 1A Lateral

Location			Rational method										Manning's Equation							
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length*** (ft)
15	15	16	2.38	0.71	1.68	1.68	7.00	7.0	5.92	9.93	0.00	9.93	24.00	0.013	0.0028	3.81	11.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	146.00
16	16	9	0.21	0.45	0.09	1.77	5.00	5.0	7.07	12.53	0.00	12.53	24.00	0.013	0.0031	4.01	12.58	VELOCITY OK	ADEQUATE PIPE CAPACITY	208.00

Project Name: Trunkline 1B

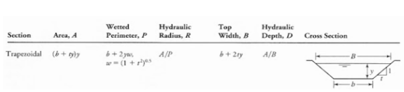
Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	3.11	0.90	2.80	2.80	7.00	7.0	5.92	16.57	0.00	16.57	**36.00**	0.013	0.0011	3.06	21.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	370.00	1338.67	1338.28
2	2	3	7.00	0.77	5.36	8.16	15.00	15.0	3.96	32.28	0.00	32.28	**48.00**	0.013	0.0007	3.02	37.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	297.00	1338.28	1338.07
3	3	4	4.42	0.77	3.39	11.55	10.00	10.0	4.90	56.58	0.00	56.58	**48.00**	0.013	0.0016	4.57	57.40	VELOCITY OK	ADEQUATE PIPE CAPACITY	215.00	1338.07	1337.73
4	4	5	1.97	0.55	1.08	12.62	7.00	10.8	4.71	59.43	0.00	59.43	**48.00**	0.013	0.0018	4.85	60.88	VELOCITY OK	ADEQUATE PIPE CAPACITY	144.00	1337.73	1337.47
5	5	6	2.56	0.42	1.09	13.71	15.00	11.3	4.60	63.04	0.00	63.04	**54.00**	0.013	0.0011	4.10	65.15	VELOCITY OK	ADEQUATE PIPE CAPACITY	300.00	1337.47	1337.14
6	6	7	2.60	0.75	1.94	15.65	10.00	12.5	4.36	68.18	0.00	68.18	**54.00**	0.013	0.0013	4.46	70.83	VELOCITY OK	ADEQUATE PIPE CAPACITY	205.00	1337.14	1336.87
7	7	8	3.78	0.64	2.44	18.09	10.00	13.3	4.22	76.35	0.00	76.35	**54.00**	0.013	0.0016	4.87	77.34	VELOCITY OK	ADEQUATE PIPE CAPACITY	569.00	1336.87	1335.99
8	8	9	6.29	0.81	5.13	23.21	10.00	10.0	4.90	113.76	0.00	113.76	**60.00**	0.013	0.0020	5.93	116.35	VELOCITY OK	ADEQUATE PIPE CAPACITY	498.00	1335.99	1334.99
9	9	Outfall	3.70	0.71	2.63	25.84	10.00	11.4	4.57	118.19	0.00	118.19	**60.00**	0.013	0.0021	6.08	119.22	VELOCITY OK	ADEQUATE PIPE CAPACITY	233.00	1334.99	1334.50

Project Name: Trunkline 1B Lateral

Location			Rational Method										Manning's Equation							
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length*** (ft)
10	10	8	9.47	0.69	6.49	6.49	20.00	20.0	3.40	22.06	0.00	22.06	30.00	0.013	0.0030	4.58	22.44	VELOCITY OK	ADEQUATE PIPE CAPACITY	358.00

*Pipe length is approximate
** Inverts listed are approximate and are calcualted to provide additional guidance regarding ditch tie in elevations.

Project Name: Existing Trunkline (West Hangars and T-Hangars)



$$Q = \frac{[(b+t\cdot y)y]^{5/3}\cdot S^{1/2}}{n\cdot[[b+2y(1+t^2)^{0.5}]^{2/3}}$$

DITCH REGRADING

This spreadsheet verifies that changes to ditch elevations and dimesnions are able to provide proper capacity

Location Description	Top Width	Bottom Width	Approx Side Slope	Depth [ft]	Start Elev	End Elev	Slope [ft/ft]	Length (ft)	n	A (ft^2)	P (ft)	R (ft)	Vol approx. (cf)
South Ditch (Existing)	50	20	7	2	1344	1338	0.004	1554	0.027	68	48.28	1.41	105672.00
South Ditch (Regraded)	50	20	7	3	1342	1338	0.003	1554	0.027	123	62.43	1.97	191142.00

ALTERNATIVE 2 STORM SEWER DESIGN

This spreadsheet accomplishes a storm sewer design using the rational method. Data is entered in the non-shaded areas only. This study is preliminary and therefore only major trunklines and laterals were sized. Sizes of pipes not included in this spreadsheet were assumed based on calcuations done for pipes with a simialr contribting area.

Project Name: Trunk Line 2A

m = 16.529 n = 0.528 Design Storm Event = 10

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev.** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	1.59	0.90	1.43	1.43	5	5.0	7.07	10.11	0.00	10.11	24.00	0.013	0.0020	3.23	10.13	VELOCITY OK	ADEQUATE PIPE CAPACITY	275	1349.25	1348.70
2	2	3	2.27	0.51	1.16	2.59	10	10.0	4.90	12.68	0.00	12.68	24.00	0.013	0.0033	4.14	12.98	VELOCITY OK	ADEQUATE PIPE CAPACITY	276	1348.70	1347.78
3	3	4	2.78	0.45	1.25	3.84	15	15.0	3.96	15.19	0.00	15.19	30.00	0.013	0.0014	3.13	15.33	VELOCITY OK	ADEQUATE PIPE CAPACITY	289	1347.78	1347.38
4	4	5	3.08	0.53	1.62	5.46	10	10.0	4.90	26.77	0.00	26.77	36.00	0.013	0.0017	3.89	27.47	VELOCITY OK	ADEQUATE PIPE CAPACITY	316	1344.21	1343.67
5	5	6	4.97	0.68	3.38	8.84	10	10.0	4.90	43.32	0.00	43.32	36.00	0.013	0.0050	6.67	47.11	VELOCITY OK	ADEQUATE PIPE CAPACITY	429	1343.67	1341.53
6	6	7	2.11	0.54	1.14	9.98	10.00	11.1	4.64	46.34	0.00	46.34	42.00	0.013	0.0030	5.73	55.05	VELOCITY OK	ADEQUATE PIPE CAPACITY	207.00	1341.53	1340.91
7	7	8	1.76	0.78	1.37	11.35	5.00	11.7	4.52	51.27	0.00	51.27	48.00	0.013	0.0013	4.12	51.74	VELOCITY OK	ADEQUATE PIPE CAPACITY	154.00	1340.91	1340.70
8	8	9	1.26	0.76	0.95	12.31	5.00	12.3	4.39	54.07	0.00	54.07	48.00	0.013	0.0015	4.35	54.64	VELOCITY OK	ADEQUATE PIPE CAPACITY	150.00	1340.70	1340.49
9	9	10	1.69	0.76	1.28	13.59	5.00	12.9	4.29	58.29	0.00	58.29	54.00	0.013	0.0009	3.71	58.93	VELOCITY OK	ADEQUATE PIPE CAPACITY	234.00	1340.49	1340.28
10	10	11	8.79	0.76	6.65	20.24	15.00	15.0	3.96	80.07	0.00	80.07	60.00	0.013	0.0010	4.09	80.19	VELOCITY OK	ADEQUATE PIPE CAPACITY	160.00	1340.28	1340.12
11	11	12	8.16	0.83	6.79	27.03	15.00	15.0	3.96	106.95	0.00	106.95	60.00	0.013	0.0017	5.47	107.27	VELOCITY OK	ADEQUATE PIPE CAPACITY	264.00	1340.12	1339.68
12	12	13	6.41	0.85	5.41	32.45	10.00	15.8	3.85	124.87	0.00	124.87	60.00	0.013	0.0024	6.50	127.45	VELOCITY OK	ADEQUATE PIPE CAPACITY	254.00	1339.68	1339.07
13	13	14	6.72	0.39	2.65	35.09	20.0	16.5	3.77	132.20	0.00	132.20	60.00	0.013	0.0026	6.76	132.66	VELOCITY OK	ADEQUATE PIPE CAPACITY	214	1339.07	1338.51
14	14	pond	3.55	0.31	1.09	36.18	15.0	17.0	3.70	134.05	0.00	134.05	60.00	0.013	0.0027	6.89	135.19	VELOCITY OK	ADEQUATE PIPE CAPACITY	436	1338.51	1337.33

Project Name: Trunk Line 2A Lateral 1

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
15	15	1	11.34	0.76	8.57	8.57	15.00	15.0	3.96	33.91	0.00	33.91	**36.00**	0.013	0.0026	4.81	33.97	VELOCITY OK	ADEQUATE PIPE CAPACITY	296.00	1345.96	1345.19

Project Name: Trunk Line 2A Lateral 2

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
16	16	17	2.27	0.72	1.63	1.63	7.00	7.0	5.92	9.65	0.00	9.65	**24.00**	0.013	0.0019	3.14	9.85	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1346.75	1346.23
17	17	18	2.32	0.66	1.52	3.15	10.00	10.0	4.90	15.43	0.00	15.43	**30.00**	0.013	0.0015	3.18	15.60	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1346.23	1345.83
18	18	3	3.66	0.67	2.47	5.62	10.00	10.0	4.90	27.53	0.00	27.53	**36.00**	0.013	0.0018	4.00	28.27	VELOCITY OK	ADEQUATE PIPE CAPACITY	275.00	1345.83	1345.34

Project Name: Trunk Line 2A Lateral 3

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev.** (ft)	Downstr. Invert Elev. **(ft)
19	19	20	1.59	0.60	0.95	0.95	7.00	7.0	5.92	5.62	0.00	5.62	18.00	0.013	0.0030	3.25	5.75	VELOCITY OK	ADEQUATE PIPE CAPACITY	233.00	1347.29	1346.59
20	20	19	1.75	0.47	0.82	1.77	10.00	10.0	4.90	8.65	0.00	8.65	24.00	0.013	0.0018	3.05	9.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	265.00	1346.75	1346.27
21	21	4	1.95	0.45	0.88	2.64	10.00	10.0	4.90	12.95	0.00	12.95	24.00	0.013	0.0033	4.14	12.98	VELOCITY OK	ADEQUATE PIPE CAPACITY	238.00	1346.75	1345.96

Project Name: Trunk Line 2A Lateral 4

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
15	15	16	2.38	0.71	1.68	1.68	7.00	7.0	5.92	9.93	0.00	9.93	24.00	0.013	0.0028	3.81	11.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	146.00	1346.75	1346.34
16	16	9	0.21	0.45	0.09	1.77	5.00	5.0	7.07	12.53	0.00	12.53	24.00	0.013	0.0032	4.07	12.78	VELOCITY OK	ADEQUATE PIPE CAPACITY	208.00	1346.75	1346.08

Project Name: Trunk Line 2B

Location			Rational Method										Manning's Equation									
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev.** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	3.11	0.90	2.80	2.80	7.00	7.0	5.92	16.57	0.00	16.57	**36.00**	0.013	0.0011	3.06	21.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	370.00	1338.67	1338.28
2	2	3	7.00	0.77	5.36	8.16	15.00	15.0	3.96	32.28	0.00	32.28	**48.00**	0.013	0.0007	3.02	37.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	297.00	1338.28	1338.07
3	3	4	4.42	0.77	3.39	11.55	10.00	10.0	4.90	56.58	0.00	56.58	**48.00**	0.013	0.0016	4.57	57.40	VELOCITY OK	ADEQUATE PIPE CAPACITY	215.00	1338.07	1337.73
4	4	5	1.97	0.55	1.08	12.62	7.00	10.8	4.71	59.43	0.00	59.43	**48.00**	0.013	0.0018	4.85	60.88	VELOCITY OK	ADEQUATE PIPE CAPACITY	144.00	1337.73	1337.47
5	5	6	2.56	0.42	1.09	13.71	15.00	11.3	4.60	63.04	0.00	63.04	**54.00**	0.013	0.0011	4.10	65.15	VELOCITY OK	ADEQUATE PIPE CAPACITY	300.00	1337.47	1337.14
6	6	7	2.60	0.75	1.94	15.65	10.00	12.5	4.36	68.18	0.00	68.18	**54.00**	0.013	0.0013	4.46	70.83	VELOCITY OK	ADEQUATE PIPE CAPACITY	205.00	1337.14	1336.87
7	7	8	3.78	0.64	2.44	18.09	10.00	13.3	4.22	76.35	0.00	76.35	**54.00**	0.013	0.0016	4.87	77.34	VELOCITY OK	ADEQUATE PIPE CAPACITY	569.00	1336.87	1335.99
8	8	9	6.29	0.81	5.13	23.21	10.00	10.0	4.90	113.76	0.00	113.76	**60.00**	0.013	0.0020	5.93	116.35	VELOCITY OK	ADEQUATE PIPE CAPACITY	498.00	1335.99	1334.99
9	9	Outfall	3.70	0.71	2.63	25.84	10.00	11.4	4.57	118.19	0.00	118.19	**60.00**	0.013	0.0021	6.08	119.22	VELOCITY OK	ADEQUATE PIPE CAPACITY	230.00	1334.99	1334.51

Project Name: Trunk Line 2B Lateral 1

Location			Rational Method										Manning's Equation							
STR. #	START STR. #	END STR. #	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)
10	10	8	9.47	0.69	6.49	6.49	20.00	20.0	3.40	22.06	0.00	22.06	30.00	0.013	0.0030	4.58	22.44	VELOCITY OK	ADEQUATE PIPE CAPACITY	358.00

*Pipe length is approximate

** Inverts listed are approximate and are calcualted to provide additional guidance regarding ditch tie in elevations.

ALTERNATIVE 3 STORM SEWER DESIGN

This spreadsheet accomplishes a storm sewer design using the rational method. Data is entered in the non-shaded areas only. This study is preliminary and therefore only major trunklines and laterals were sized. Sizes of pipes not included in this spreadsheet were assumed based on calcuations done for pipes with a simialr contribting area.

Project Name: Trunkline 3A

m = 16.529 **n = 0.528** **Design Storm Event = 10**

Location			Rational Method										Manning's Equation									
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev.** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	2.27	0.51	1.16	1.16	10	10.0	4.90	5.67	0.00	5.67	24.00	0.013	0.0018	3.05	9.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	277	1345.75	1345.25
2	2	3	2.78	0.45	1.25	2.41	15	15.0	3.96	9.53	0.00	9.53	24.00	0.013	0.0018	3.05	9.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	288	1345.25	1344.73
3	3	4	3.08	0.53	1.62	4.03	10	10.0	4.90	19.76	0.00	19.76	30.00	0.013	0.0024	4.09	20.07	VELOCITY OK	ADEQUATE PIPE CAPACITY	316	1344.21	1343.45
4	4	5	4.97	0.68	3.38	7.41	10	10.0	4.90	36.31	0.00	36.31	36.00	0.013	0.0040	5.97	42.14	VELOCITY OK	ADEQUATE PIPE CAPACITY	429	1343.45	1341.73
5	5	6	2.11	0.54	1.14	8.55	10.00	11.2	4.62	39.46	0.00	39.46	42.00	0.013	0.0020	4.68	44.95	VELOCITY OK	ADEQUATE PIPE CAPACITY	207.00	1341.73	1341.32
6	6	7	1.76	0.78	1.37	9.92	5.00	11.9	4.46	44.28	0.00	44.28	42.00	0.013	0.0021	4.79	46.06	VELOCITY OK	ADEQUATE PIPE CAPACITY	154.00	1341.32	1341.00
7	7	8	1.26	0.76	0.95	10.88	5.00	12.5	4.36	47.43	0.00	47.43	48.00	0.013	0.0022	5.36	67.30	VELOCITY OK	ADEQUATE PIPE CAPACITY	150.00	1341.00	1340.67
8	8	9	1.69	0.76	1.28	12.16	5.00	12.9	4.28	52.01	0.00	52.01	48.00	0.013	0.0015	4.43	55.57	VELOCITY OK	ADEQUATE PIPE CAPACITY	234.00	1340.67	1340.32
9	9	10	8.79	0.76	6.65	18.81	15.00	15.0	3.96	74.41	0.00	74.41	54.00	0.013	0.0015	4.79	76.08	VELOCITY OK	ADEQUATE PIPE CAPACITY	160.00	1340.32	1340.08
10	10	11	8.16	0.83	6.79	25.60	15.00	15.0	3.96	101.29	0.00	101.29	60.00	0.013	0.0016	5.30	104.07	VELOCITY OK	ADEQUATE PIPE CAPACITY	264.00	1340.08	1339.65
11	11	12	6.41	0.85	5.41	31.02	10.00	15.8	3.85	119.27	0.00	119.27	60.00	0.013	0.0022	6.15	120.63	VELOCITY OK	ADEQUATE PIPE CAPACITY	254.00	1339.65	1339.11
12	12	13	6.72	0.39	2.65	33.66	20.0	16.5	3.76	126.56	0.00	126.56	60.00	0.013	0.0024	6.50	127.45	VELOCITY OK	ADEQUATE PIPE CAPACITY	214	1339.11	1338.59
12	13	pond	3.55	0.31	1.09	34.75	15.0	17.1	3.70	128.42	0.00	128.42	60.00	0.013	0.0025	6.63	130.08	VELOCITY OK	ADEQUATE PIPE CAPACITY	440	1338.59	1337.49

Project Name: Trunkline 3A Lateral 1

Location			Rational Method										Manning's Equation							
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)
14	14	15	2.38	0.71	1.68	1.68	7.00	7.0	5.92	9.93	0.00	9.93	24.00	0.013	0.0028	3.81	11.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	146.00
15	15	8	0.21	0.45	0.09	1.77	5.00	5.0	7.07	12.53	0.00	12.53	24.00	0.013	0.0032	4.07	12.78	VELOCITY OK	ADEQUATE PIPE CAPACITY	208.00

Project Name: Trunkline 3B

Location			Rational Method										Manning's Equation									
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev.** (ft)	Downstr. Invert Elev.** (ft)
1	1	2	3.11	0.90	2.80	2.80	7.00	7.0	5.92	16.57	0.00	16.57	**36.00**	0.013	0.0011	3.06	21.59	VELOCITY OK	ADEQUATE PIPE CAPACITY	370.00	1338.67	1338.28
2	2	3	7.00	0.77	5.36	8.16	15.00	15.0	3.96	32.28	0.00	32.28	**48.00**	0.013	0.0007	3.02	37.96	VELOCITY OK	ADEQUATE PIPE CAPACITY	297.00	1338.28	1338.07
3	3	4	4.42	0.77	3.39	11.55	10.00	10.0	4.90	56.58	0.00	56.58	**48.00**	0.013	0.0016	4.57	57.40	VELOCITY OK	ADEQUATE PIPE CAPACITY	215.00	1338.07	1337.73
4	4	5	1.97	0.55	1.08	12.62	7.00	10.8	4.71	59.43	0.00	59.43	**48.00**	0.013	0.0018	4.85	60.88	VELOCITY OK	ADEQUATE PIPE CAPACITY	144.00	1337.73	1337.47
5	5	6	2.56	0.42	1.09	13.71	15.00	11.3	4.60	63.04	0.00	63.04	**54.00**	0.013	0.0011	4.10	65.15	VELOCITY OK	ADEQUATE PIPE CAPACITY	300.00	1337.47	1337.14
6	6	7	2.60	0.75	1.94	15.65	10.00	12.5	4.36	68.18	0.00	68.18	**54.00**	0.013	0.0013	4.46	70.83	VELOCITY OK	ADEQUATE PIPE CAPACITY	205.00	1337.14	1336.87
7	7	8	3.78	0.64	2.44	18.09	10.00	13.3	4.22	76.35	0.00	76.35	**54.00**	0.013	0.0016	4.87	77.34	VELOCITY OK	ADEQUATE PIPE CAPACITY	569.00	1336.87	1335.99
8	8	9	6.29	0.81	5.13	23.21	10.00	10.0	4.90	113.76	0.00	113.76	**60.00**	0.013	0.0020	5.93	116.35	VELOCITY OK	ADEQUATE PIPE CAPACITY	498.00	1335.99	1334.99
9	9	Outfall	3.70	0.71	2.63	25.84	10.00	11.4	4.57	118.19	0.00	118.19	**60.00**	0.013	0.0021	6.08	119.22	VELOCITY OK	ADEQUATE PIPE CAPACITY	253.00	1334.99	1334.46

Project Name: Trunkline 3C

Location			Rational Method										Manning's Equation									
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev. **(ft)
1	1	2	1.59	0.90	1.43	1.43	5.00	5.0	7.07	10.11	0.00	10.11	36.00	0.013	0.0011	3.13	22.10	VELOCITY OK	ADEQUATE PIPE CAPACITY	476	1349.96	1349.4364
2	2	3	0.00	0.00	0.00	1.43	0	7.5	5.69	10.11	0.00	10.11	36.00	0.013	0.0011	3.13	22.10	VELOCITY OK	ADEQUATE PIPE CAPACITY	422	1349.4364	1348.9722
3	3	4	10.43	0.32	3.31	4.74	5	5.0	7.07	33.48	0.00	33.48	42.00	0.013	0.0015	4.05	38.92	VELOCITY OK	ADEQUATE PIPE CAPACITY	631	1343.33	1342.3835
4	4	5	13.37	0.38	5.09	9.83	20	20.0	3.40	33.42	0.00	33.42	42.00	0.013	0.0015	4.05	38.92	VELOCITY OK	ADEQUATE PIPE CAPACITY	636.00	1342.3835	1341.4295
5	5	6	4.72	0.32	1.52	11.35	20.00	22.6	3.18	36.16	0.00	36.16	42.00	0.013	0.0015	4.05	38.92	VELOCITY OK	ADEQUATE PIPE CAPACITY	449.00	1341.4295	1340.756
6	6	Outfall	3.80	0.31	1.19	12.54	15.00	24.5	3.06	38.31	0.00	38.31	42.00	0.013	0.0015	4.05	38.92	VELOCITY OK	ADEQUATE PIPE CAPACITY	256.00	1340.756	1340.372

Project Name: Trunkline 3C Lateral 1

Location			Rational Method										Manning's Equation									
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev. ** (ft)
7	7	8	3.66	0.67	2.47	2.47	10.00	10.0	4.90	12.10	0.00	12.10	**30.00**	0.013	0.0013	3.01	14.77	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1345.21	1344.85
8	8	9	2.32	0.66	1.52	3.99	10.00	10.0	4.90	19.53	0.00	19.53	**30.00**	0.013	0.0023	4.01	19.65	VELOCITY OK	ADEQUATE PIPE CAPACITY	274.00	1344.85	1344.22
9	9	12	2.27	0.72	1.63	5.62	10.00	10.0	4.90	27.53	0.00	27.53	**36.00**	0.013	0.0018	4.00	28.27	VELOCITY OK	ADEQUATE PIPE CAPACITY	307.00	1344.22	1343.67

Project Name: Trunkline 3C Lateral 2

Location			Rational Method										Manning's Equation									
Drain Located On	From Sta.	To Sta.	Drainage Area A (acre)	Runoff Coeff. C	CA (acre)	Sum CA (acre)	T_c Across Area (minutes)	Total Tc (minutes)	Rainfall Intensity (in/hr)	Runoff (cfs)	Contrib. Inflow (cfs)	Total Flow (cfs)	Pipe Dia. (in)	Manning roughness coefficient "n"	Pipe Slope (ft/ft)	Velocity Of Flow (ft/s)	Pipe Capacity (cfs)	Pipe Velocity Check (Desirable Minimum 3 ft/sec; Desirable Maximum 10 ft/sec for Column 16)	Pipe Capacity Check (Column 13 vs. Column 17)	Pipe Length* (ft)	Upstr. Invert Elev. ** (ft)	Downstr. Invert Elev.** (ft)
10	10	11	1.75	0.47	0.82	0.82	10.00	10.0	4.90	4.00	0.00	4.00	18.00	0.013	0.0026	3.03	5.35	VELOCITY OK	ADEQUATE PIPE CAPACITY	232.00	1344.89	1344.29
11	11	12	1.59	0.60	0.95	1.77	7.00	7.0	5.92	10.45	0.00	10.45	24.00	0.013	0.0023	3.45	10.84	VELOCITY OK	ADEQUATE PIPE CAPACITY	287.00	1344.29	1343.63
12	12	3	2.29	0.58	1.33	3.10	10.00	10.0	4.90	15.18	0.00	15.18	36.00	0.013	0.0011	3.13	22.10	VELOCITY OK	ADEQUATE PIPE CAPACITY	177.00	1343.63	1343.43

*Pipe length is approximate

** Inverts listed are approximate and are calcualted to provide additional guidance regarding ditch tie in elevations.

Basin Calculations

Pre-Development Drainage				
Basin	**Area**	**% Imp.**	**Cw**	**Tc (min)**
Dempsey Creek	537.64	17%	0.40	30.0

Post-Development Drainage Basins				
Basin	**Area**	**% Imp.**	**Cw**	**Tc (min)**
Dempsey Creek	537.64	32%	0.49	15.0

C Impervious	0.9
C Pervious	0.3

Drainage Basins Peak Flow Rate

Project Area											
	Pre-Development					Post-Development					
Year	C	Tc (min)	I (in/hr)	A (ac)	Q (cfs)	C	Tc (min)	I (in/hr)	A (ac)	Q (cfs)	ΔQ (cfs)
2-yr	0.40	30.0	1.89	537.64	410.8598	0.49	15.0	2.72	537.64	716.3206	305.4608
5-yr	0.40	30.0	2.41	537.64	523.9006	0.49	15.0	3.45	537.64	908.5685	384.6678
10-yr	0.40	30.0	2.84	537.64	617.3767	0.49	15.0	4.06	537.64	1069.214	451.8372
50-yr	0.40	30.0	3.91	537.64	849.9798	0.49	15.0	5.59	537.64	1472.144	622.1644
100-yr	0.40	30.0	4.38	537.64	952.1513	0.49	15.0	6.27	537.64	1651.224	699.0731

Retention Facility Sizing

Peak Flow Volume = ΔQ*Post-Dev Tc*(60 sec/1 min)*(1 ac/43560 sf)

Treatment Volume = Impervious Area*1 in*(1 ft/12in)*(Impervious C)

V (acre-ft): 14.4
V treatment (acre-feet) 5.89

Alternative 1 and 2 Detention Facility Sizing

Proposed Detention Pond Stage Area and Volume			
Stage	**Area (ac)**	**Incremental Volume (ac-ft)**	**Cumulative Volume (ac-ft)**
1334	1		
		1.25	1.25
1335	1.5		
		1.75	3.00
1336	2.00		
		2.25	5.25
1337	2.50		
		1.97	**7.22**
1337.75	2.75		
		0.72	7.94
1338	3.00		

Proposed Detention Pond Stage Area and Volume			
Stage	**Area (ac)**	**Incremental Volume (ac-ft)**	**Cumulative Volume (ac-ft)**
1337	1		
		1.25	1.25
1338	1.5		
		1.75	3.00
1339	2.00		
		2.25	5.25
1340	2.50		
		1.97	**7.22**
1340.75	2.75		
		0.72	7.94
1341	3.00		

Alternative 3 Detention Facility Sizing

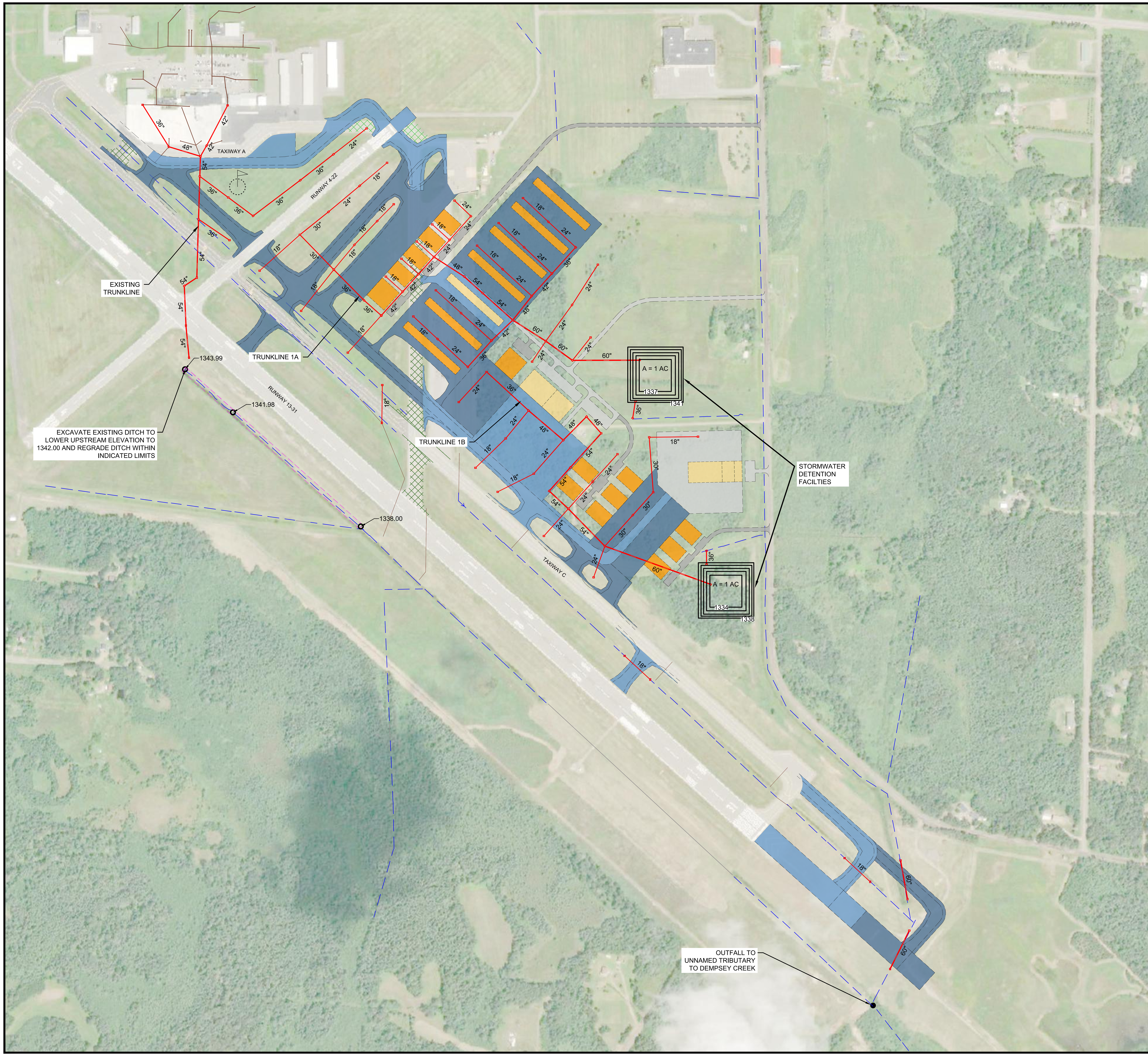
Proposed Detention Pond Stage Area and Volume			
Stage	**Area (ac)**	**Incremental Volume (ac-ft)**	**Cumulative Volume (ac-ft)**
1334	0.60		
		0.76	0.76
1335	0.91		
		1.09	1.85
1336	1.28		
		1.49	3.33
1337	1.70		
		1.52	**4.85**
1337.8	2.10		
		0.43	5.28
1338	2.17		

Proposed Detention Pond Stage Area and Volume			
Stage	**Area (ac)**	**Incremental Volume (ac-ft)**	**Cumulative Volume (ac-ft)**
1337	0.60		
		0.76	0.76
1338	0.91		
		1.09	1.85
1339	1.28		
		1.49	3.33
1340	1.70		
		1.52	**4.85**
1340.8	2.10		
		0.43	5.28
1341	2.17		

Proposed Detention Pond Stage Area and Volume			
Stage	**Area (ac)**	**Incremental Volume (ac-ft)**	**Cumulative Volume (ac-ft)**
1340	0.60		
		0.76	0.76
1341	0.91		
		1.09	1.85
1342	1.28		
		1.49	3.33
1343	1.70		
		1.52	**4.85**
1343.8	2.10		
		0.43	5.28
1344	2.17		

Bolded value indicates runoff storge volume below discharge pipe

ATTACHMENT 2: EXHIBITS



LEGEND

- EXISTING STORM SEWER
- FUTURE STORM SEWER
- EXISTING DRAINAGE DITCH
- FUTURE STORM STRUCTURE
- LIMITS OF DITCH EXCAVATION/GRADING
- ○1338.00 EXISTING SPOT ELEVATION
- AIRFIELD PAVEMENT (FUTURE)
- AIRFIELD PAVEMENT TO BE REMOVED (FUTURE)
- BUILDINGS (FUTURE)
- BUILDINGS TO BE REMOVED (FUTURE)
- ROADWAY/PARKING (FUTURE)
- AIRFIELD PAVEMENT (ULTIMATE)
- AIRFIELD PAVEMENT TO BE REMOVED (ULTIMATE)
- BUILDINGS (ULTIMATE)
- ROADWAY/PARKING (ULTIMATE)
- PROPOSED 1' CONTOUR

NORTH

0 300' 600'

RS&H

RS&H, Inc.
4525 AIRPORT APPROACH RD.
SUITE A
DULUTH, MINNESOTA 55811
218-722-1227
www.rsandh.com

RANGE REGIONAL AIRPORT

HIBBING, MINNESOTA

MASTER PLAN - DRAINAGE STUDY

CONSULTANTS

REVISIONS

NO.	DESCRIPTION	DATE

DATE ISSUED: 2021 v1
REVIEWED BY:
DRAWN BY: ELH
DESIGNED BY: ELH

PROJECT NUMBER
214-0055-001

SHEET TITLE

DRAINAGE ALT. 1 LAYOUT

EXHIBIT

LEGEND

- EXISTING STORM SEWER
- FUTURE STORM SEWER
- EXISTING DRAINAGE DITCH
- FUTURE STORM STRUCTURE
- AIRFIELD PAVEMENT (FUTURE)
- AIRFIELD PAVEMENT TO BE REMOVED (FUTURE)
- BUILDINGS (FUTURE)
- BUILDINGS TO BE REMOVED (FUTURE)
- ROADWAY/PARKING (FUTURE)
- AIRFIELD PAVEMENT (ULTIMATE)
- AIRFIELD PAVEMENT TO BE REMOVED (ULTIMATE)
- BUILDINGS (ULTIMATE)
- ROADWAY/PARKING (ULTIMATE)
- PROPOSED 1' CONTOUR

NORTH

0 300' 600'

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REVISIONS

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DESIGNED BY: ELH

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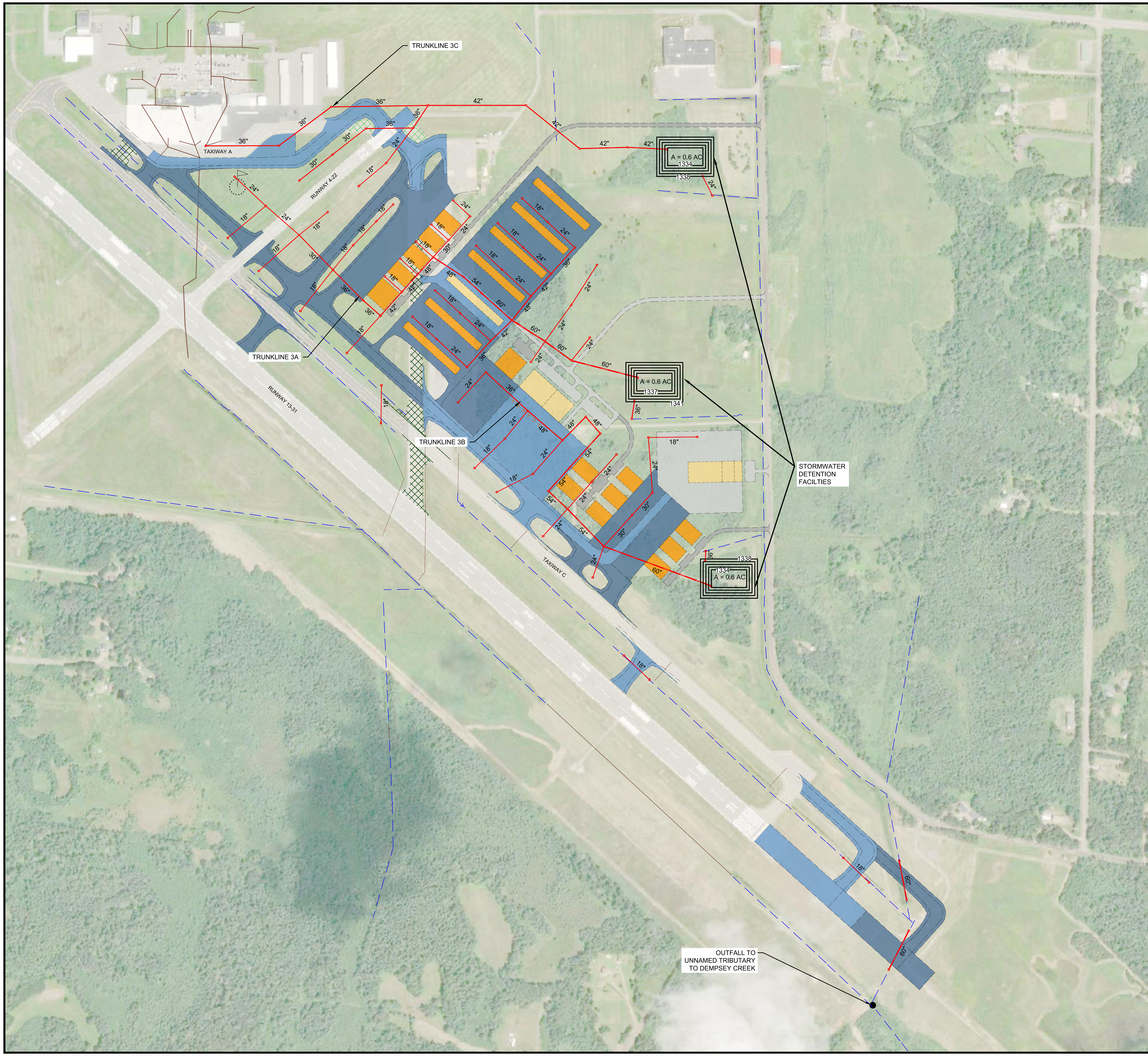
SHEET TITLE

DRAINAGE ALT. 2 LAYOUT

EXHIBIT



LEGEND

- EXISTING STORM SEWER
- FUTURE STORM SEWER
- EXISTING DRAINAGE DITCH
- FUTURE STORM STRUCTURE
- AIRFIELD PAVEMENT (FUTURE)
- AIRFIELD PAVEMENT TO BE REMOVED (FUTURE)
- BUILDINGS (FUTURE)
- BUILDINGS TO BE REMOVED (FUTURE)
- ROADWAY/PARKING (FUTURE)
- AIRFIELD PAVEMENT (ULTIMATE)
- AIRFIELD PAVEMENT TO BE REMOVED (ULTIMATE)
- BUILDINGS (ULTIMATE)
- ROADWAY/PARKING (ULTIMATE)
- PROPOSED 1' CONTOUR

NORTH

0 300' 600'

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SUITE A
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REVISIONS

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SHEET TITLE

DRAINAGE ALT. 3 LAYOUT

EXHIBIT