Final Report

Green Infrastructure/ Low Impact Development Plan

Joint Base Elmendorf-Richardson
Anchorage, Alaska

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Prepared for

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Acronyms

ADEC	Alaska Department of Environmental Conservation
AFCEC	Air Force Civil Engineering Center
APDES	Alaska Pollution & Discharge Elimination System
BASH	Bird/Wildlife Air Strike Hazard
BMP	Best management practice
BOD	Biological oxygen demand
COD	Chemical oxygen demand
DoD	Department of Defense
ETL	Engineering Technical Letter
GI	Green infrastructure
H&H	Hydrologic and hydraulic
JBER	Joint Base Elmendorf-Richardson
JBER-E	Joint Base Elmendorf-Richardson - Elmendorf District
JBER-R	Joint Base Elmendorf-Richardson - Richardson District
lf	Linear foot
LID	Low impact development
MOA	Municipality of Anchorage
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operation and maintenance
PACAF	Pacific Air Forces
sf	Square foot
SWMP	Storm water management plan
TMDL	Total maximum daily load
UA	Urbanized area
UFC	Unified Facilities Criteria
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Joint Base Elmendorf-Richardson (JBER) is expanding its stormwater program to include green infrastructure/low impact development (GI/LID) best management practices (BMPs) as a means of managing runoff. These practices capture stormwater where it falls – at the source – to reduce pollutant loading and runoff volume entering the stormwater conveyance system and into the Waters of the United States. The goal of this GI/LID plan is to respond to JBER's regulatory Alaska Pollution and Discharge Elimination System (APDES) small municipal separate storm sewer system (MS4) permit for developing a GI/LID strategy and for addressing pollutant loading, the JBER stormwater management plan, and to the Ship Creek total maximum daily load (TMDL) for fecal coliform. The objectives of the plan are to select BMPs most practical for JBER, identify priority sites for strategic GI/LID implementation, and identify next steps for developing a GI/LID program.

JBER is located northeast of Anchorage, Alaska, and the project area is defined by its 26,700 acre Urbanized Area (UA) where the majority of impervious surfaces are located. Stormwater runoff within the UA is conveyed with a combination of storm sewers and open channels that discharge at six outfalls into Ship Creek and Cook Inlet. JBER soil types, depth to groundwater, location of wetlands and floodplains, available green space, and administrative and residential land use areas provide ample opportunities for implementing GI/LID. Implementation constraints include environmental contamination, bird/wildlife air strike hazard (BASH) zones, air accident zones, and industrial and airfield land use.

Six GI/LID BMPs are recommended for use on JBER, and include bioinfiltration, dry infiltration, vegetated swales, constructed wetlands, permeable pavers, and rainwater collection. They were chosen based on their ability to capture pollutants, viability in cold climates, and JBER's opportunities and constraints. Their selection was also based on GI practices recommended by Municipality of Anchorage (MOA) and the availability of local contractors familiar with their construction and maintenance. Other types of BMPs, such as downspout disconnection, compost soil amendments, native landscaping, stormwater trees, and vegetated buffers, may be applied in combination with these six practices.

A planning charrette and individual stakeholder meetings were held to inform, receive feedback, and collaboratively discuss the GI/LID planning. From those stakeholder involvement efforts, five strategies are recommended for implementing GI/LID and include requiring GI/LID as a stormwater management plans for new and re-development projects; maintaining all undeveloped areas for open, outdoor recreational, and buffer areas; working with housing property management groups to implement GI/LID; retro-fitting sites that are not identified installation development plans; and develop design, installation, and maintenance resources to support a GI program. Twelve sites were identified for strategic retro-fitting of their stormwater system with GI/LID BMPs due to their location within the stormwater conveyance system, land use, and proximity to wetlands and Ship Creek.

INTRODUCTION

Joint Base Elmendorf-Richardson (JBER) has planned and implemented numerous practices for improving the quality of stormwater entering the waters of the United States through structural methods, public education and outreach, pollution prevention, and construction site stormwater controls. Traditional structural methods involve directing stormwater runoff from a parking lot or roof drain directly into a storm sewer. Runoff flowing across these impervious surfaces encounter sediment and contaminants, which then travel with the runoff. Therefore, end-of-pipe solutions are required for traditional structural methods to address the resulting stormwater pollution prior to entering waters of the United States.

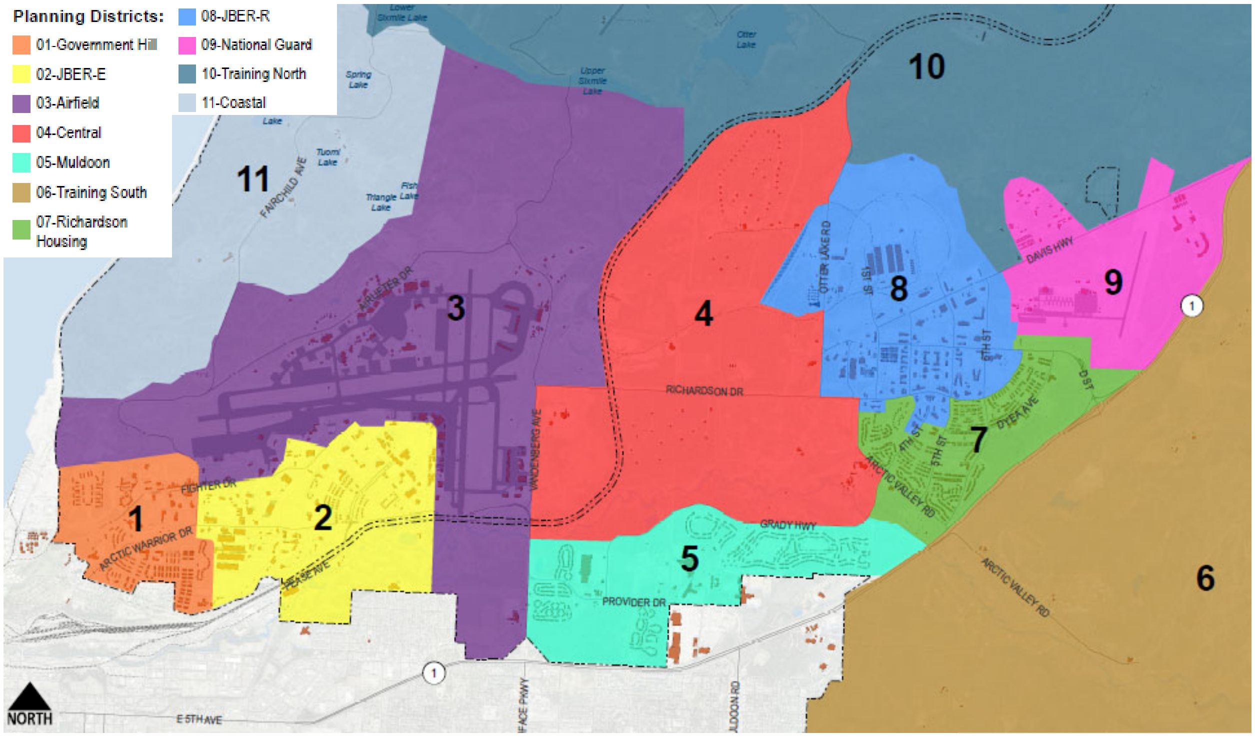
To become less reliant on end-of-pipe solutions, JBER is altering its stormwater management practices to include managing stormwater where it falls - at the source - using green infrastructure/low-impact development (GI/LID) best management practices (BMPs). This before-pipe approach is supported at the federal and state level by applicable regulations and building facility codes. This planning document takes the initial steps to developing a GI/LID program specific to JBER.

Project Area

JBER is located in southcentral Alaska and covers over 79,000 acres. The installation is bordered by the Knik Arm coastline to the north and west, Chugach State Park to the east, and Ship Creek and the Municipality of Anchorage (MOA) to the south and southwest. The installation includes 2,343 facilities, airfields, ranges, and training areas.

The project area is focused on JBER's Urbanized Area (UA) as defined by the 2010 U.S. Census Bureau (Figure 1) and matches JBER's Alaska Pollution and Discharge Elimination System (APDES) small municipal separate storm sewer system (MS4) permit area. The UA is approximately 26,700 acres.

For this GI plan, the JBER UA is divided into six districts based on existing installation development planning (Jacobs 2015). The six districts are shown on the following image and include Government Hill, JBER-Elmendorf (JBER-E), Airfield, Muldoon, Richardson Housing, and JBER-Richardson (JBER-R).



Taken from Jacobs 2015

Stormwater from the JBER UA drains into three areas (Figure 2): Ship Creek, Knik Arm-Frontal Cook Inlet, and Chester Creek (Stantec 2018). The majority of the JBER UA is within the Ship Creek drainage area, which has its headwaters in the Chugach Mountains. Ship Creek flows within the JBER installation boundary and ends at the river mouth at the Knik Arm and Cook Inlet west and outside of JBER. The Knik Arm-Frontal Cook Inlet drainage area covers the western portion of JBER to the Knik Arm coastline. It is mostly undeveloped except for the southwestern portion, which enters the Government Hill, JBER-E, and Airfield Districts. The Chester Creek drainage area is south of the Muldoon District. Stormwater from the Muldoon District discharges into the Chester Creek and Ship Creek drainage areas.

Regulatory Context

Regulations Specific to JBER Stormwater

The regulatory context serves as the backbone for developing this GI plan and includes the established Ship Creek total maximum daily load (TMDL), JBER's APDES permit, and Unified Facilities Criteria (UFC).

The State of Alaska lists Ship Creek as water quality-limited for fecal coliform on the Alaska 303(d) list under the Federal Clean Water Act. Reaches of Ship Creek listed as impaired receive stormwater flows from the JBER UA. A fecal coliform TMDL (ADEC 2004) was established to develop water quality standards and pollutant waste load allocations from point and non-point sources for the impaired reaches of Ship Creek. JBER has four outfalls draining stormwater from its UA into the impaired reaches (Figure 2), and therefore, must address its fecal coliform waste loadings. Non-point source runoff from JBER directly discharges into Ship Creek and must also be managed. The TMDL is implemented through JBER's MS4 permit and associated stormwater management plan (SWMP) (JBER 2019) for point sources.

Both the MS4 permit and SWMP require green infrastructure as a BMP to address pollutant loading. Green infrastructure is also used to intercept and manage non-point source runoff.

Stormwater discharges from JBER's MS4 system into Ship Creek and Cook Inlet are permitted through APDES MS4 Permit AKS053651, issued 01 October 2019 (ADEC 2019). The APDES MS4 permit addresses loadings of state regulated pollutants, including but not limited to fecal coliform, nutrients, sediment, heavy metals, and glycol-based deicing/inti-icing agents and the corresponding biological oxygen demand (BOD) and chemical oxygen demand (COD). The permit includes requirements for incorporating green infrastructure into managing JBER's storm water discharges. Specifically, the permit states in Section 3.5.6:

> "Develop a Green Infrastructure/Low Impact Development (GI/LID) strategy that provides incentives for the increased use of GI/LID technique(s) or practice(s) described in Engineering Technical Letter (ETL 14-1) (or subsequent document with a revised name) in development projects. The written strategy must address planning, constructing, and evaluating GI/LID projects within JBER."

This plan fulfills Section 3.5.6 of the APDES MS4 permit. The permit includes subsequent GI requirements following the completion of this GI/LID plan.

The UFC 3-210-10, *Low Impact Development* (DoD 2020) defines low impact development as:

> "LID is a stormwater management strategy designed to maintain site hydrology and mitigate the adverse impacts of stormwater runoff and nonpoint source pollution…LID actively manages stormwater runoff by mimicking a project site's pre-development hydrology using design techniques that infiltrate, store, and evaporate runoff close to its source of origin. LID strategies provide decentralized hydrologic source control for stormwater runoff. In short, LID seeks to manage the rain, beginning at the point where it falls. The LID features are distributed small scale controls that closely mimic hydrological behavior of the pre-project sites for a design storm event."

Section 1-4 of the code states that the criteria and design standards are required for the planning, design, and construction of Department of Defense (DoD) projects that includes:

> 1) Construction or expansion of building as part of its primary scope and
>
> 2) For projects that will create more than 5,000 gross square feet (sf) of impervious surface, or
>
> 3) To the extent practical for projects that do not meet 1) or 2).

Green infrastructure is a method that meets the LID UFC requirements and thus, this code provides the DoD guideline for including GI/LID practices in the planning, design, and construction of new and re-development facilities at JBER.

Applicable Stormwater Planning Documents

Several planning documents were referenced in the preparation of this GI/LID plan, which builds on work completed and lessons learned from applying GI/LID BMPs in Alaska, in other cold climates, and from Air Force Civil Engineering Center (AFCEC) guidance.

1) JBER's SWMP (JBER 2019) was prepared in compliance with JBER's APDES MS4 permit. It documents actions and activities that will be implemented for managing storm water and reducing pollutant loadings prior to discharging into Ship Creek and Cook Inlet. The SWMP includes actions towards developing a GI/LID program.

2) MOA developed a GI program in compliance with their ADPES MS4 permit that aims to manage and treat the first 0.52 inches of rainfall and requires and promotes the use of GI and LID on new and re-development projects in the private and public sectors (MOA 2017). Their implementation strategy includes demonstration projects, monitoring, GIS mapping of projects, training for designers, contractors, and inspectors, training for MOA staff, and public outreach. MOA has updated their stormwater manual (MOA 2017b) to include design guidance and criteria and maintenance protocols for GI BMPs applicable to the MOA climate, including those discussed in the GI Implementation Recommendations section of this plan.

3) Fairbanks Green Infrastructure Group developed a GI Project Guide on behalf of the City of Fairbanks (Heinchon, et. al. 2015). The guide provides an overview of GI, feasibility of various GI BMPs applicable to Fairbank's climate, cost effectiveness, and installation and maintenance guidance. The guide selected GI practices with lower maintenance requirements for their residential and commercial audience.

4) Minnesota's Stormwater Manual (MPCA 2014) is a thorough resource for consideration and implementation of various stormwater controls, including GI practices discussed in the plan. The manual includes considerations for applying GI/LID in cold climates, effectiveness of GI practices for reducing pollutant loading, and GI installation and maintenance needs. It is updated on a regular basis to incorporate the latest science.

5) AFCEC developed ETL-14 (AFCEC 2014) to provide guidance for construction, operation, and maintenance of storm water systems for all Air Force, Air National Guard, Air Force Reserve, and Army National Guard installations. The guide indicates that the optimal time to include post-construction permanent storm water controls, including GI, is at the planning and design phase. The guide provides design considerations, operation and maintenance (O&M) troubleshooting, estimated hours and frequency needed to complete O&M tasks, and O&M checklists for each storm water control. The guide does not provide GI/LID standards details, specifications, or list specific equipment needed for maintaining a GI program.

Pollutant Loading Context

The Ship Creek TMDL (ADEC 2004) identifies urban runoff across impervious surfaces as the primary source of fecal coliform bacteria loadings into Ship Creek. The highest loadings occur during spring thaw (late May to early June) and in autumn (September to October) due to rain and sleet events. Sources of fecal coliform bacteria include pet waste, waterfowl (Canadian geese and mallard ducks), native animals (moose and bears), septic systems, and illicit connections to the storm sewer system (ADEC 2004 and JBER 2019). JBER has implemented several BMPs to address pollutant loadings, including requiring sanitary sewer systems (rather than septic systems) in new developments within the UA, surveys to detect illicit sewer system connections, pet waste rules, and street sweeping of road grit in early spring. The timing of highest loadings for other pollutants of concern, such as nutrients and sediment, is anticipated to be similar.

PLAN GOALS & OBJECTIVES

GI Goals for JBER

The goals for implementing GI/LID at JBER are based on its regulatory context and include:

1. Responding to the JBER APDES MS4 permit and SWMP. The APDES MS4 permit specifically includes GI/LID as a method for post-construction storm water management in new and re-development projects and outlines specific steps to implement a GI/LID program. The SWMP provides step by step measureable goals to address the permit's requirements, which includes the development of this GI/LID plan.
2. Responding to the Ship Creek TMDL for reducing fecal coliform pollutant loading from point and non-point sources.
3. Responding to the APDES MS4 permit and SWMP for managing runoff containing deicing agents and the resulting BOD and COD levels and other common stormwater pollutants such as heavy metals, total suspended solids, and nutrients.

Plan Objectives

The objectives of this GI/LID plan are to:

1. Select GI methods most practical for JBER and how they address the GI goals.
2. Identify priority areas and sites for strategic GI implementation.
3. Identify next steps for implementation and needed resources.

GREEN INFRASTRUCTURE AS A STORMWATER MANAGEMENT BMP

There are various management methods for decreasing the volume of pollutants discharged from JBER. Methods include public education and outreach, illicit discharge detection and elimination, managing construction site runoff, maintaining and monitoring the existing stormwater system, and post-construction site runoff management. GI is one tool that fits within the overall stormwater management framework.

GI Defined

Green infrastructure is an alternative method of managing stormwater. Traditional stormwater management has been in the form of *gray infrastructure*, which involves directly conveying runoff from impervious surfaces (i.e. buildings, parking lots, roadways, and airways) off-site and into underground sewer systems that discharge into wetlands, rivers, and open water bodies. Stormwater at the discharge points is often untreated, and thus, transports pollutants that are picked up from impervious surfaces into the receiving water body.

Green infrastructure works in tandem with the existing gray infrastructure system in two ways:

1. GI manages stormwater where it falls – at the source. It intercepts stormwater on-site via infiltration into the underlying soil column or is collected for re-use. Thereby, it provides both a quality and quantity benefit prior to entering the storm sewer system.

2. GI provides an opportunity to set a net-zero increase or minimize to the extent practicable of increased runoff from new and re-developments such that larger, gray infrastructure capital investments can be minimized.

Co-Benefits of GI

Green infrastructure has environmental, social, and economic co-benefits, including:

- Reduces water quantity, rate of discharge, and pollutant loadings, such as phosphorus, total suspended solids, heavy metals, and bacteria, entering the gray infrastructure system.
- Preserves or enhances the amount of available open space - Infiltration-based GI methods optimize the amount of green space as pervious surface for capturing and infiltrating stormwater into the underlying soil column.
- Improves the overall visual aesthetic - A site can become a public amenity by preserving and enhancing the amount of available green space.
- Serves as a buffer to ecologically sensitive areas - GI practices can be used to intercept stormwater adjacent to sensitive areas such as Ship Creek, wetlands, and wetlands hydrologically connected to Ship Creek.
- Enhances habitat - GI practices often use vegetation to increase infiltration and evapotranspiration. The resulting plant communities can be designed to enhance wildlife and pollinator habitat in conformance with site development goals. Also, GI reduces the rate of discharge into water bodies which enhances habitat due to less scouring of stream beds.
- Re-uses water on-site – GI practices can harvest rainwater for re-use such as watering lawns and planting beds and other on-site uses.

OPPORTUNITIES & CONSTRAINTS ANALYSIS

Several factors must be considered when analyzing the feasibility for including GI as part of the overall stormwater management strategy. This section provides an opportunities and constraints analysis and provides a framework for assessing sites.

Natural Character

Green Infrastructure generally uses infiltration as its means for managing stormwater at the source. Thereby, subsurface conditions will influence the design approach, including soil, groundwater depth, surface water features, the stormwater routing system, and environmental contamination.

The majority of the soils within the urbanized area are classified as Cryorthents and Urban Land with a typical soil profile of very gravelly sandy loam to a depth of five feet (NRCS 2020). Cryorthents characteristically are soils that are cold and dry, coarser in texture, and lack soil horizon development. The Urban Land classification indicates that the native soils have been disturbed for development. This information forms the basis for the hydrologic soil group (HSG) classifications that re-organizes soil based on their infiltration rates and runoff potential. Figure 3 maps the project area by soil hydrologic group, A through D and Disturbed. HSGs are applied when planning and designing GI, as they are used in stormwater models to calculate the volume capture and resulting pollutant loading of a site stormwater design. HSGs range from A - having high infiltration rates and a low runoff potential, through D - having slow infiltration rates and a high runoff potential. The project area HSGs contain B, D, and Disturbed. In Disturbed HSGs, soils are sampled and tested for their infiltration rate.

In general, the base or bottom elevation of an infiltration-based BMP is designed for a minimum groundwater depth of two feet. At shallower depths, either a non-infiltration based GI/LID BMP is used or the GI system is lined to convey retained water into the storm sewer system (the system is designed for retention versus infiltration). Groundwater within the majority of the project area is greater than 6 feet and therefore, groundwater separation is not a constraining factor. Nevertheless, the depth to groundwater should still be evaluated at the site scale.

Green infrastructure is used to intercept site runoff prior to discharging into wetlands, 100-year floodplain, streams, and open water bodies. Figure 2 shows the location of these surface water features relative to the project area. The majority of floodplain, wetlands, and open water bodies are in close proximity to Ship Creek, and only a few wetlands exist within the developed portions of the UA. The map also locates six outfalls that are monitored as part of the JBER APDES MS4 permit, JBER-E #1 through JBER-E #5 and JBER-R #1. The information on the map is used to identify developed areas in relation to surface water features and outfall points and determine where GI can be optimally used. For instance, there are several residential areas in the Muldoon District that are adjacent to wetlands hydrologically connected to Ship Creek. These are optimal areas for implementing a series of GI/LID BMPs to intercept stormwater.

Storm sewers and open channels are used to convey stormwater throughout JBER (Figure 4). There are instances in JBER-R and the Richardson Housing District where stormwater is routed to existing BMPs, such as infiltration basins and wet detention ponds, to receive and capture pollutant loadings. GI is used in tandem with this stormwater infrastructure by installing BMPs at the “headwaters” of storm sewer sewersheds/open channels or at storm sewer/open channel “tributaries” where space allows. The cumulative effect is reducing the quantity of water and thus the pollutant loading that enters the stormwater conveyance system and the end-of-pipe BMPs.

Environmental contamination provides a constraint for implementing GI as contaminated sites are often prohibited from allowing infiltration into the subsurface. The JBER Environmental Restoration Program (ERP) Atlas (JBER 2017) provides detailed information on the location and type of subsurface contamination. The ERP Atlas is currently being updated and should be used when assessing the GI feasibility of a site.

Developed Character

Land use maps are used as a first-glance view for implementing GI. Current and proposed parks and open spaces are considered green infrastructure, per Section 3-6.4.5 of UFC 2-100-01, due to their undeveloped, pervious condition. The JBER land use map (Figure 5) illustrates these areas as open space and outdoor recreation. UFC 2-100-01 includes wetlands, riparian corridors, and significant bodies of water for GI planning. These areas are labelled as buffer areas on Figure 5. Administrative, housing, and community land uses are the next logical areas to focus implementing GI as they are less likely to be constrained from environmental contamination, bird/wildlife air strike hazard (BASH) zones, air accident zones, and JBER mission operations.

Following an overview of land use, impervious area (Figure 6) is assessed to identify locations producing stormwater runoff. Parking lots, roadways, and roof areas in all land use types are impervious and contribute to the cumulative stormwater runoff quality. The larger impervious areas are located in the airfield, airfield operations/maintenance, and industrial land use areas. The administrative, housing, and community land uses also show significant amounts of impervious area and provide good initial opportunities for addressing site runoff.

STAKEHOLDER INVOLVEMENT

Outreach efforts were completed with JBER stakeholders to inform, gather input, receive feedback, and collaboratively discuss the green infrastructure planning. These outreach efforts are integral to developing goals, working through upfront concerns, furthering analysis of opportunities and constraints, and developing consensus for implementing GI strategically. The outreach effort is meant to have those affected by the plan participate at its inception, include their input, and make them part of the decision making process. The goal is to have a unified vision going forward. The following section discusses outreach efforts with stakeholders.

Planning Charrette

A planning charrette was held on 04 June 2020 via Microsoft Teams virtual meeting platform. The charrette purpose was to provide a collaborative forum for all interested parties to have an open exchange of ideas and feedback for developing a unified vision. The goals for the meeting were to:

1) Introduce and have attendees understand the need for a GI/LID plan
2) Understand what GI is
3) Discuss the opportunities and constraints for implementing GI
4) Identify priority areas for strategic GI implementation.

The charrette was attended by thirty stakeholders from across the joint base, including those representing the Air National Guard, Army National Guard, 673rd Civil Engineering Group, 773rd Civil Engineering Group, planning and development, housing management, environmental conservation (cultural and natural resources), environmental compliance, environmental restoration, stormwater management, grounds and maintenance, and utilities.

The charrette started with a presentation on the regulatory context surrounding JBER for the need of a GI/LID plan. The pollutants of concern and their main sources were explained. Also, the definition of GI, examples of installed GI, and JBER's existing conditions that lend to and constrain using GI were explained. Attendees were asked to review aerial maps of the JBER installation and were shown how to assess sites for GI. Opened discussion followed. From the discussion, attendees identified potential sites for consideration.

The main themes expressed by attendees included altering mowing practices, not developing existing green space, constraints of subsurface contamination and the capping of contaminated sites. The durability and costs associated with permeable paving was also mentioned. Administrative and housing areas were identified as being optimal locations for GI. Opportunities within the Airfield District were identified but may incur more constraints due to gross heavy weight of normal vehicle traffic and underlying contamination.

Stakeholder Discussions

Follow up conference calls were held with members of the Air National Guard and the Airfield District. Information gathered included:

- Mowing protocols for the Airfield District are set at 7 to 14 inches of height to ward off waterfowl (geese and ducks) but has in the meantime attracted predator birds (owls, ravens, eagles, and hawks). A bird hazard working group is currently investigating avian activities and developing recommendations to reduce the presence of birds and large mammals within the Airfield District. These protocols are for the Airfield District and does not represent areas managed by others, including the housing property management group.
- Green infrastructure should be included as a design criteria when developing work orders at the planning and design phase. Target audiences would be the 673rd Civil Engineering team and design consultants.

RECOMMENDATIONS FOR GI IMPLEMENTATION

ETL-14 provides a comprehensive description of stormwater BMPs for all DoD sites, including multiple GI/LID practices and their advantages and disadvantages, design considerations, operation and maintenance needs, and checklists. This GI/LID plan takes ETL-14 a step further by recommending GI/LID practices that are most feasible for JBER and its water quality goals and identifying potential sites for implementing GI and next actions for implementing a JBER GI/LID program.

It should be noted that this document has been developed in response to permit requirements for the JBER UA (Figure 1). However, the principles and recommendations can be applied to JBER as a whole.

Recommended GI/LID Practices

All GI/LID practices have the ability to retain stormwater. However, each practice has differing landscape benefits and are more suitable to certain situations. Understanding which practice to use where requires selecting applicable practices based on the opportunities and constraints of the site and site development goals.

Six GI/LID BMPs are recommended for use on JBER. They are described in this section and summarized in Table 1. They were chosen based on their ability to capture pollutants, use of designs that target smaller rain and sleet storm events and spring thaw, viability in cold climates, and JBER's opportunities and constraints. They were also based on GI practices recommended by MOA and the availability of local contractors familiar with their construction and maintenance. Other types of BMPs, such as downspout disconnection, compost soil amendments, native landscaping, stormwater trees, and vegetated buffers, are to be applied in combination with these six practices.

Each of the selected BMPs will address the GI/LID plan objectives for the Ship Creek fecal coliform TMDL and the APDES MS4 permit & SWMP for heavy metals, total suspended solids, and nutrients. Table 2 summarizes GI/LID BMP relative stormwater performance, co-benefits, and planning-level construction and maintenance costs. However, consistent data is not available for GI/LID BMP capability in addressing pollutant loading of glycol-based deicing agents used on airfields that cause elevated BOD and COD. The basis of GI/LID BMPs is to mimic natural hydrology and use soil water holding capacity, base layer storage, evapotranspiration, and infiltration as the mechanisms for capturing pollutants. The geochemistry of glycol-based compounds is to dissolve in water, bypass the soil organic matter and biological processes, and thus transport and percolate into the underlying groundwater system. Infiltration of stormwater containing glycol-based deicing agents may result in reduction of BOD and COD concentrations but may also result in groundwater contamination. Coordination with the JBER environmental restoration group is required to evaluate if the use of GI/LID BMPs in capturing airfield runoff would compromise groundwater quality.

Bioinfiltration Basins & Swales

Bioinfiltration basins and swales are shallow depressions that temporarily retain stormwater runoff, filter and retain pollutants, and reduce peak flows. They are generally used to collect runoff from roof downspouts, parking lots, and roadways. Inflow to these facilities are filtered and infiltrated through bioengineered soil media or compost amended soil in addition to plant evapotranspiration. Native plants are recommended due to their long root system, but they can be planted with turf grass. In the latter case, the bioengineered soil media or compost amended soil provide the majority of the water quality and quantity benefits. Overall, the best practice is to keep the plant palette simple for maintenance crews.

Bioinfiltration basin collecting stormwater from surface runoff and roof downspout at a school; provides co-benefits of depaving an area for green space used as an outdoor classroom, aesthetics to the neighborhood, and habitat.

Vegetated Swales

Vegetated swales are used to treat runoff as it is conveyed to downstream BMPs. They are wide, shallow, and linear with gentle slopes to slow the flow rate, promote infiltration, and allow silt and other pollutants to settle or be filtered by vegetation. They are generally used along streets and parking lots. They provide little overall volume control and thus, are used with other BMPs. JBER already uses vegetated swales to convey stormwater to dry infiltration basins and to the storm sewer system.

Parking lot with bioinfiltration swale, curb cut, and permeable pavers.

Dry Infiltration Basins

These basin types reduce peak storm water flow rates, promote the settling of suspended pollutants, and minimize erosive velocities downstream of the outlet structure. They also are known to have fewer BASH issues compared to constructed wetlands. There are several dry infiltration basins already in use at JBER.

Dry Infiltration basin at stormwater outfall to capture and treat stormwater prior to public beach; provides co-benefits of aesthetics, buffer to water body, and habitat.

Permeable Pavement

Permeable pavement and pavers encompass a suite of hardscape surfaces that are specifically designed to infiltrate rainwater and reduce pollutant loading, runoff rate, and volume. Permeable pavement includes permeable concrete and permeable asphalt which are mixed and laid in place. A third type of permeable pavement is interlocking pavers, which are shaped such that void spaces are created between the individual pavers allowing for infiltration. They are installed paver by paver or in an assembled mat. A site's loading requirements, use of deicing agents such as sand and salt, aesthetic concerns, and cost considerations will determine the right approach for the site. In general, interlocking pavers are the preferred method in cold climates. All systems require a coarse stone sub-base that acts as both a storage reservoir for stormwater and a structural base. Maintenance includes vacuum-truck street sweeping on an annual basis, and the entire system can be rejuvenated by removing and replacing grout.

Rainwater is collected into an underground cistern from roof downspouts overlaid with 10,000 sf of permeable pavers. The cistern is lined with an EPDM liner, filled with large wash stone and "GeoBlocks" to create a base and a large water holding capacity. The harvested rain water is re-used for watering landscaping and greenhouses.

Constructed Wetlands

Constructed wetlands mimic natural wetlands and are designed to have multiple treatment zones of different water depths. They are an effective stormwater quality and quantity BMP, provide an aesthetic benefit, and support habitat. Considerations must be made as they occupy more land, must be located away from airfields, and require good ecological design and maintenance.

A series of constructed wetlands adjacent to a river that collect and treat stormwater from a light industrial 100-acre development with co-benefits of providing green space for a park and trail system, aesthetics, buffer to a river, and habitat.

Rainwater Collection

Rainwater collection systems collect and temporarily store stormwater for non-potable re-use or for infiltration (dry wells). The systems come in many forms and sizes ranging from a 55-gallon rain barrel for a single residential downspout to underground chamber systems collecting thousands of gallons. An underground chamber system is effective when above ground space is limited and for larger runoff volumes. Rain barrels are effective at the residential scale by harvesting

The start of a 270,000 cubic foot underground concrete vault to serve as an underground stormwater basin in a development with limited space.

storm water from individual roof downspouts that can be re-used for landscape watering or infiltrated through a dry well.

Table 1. Recommended GI/LID BMPs for JBER

GI BMP Type	Description	Benefits	Disadvantages
Bioinfiltration basins & swales	Temporarily retains storm water runoff, filter and retain pollutants, and reduce peak flows. Inflow to these basins is filtered through engineered media or amended soil.	Is effective with either turf or native vegetation, effective water quality and quantity BMP, and aesthetic.	Correct installation and plant establishment critical.
Vegetated swales	Used to treat runoff as it is conveyed downstream, are wide and shallow with gentle slopes to slow the flow, promotes infiltration, and allows silt and other pollutants to settle or be filtered by vegetation.	Can reduce the use of costly gray infrastructure, aesthetic, can use wetland vegetation for additional treatment and habitat.	Essentially no volume control, must be used with other BMPs to meet most storm water rule requirements.
Dry infiltration basins & swales	Reduces peak storm water flows, promotes the settling of suspended pollutants, and minimizes erosive velocities downstream of the outlet structure.	Is effective controlling peak runoff discharge rates, effective water quality and quantity BMP, fewer BASH issues.	Debris can accumulate, can develop a soggy bottom or standing water.
Constructed wetlands	Mimics natural wetlands and has multiple treatment zones of different water depths.	Is an effective water quality and quantity BMP, aesthetic, and supports habitat.	Occupies more land, must be located away from airfields, and requires good design and ecological maintenance.
Permeable pavers	An alternative to conventional concrete and asphalt that allows for infiltration of storm water into void spaces that provide temporary storage. Pavers are recommended over permeable pavement/concrete.	Reduces the pollutant loading, runoff rate, and volume; system can be rejuvenated by removing and replacing grout.	Can become clogged without maintenance, requires thick base to prevent winter heaving.
Rainwater collection	Captures and stores storm water from rooftops for non-potable uses.	Reduces potable water consumption and effective water quantity BMP.	Debris buildup and winterizing.

Table 2. Relative Stormwater Performance, Co-Benefits, & Cost of Recommended GI/LID BMPs

GI BMP Type	Pollutant Capture Performance˜	Volume Capture Performance	Potential Co-Benefits	Construction Cost Range *^	Annual Maintenance Cost Range **+**
Bioinfiltration basins & swales	High	Moderate	Green space, aesthetic, buffer, habitat	$5 - $24/sf [1]	$700/acre [6]
Vegetated swales	Moderate	Low	Green space, buffer	$8 - $20/lf [2]	$5/lf
Dry infiltration basins & swales	Moderate	High	Green space, buffer	$1/sf	$500/acre
Constructed wetlands	Moderate	Moderate	Green space, aesthetic, buffer, habitat	$10,000/acre [3]	$800/acre [6]
Permeable pavers	High	Moderate	Aesthetic	$12 - $16/sf [4]	$150/hour for vacuum truck plus $100 for two inspections/year.
Rainwater collection	Moderate	Moderate	Water re-use	$2 - $4/gallon [5]	$250 - $1,300/system [7]

Notes: The costs are meant for planning purposes only and exclude design fees. In general, costs to install BMPs are less for new development projects compared to retro-fits. Likewise, construction costs tend to be less when the BMP is included as part of an installation construction project versus constructing the BMP as stand-alone.

˜ Pollutants includes bacteria (i.e. fecal coliform, Escherichia coli), phosphorus, total suspended solids, and heavy metals.

* Resources used for costs are from Fairbanks, AK, ETL-14, Minnesota Pollution Control Agency, Milwaukee Metropolitan Sewerage District, US Environmental Protection Agency, and personal experience and conversations with vendors.

^ Reflects installation price with materials and labor.

+ Costs reflect routine annual maintenance tasks and exclude 5-year tasks such as removing deposited sediment, removing and replacing grout in paver systems; based on labor rate of $50 per hour.

[1] Reflects residential to commercial sized bioinfiltration and design complexity.

[2] Range due to planting method of seed to sod.

[3] The range can vary depending on site characteristics and restoration goals.

[4] Reflects hand-laid pavers; machine laid ranges $7 - $11/sf.

[5] Reflects 55-gallon rain barrel to 1,000 gallon cistern. Larger systems priced per design.

[6] Reflects effort following plant community establishment.

[7] Range due to size of system and reflects semi-annual cleaning and winterization.

Table 2 provides relative performance guidelines of GI/LID BMPs for reducing pollutant runoff and stormwater volume. These guidelines are appropriate when evaluating BMP performance during the planning phase. Hydrologic and hydraulic (H&H) models then are applied during the site design phase for a more detailed evaluation. H&H models calculate the pre- and post-construction condition, and it is through an iterative process of evaluating and refining the design that the resulting GI/LID performance is optimized. The following H&H models are commonly used for evaluating GI/LID:

- Rational Method
- TR-55
- EPA Storm Water Management Model (SWMM)

The State of Alaska specifically accepts TR-55 and EPA SWMM models and is open to other recommendations (ADEC 2011).

Recommended Actions for Strategic GI Implementation

There are five main strategies for implementing GI:

1. *Include GI as a stormwater management approach for planning and design phases of new and re-development projects.* This occurs through referencing UFC 3-210-10, *Low Impact Design,* and JBER's APDES MS4 permit when developing project descriptions and scopes of work for the 673rd Civil Engineering Group and design consultants. GI/LID should also be included on internal checklists when reviewing planning and design documents.
2. *Maintain all areas designated as open space, outdoor recreation, and buffer areas per the land use plan.* In essence, keep all pervious areas pervious.
3. *Work with the housing property management group to verify that GI/LID practices per UFC 3-210-10, Low Impact Design and JBER's APDES MS4 permit are included for all new and re-development projects within the JBER residential neighborhoods.* Explore other opportunities for retro-fitting existing facilities with GI/LID practices, including developing a residential rain barrel and rain garden program and lawn mowing guidelines that encourage longer grass heights, on-site mulching of grass clippings, and use of compost soil amendments in place of synthetic fertilizers.
4. *Retro-fit existing facilities that are not included in installation development planning efforts.* Twelve example sites were identified (Figure 7) as part of this planning effort due to their location within the stormwater routing system, land use, and proximity to wetlands and Ship Creek. These sites are discussed in detail below.
5. *Develop design, installation, and maintenance resources to support a GI program.* For GI/LID BMPs to be incorporated in the JBER culture, there needs to be a support system. Refer to the Resources Needed for a GI/LID Program section for more discussion.

Potential GI Projects

Twelve sites were identified as potential GI/LID retro-fit opportunities and are shown on Figure 7. It is recognized that this list will change over time and is meant to be fluid and adaptable. The intent is to provide a starting point, illustrate how to assess sites for GI/LID based on the opportunities and constraints analysis, and have GI/LID be a recognized overall stormwater strategy with co- benefits. The next step requires completing a site stormwater analysis by a team consisting of a landscape architect, an ecologist, a stormwater engineer, and a site civil engineer for planning and design of GI/LID BMPs.

Site #1 – Building 7122

Building 7122 is located in the Government Hill District. The site was identified based on its total amount of impervious area, location outside of a BASH zone and known areas of contamination, and location within the stormwater routing system that discharges to JBER-E Outfall #1 and the Knik Arm-Frontal Cook Inlet.

The site has approximately 5.5 acres of impervious area associated with the building roof and two parking lots located to the east and west of the building. In a 0.52 inch storm, the two parking lots would produce over 67,800 gallons of stormwater that would flow across the impervious surface picking up pollutants prior to entering the stormwater routing system. The site is located at the start of a vegetated swale that leads to a storm sewer. There is available green space adjacent to the building and to the south of the site for locating GI/LID BMPs. Different GI/LID BMPs can be combined, including roof downspout disconnection leading to a bioinfiltration basin, bioinfiltration swales and permeable pavers within the parking lot, and directing stormwater into bioinfiltration basin(s) or dry infiltration basin(s) adjacent to the parking lots.

Site #2 – Infiltration Basin

The site is located in the Government Hill District and was identified based on the size of the sewershed it serves, available green space, and its location outside the BASH zone. It is outside of known areas of contamination. Stormwater discharges from this site flow through JBER-E Outfall #1 and into Knik Arm-Frontal Cook Inlet.

A vegetated swale system and storm sewer system meet at this location. Stormwater is directed into a storm sewer west of Arnold Drive and then daylights in an open channel. The site may provide enough green space to manage stormwater from the vegetated swale system using a bioinfiltration or dry infiltration basin.

Site #3 – Building 5126

Site #3 is located in the Government Hill District and is the site of Orion Elementary School, JBER-Elmendorf Education and Training Services Center, and two colleges. The site was identified based on the total amount of impervious area and its location outside of the BASH zone and known areas of contamination. It is at the headwater of a storm sewer system that discharges through JBER-E Outfall #1. A unique feature of this site is that the BMPs may provide outdoor, environmental, science, and math curricula opportunities to the educational facilities.

There is over 10 acres of impervious area from roofs and multiple parking lots. Stormwater across the impervious surfaces is directed to the storm sewer system and onto surrounding green space. Several combinations of GI/LID BMPs can be used, including multiple roof downspout disconnections leading to bioinfiltration basins, bioinfiltration swales and permeable pavers within the parking lots, vegetated swales to convey stormwater to the open green space due west of the site, and dry infiltration basins.

Site #4 – Building 17460

The site is located in the Airfield District and is used by the Air National Guard. Stormwater is generated from over five acres of impervious area that is managed by storm sewer and by sheet flow onto the surrounding green space. The site was identified based on its amount of impervious area, its location adjacent to wetlands and woodlands, and its location outside of the BASH zone and known contaminated areas.

The parking lots on the west and south sides of the site are about 2.25 acres and 1 acre in area, respectively, and are serviced with storm sewer. The parking lots can be retro-fitted with permeable pavers and a bio/infiltration swale system. There is enough green space adjacent to the buildings to direct roof runoff into bioinfiltration basins. To the north of the site, there are opportunities to place a constructed wetland system or bio/infiltration basins to intercept the runoff prior to entering the ecologically sensitive areas.

Site #5 – Building 6376

The site is located in the JBER-E District and houses the Sitka Child Development Center. The site was identified due to the available green space, the presence of a parking lot on the east side of the facility that is serviced by a vegetated swale, and the facility's use for educational purposes.

The vegetated swale for the 0.75 acre parking lot currently conveys runoff to the storm sewer system. There is ample green space surrounding the site to direct runoff into a bio/infiltration basin. Likewise, the roof downspouts can be directed into bioinfiltration basins in the green space adjacent to the building while also providing an outdoor environmental education facility and pollinator habitat.

Site #6 – Dog Park

The site is located in the JBER-E District and is adjacent to an engineered wetland restoration area designed to treat trichloroethylene-contaminated groundwater/seeps. The site was selected by stakeholders who identified the site as an area where pet waste is generated and often left behind during the winter months. There is much green space surrounding the site and surface runoff directly flows into restoration area. The site is also the location of a storm sewer outfall that discharges into the wetland.

The fenced-in portion of the site is about 0.5 acres surrounded by green space and a buffer area for the wetland. A starting measure for reducing fecal coliform pollutant loading is source control practices, including providing pet waste disposal bags and a receptacle on-site. For pollutant loading reduction measures, there is opportunity to place bioinfiltration swales surrounding the dog park and intercept sheet flow from entering the wetland system. Depending on the drainage area of the storm sewer shed, there may be an opportunity to intercept the discharging material into a bio/infiltration system. The site appears to be located in an area with groundwater contamination, and JBER’s environmental group should be consulted to determine if infiltration practices can be used at this location.

Site #7 – Discharge Point 74

The site is located in the Muldoon District and was identified based on its location in a stormwater drainage area that conveys stormwater by open channels and storm sewer into a wetland complex adjacent to Ship Creek. The stormwater drainage area includes commercial and residential land uses and is outside of BASH zones. However, there are a few locations of known contamination.

The site provides an opportunity to set up a series of GI/LID BMPs throughout the drainage area to intercept runoff. Potential practices include roof downspout disconnection into bioinfiltration basins or rainwater harvesting systems, parking lots retro-fitted with permeable pavers and bioinfiltration swales, and curb cuts in the roadways that collect stormwater into bio/infiltration swales. The design goals for the GI/LID BMPs can include other co-benefits beyond capturing pollutant loading, such as aesthetics, habitat, green space, and providing a buffer to ecologically sensitive areas.

Site #8 – Discharge Point 69

The site is located in the Muldoon District and was identified because stormwater from a residential area in the Muldoon District is discharged into a wetland complex that is hydrologically connected to Ship Creek. Similar to Site #7, a series of GI/LID BMPs can be implemented throughout the drainage area to capture and either infiltrate or harvest rainwater for re-use. The characteristics of the drainage area provides opportunities to include additional co-benefits of aesthetics, habitat, green space, and providing a buffer to ecologically sensitive areas.

Site #9 – Cottonwood Dog Park

The site is located in the Richardson Housing District and is adjacent to Ship Creek. The site was selected by stakeholders who identified the site as a location where pet waste is generated and often left behind during the winter months. Similar to Site #6, providing pet waste bags and a receptacle can is a practical method of source control. Bioinfiltration basins and swales can be used to intercept stormwater and provide co-benefits of habitat, aesthetics, and a buffer to Ship Creek.

Site #10 – Airborne Drive

The site is located in the Richardson Housing District and was selected based on its location in the stormwater routing system. Stormwater from the residential area is routed by open channels that enter the storm sewer system and discharge at JBER-R Outfall #1. The residential development along Airborne Drive is surrounded by ample green space and provides an opportunity to manage stormwater prior to entering the storm sewer system. Roof downspouts can be disconnected and directed to rainwater harvesting systems that overflow into bioinfiltration basins and swales. Curb cuts in Airborne Drive can divert road runoff into bio/infiltration swales along the roadway. The BMPs can be designed to include co-benefits of enhancing green space, aesthetics, serve as a buffer to the adjacent woodland, and enhance habitat. This provides an opportunity for education and outreach of JBER's SWMP program for the neighborhood.

Residential example showing roof downspout disconnect to a rain barrel and a bioinfiltration basin; provides co-benefits of rainwater harvesting and green space; bioinfiltration can be landscaped with either turf or native plants.

Site #11 – Building 77705

The site is located in the JBER-E District and was selected as there is ample greenspace adjacent to Building 77705 and associated parking lots. Runoff currently is directed to open channels that enter the storm sewer system at Richardson Drive. The site is surrounded by available green space that can be used for infiltration BMPs. The location is outside of BASH zones and known areas of contamination allowing for other co-benefits.

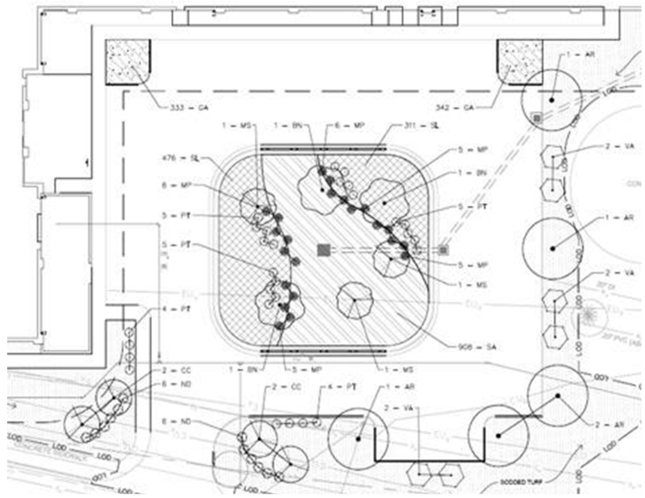
Site #12 – Pocket Park

The site is located in the JBER-E District and selected as it is identified as a short-range project in the JBER-R Area Development Plan (JBER 2018) for a pocket park. The available green space at this location and the planned land use opens the opportunity of becoming a public amenity while also managing on-site and adjacent stormwater. The site is outside of BASH zones and known areas of contamination. Potential GI/LID BMPs at this location include constructed wetlands or bioinfiltration basins and swales. Permeable pavers could be used for any proposed parking.

Resources Needed for GI/LID Program Development

Several resources are needed to ensure that a GI/LID program is supported and becomes part of JBER's routine engineering and development culture. The following are essential next steps to developing a GI/LID program.

1. GI/LID Standard Guidance, Plans/Details, and Specifications



Example plan drawing of a bioretention basin for a Training Support Squadron Facility.

A set of GI/LID design standards specific to JBER should be developed for the target audience of the 673rd Civil Engineering Group and planning and design consultants. The design standards would include plans/details, specifications, site considerations, stormwater pre- and post-construction runoff calculation methods, and design review checklists.

ETL-14 provides design guidelines, O&M task lists with estimated labor hours and frequency, O&M troubleshooting examples, and an O&M inspection checklist. The Municipality of Anchorage's stormwater manual (MOA 2017) includes design criteria, site analysis guidelines, stormwater quantitative calculation methods, maintenance tasks, and cold weather guidelines for GI/LID BMPs. The Airfield District Development Plan (SG-JG&A JV 2019) includes landscape standards specific to JBER. These documents can serve as a foundation for developing JBER specific standards that meet DoD and State of Alaska requirements.

Developing this resource will address several tasks in Section 3.5 of the APDES MS4 permit, including:

- Section 3.5.3 – Developing a BMP post-construction storm water management design manual that includes LID methods.
- Section 3.5.4 – Implement an inspection schedule and O&M plan for post-construction BMPs.
- Section 3.5.8 – Outlining the method(s) for quantitatively evaluating the performance of the BMPs that complies with federal and State of Alaska standards. During the planning and design phases, stormwater models are used to evaluate design alternatives and the resulting pollutant loading and volume capture.

2. Training for Construction Inspectors and Contractors

Proper GI/LID installation is critical for reaching design intent and longevity. Inspectors and contractors must be knowledgeable of correct landscape and plumbing materials and installation. Training sessions involving both classroom and outdoor installation sessions provides the most benefit. Outdoor sessions can include topics such as:

- How to inspect and approve materials (i.e. compost, bioengineered soil media, and plant material),
- Planting methods (i.e. tree, shrub, herbaceous plugs, and seed),
- Excavation methods such that the underlying native soil maintains infiltration,

- Hydro-seeding and mulching to diminish compaction of newly placed soil layers, and
- Base layer and permeable paver installation.

Developing this resource will address Section 3.5.5 of the APDES MS4 permit for developing and conducting at least one training session.

3. Operations and Maintenance Capacity and Training

O&M of GI/LID BMPs require a different approach from traditional turf maintenance. Permeable pavers require vacuum street sweeping one to two times per year. Bioinfiltration basins often require weeding and removal of debris. Any mowing or string trimming is done at longer cut heights. Training sessions for staff and procuring maintenance equipment dedicated to GI/LID BMPs are recommended to provide up-front support for JBER grounds crews. Maintenance can also be completed by hiring a contractor that is dedicated to the O&M of the GI/LID BMPs with qualifications and performance standards written in the contract. Regardless, GI/LID programs with maintenance trainings are the most successful for the longevity of the BMP and for public perception.

Training session for GI/LID inspection and maintenance activities. Sessions include outdoor sessions for installing and identifying commonly used plants, practice installing bioinfiltration basins, and practice laying base layers and permeable pavers.

Developing this resource will address Section 3.5.5 of the APDES MS4 permit for developing and conducting at least one training.

4. GI/LID Outreach Program

Developing an outreach program will bring awareness and understanding of GI/LID and its co-benefits while garnering interest and further implementation. The target audience is the entire JBER community, including the Air Force, Air National Guard, Army National Guard, 673rd Civil Engineering Group, planning staff for JBER operations, and the JBER property management groups. The goal is to bring interest at all levels, from single housing to commercial areas and to JBER operations.

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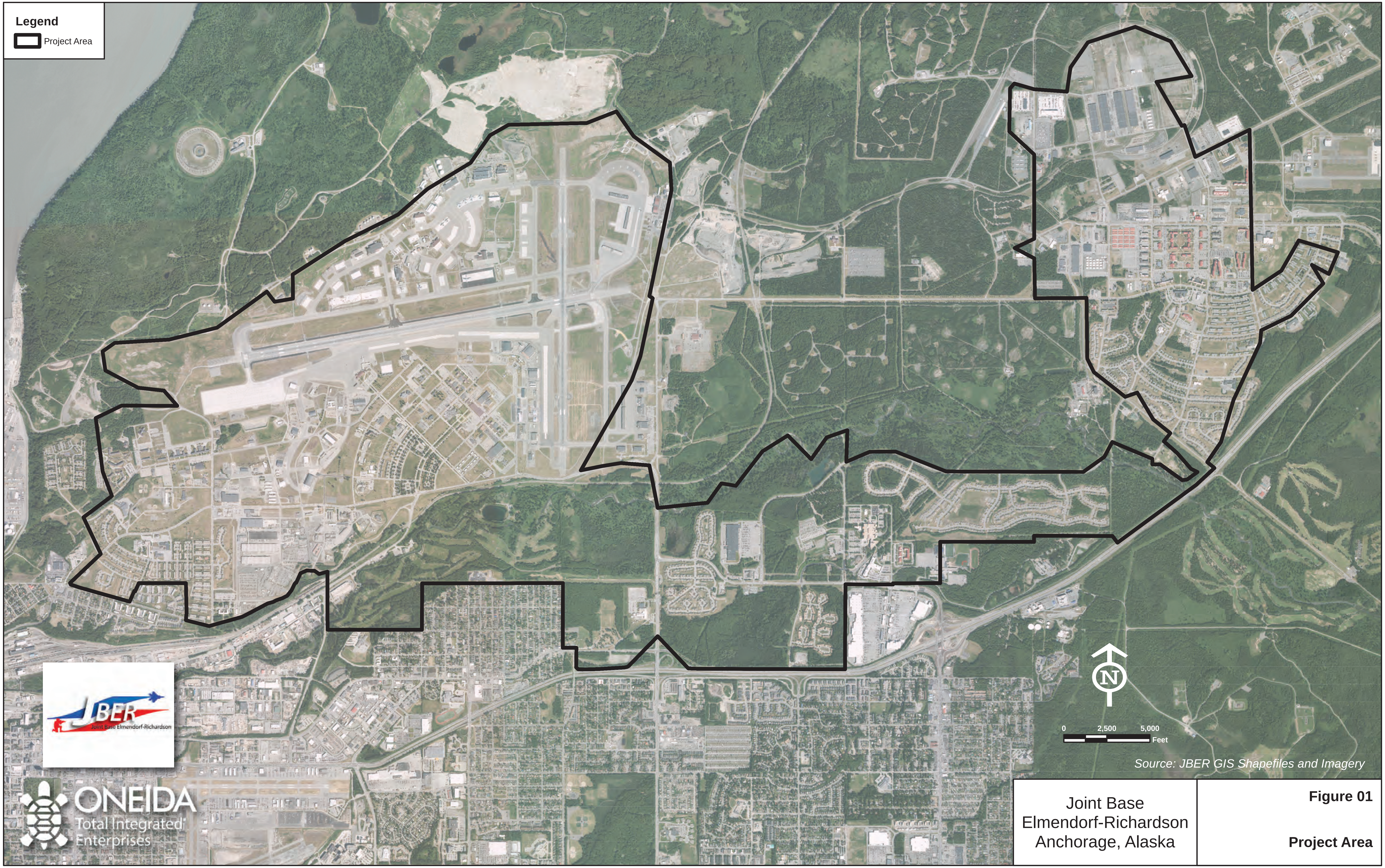
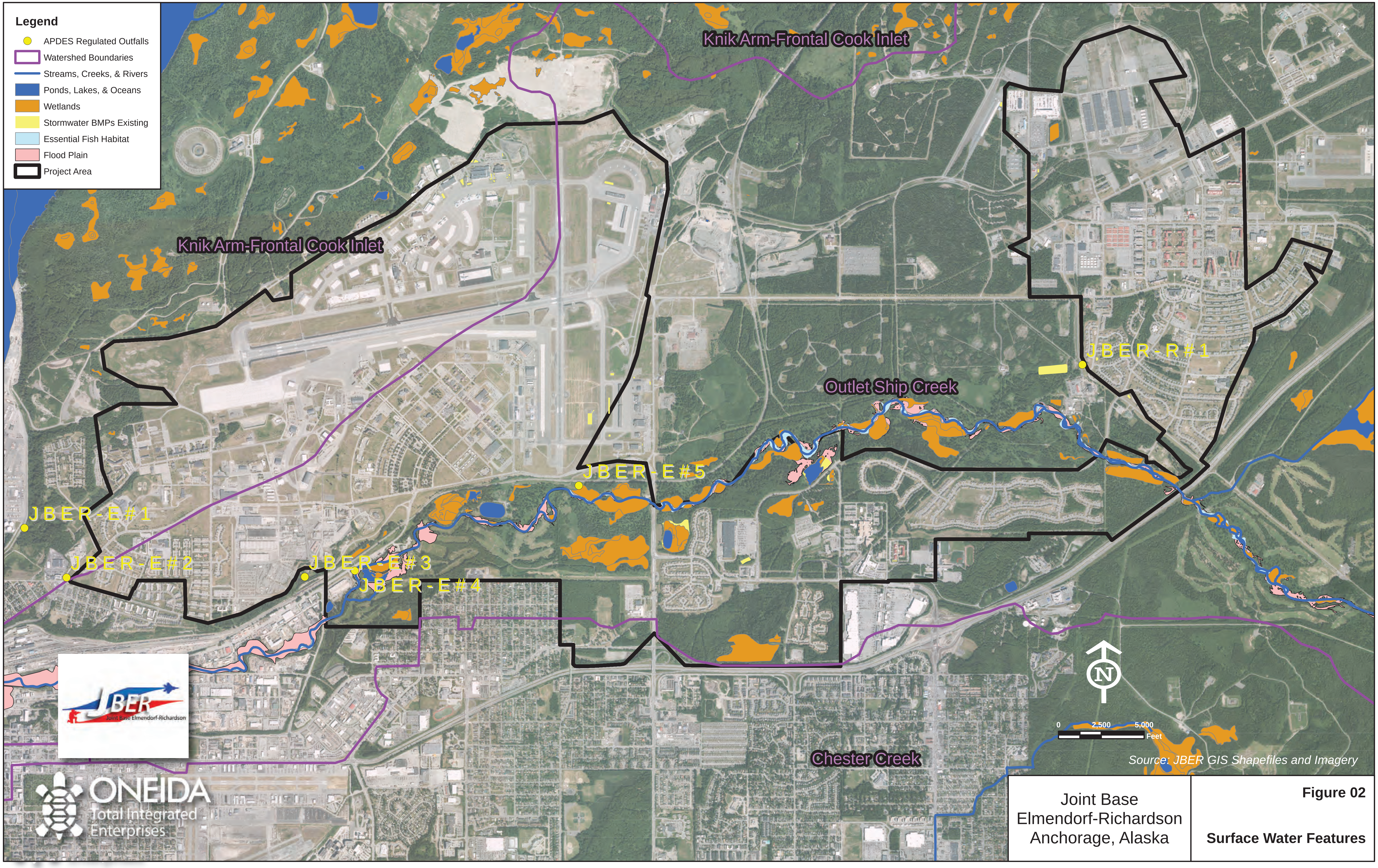
FIGURES



Joint Base Elmendorf-Richardson Anchorage, Alaska

Figure 01

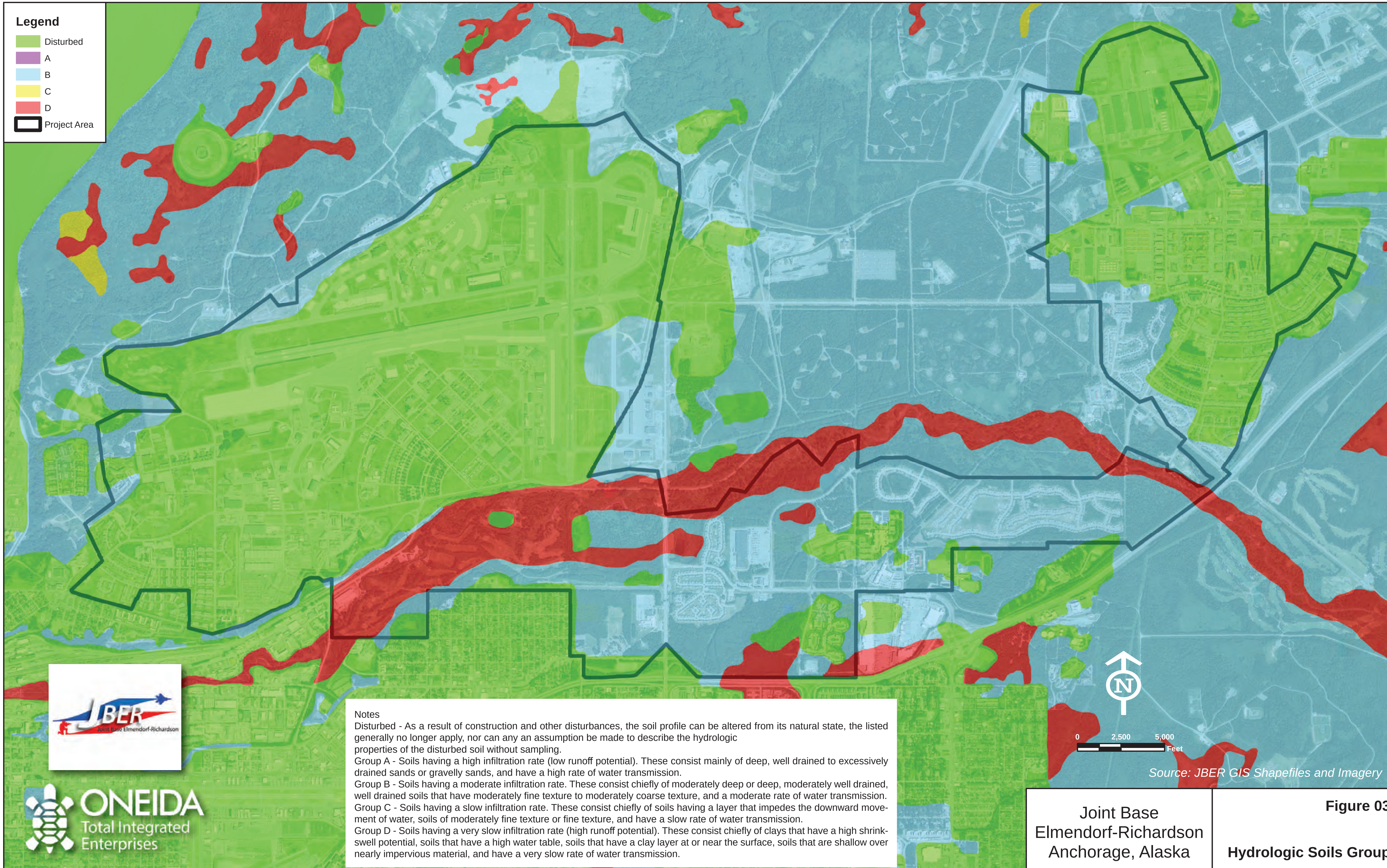
Project Area



Joint Base Elmendorf-Richardson
Anchorage, Alaska

Figure 02

Surface Water Features



Notes

Disturbed - As a result of construction and other disturbances, the soil profile can be altered from its natural state, the listed generally no longer apply, nor can any an assumption be made to describe the hydrologic properties of the disturbed soil without sampling.

Group A - Soils having a high infiltration rate (low runoff potential). These consist mainly of deep, well drained to excessively drained sands or gravelly sands, and have a high rate of water transmission.

Group B - Soils having a moderate infiltration rate. These consist chiefly of moderately deep or deep, moderately well drained, well drained soils that have moderately fine texture to moderately coarse texture, and a moderate rate of water transmission.

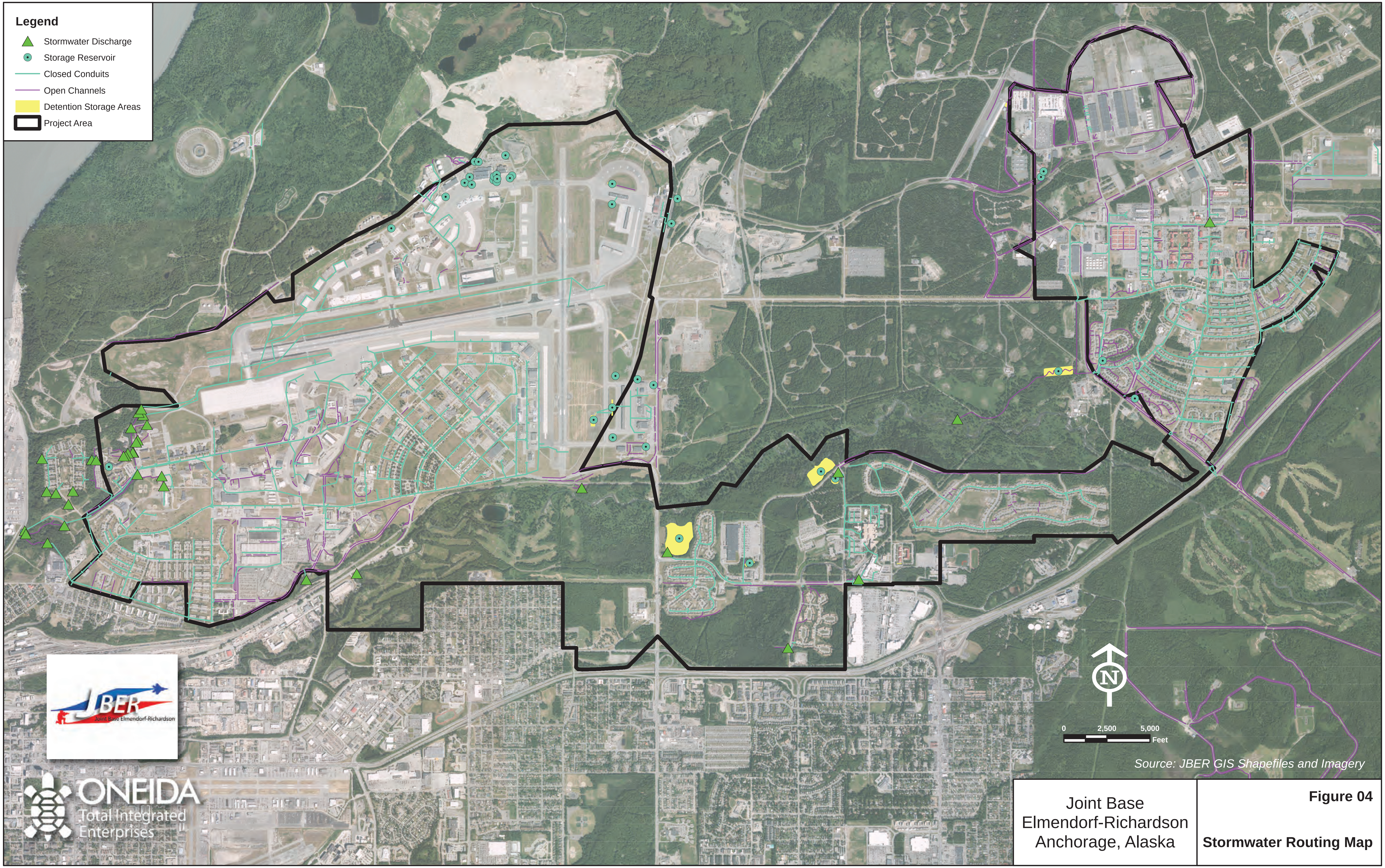
Group C - Soils having a slow infiltration rate. These consist chiefly of soils having a layer that impedes the downward movement of water, soils of moderately fine texture or fine texture, and have a slow rate of water transmission.

Group D - Soils having a very slow infiltration rate (high runoff potential). These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay layer at or near the surface, soils that are shallow over nearly impervious material, and have a very slow rate of water transmission.

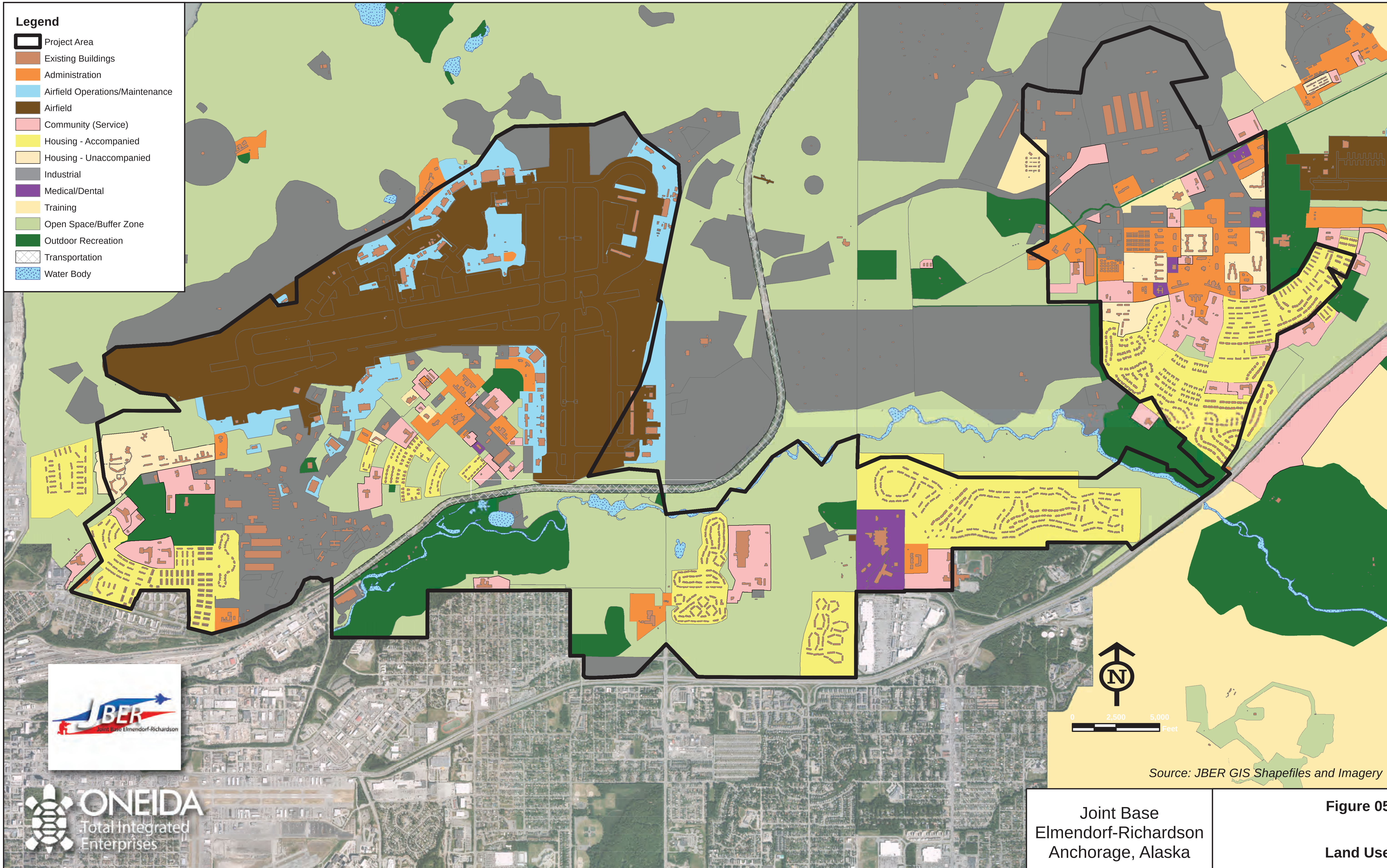
Joint Base
Elmendorf-Richardson
Anchorage, Alaska

Figure 03

Hydrologic Soils Group



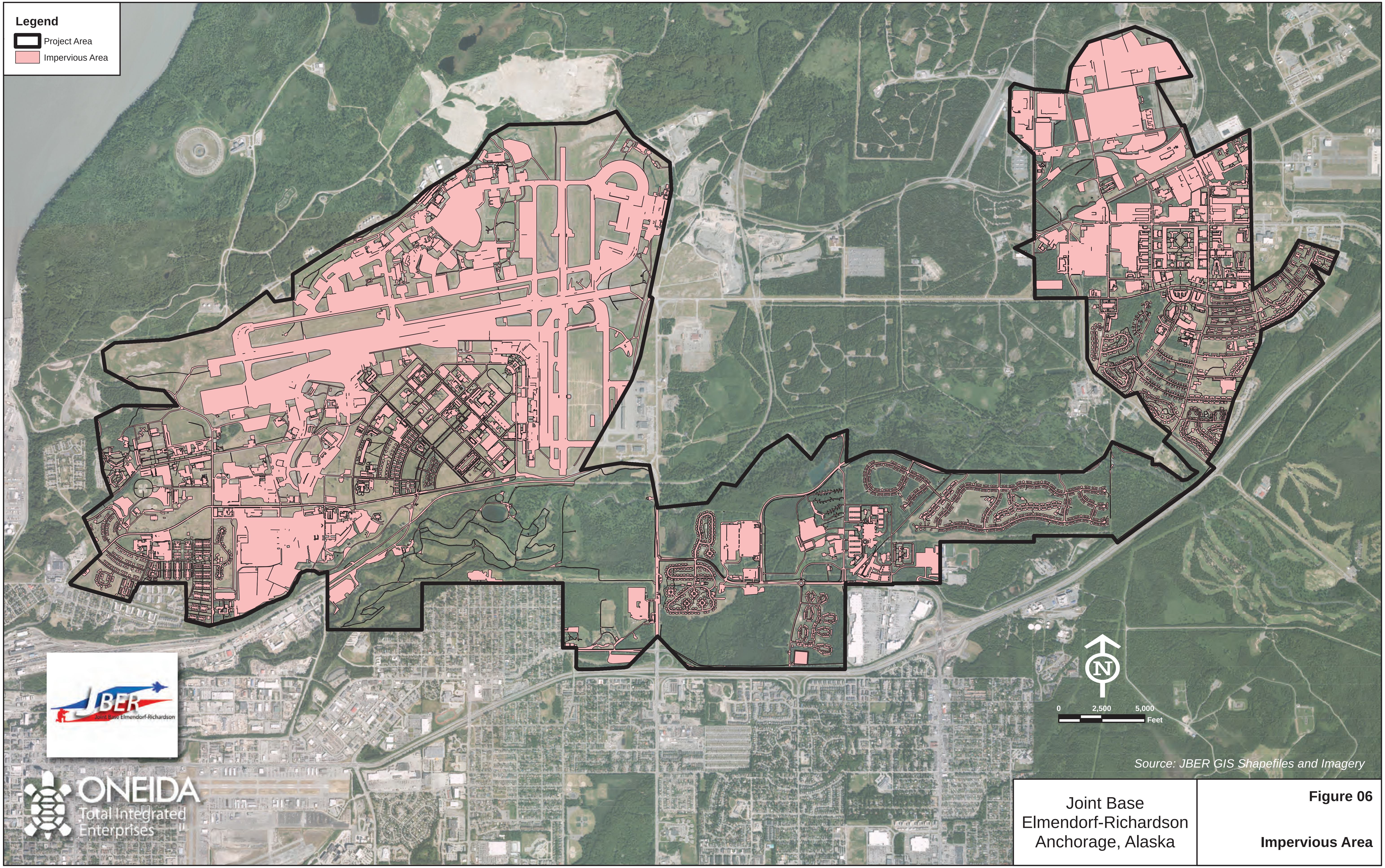
Legend
Stormwater Discharge
Storage Reservoir
Closed Conduits
Open Channels
Detention Storage Areas
Project Area
JBER
Joint Base Elmendorf-Richardson
ONEIDA
Total Integrated Enterprises
N
0
2,500
5,000
Feet
Source: JBER GIS Shapefiles and Imagery
Joint Base
Elmendorf-Richardson
Anchorage, Alaska
Figure 04
Stormwater Routing Map



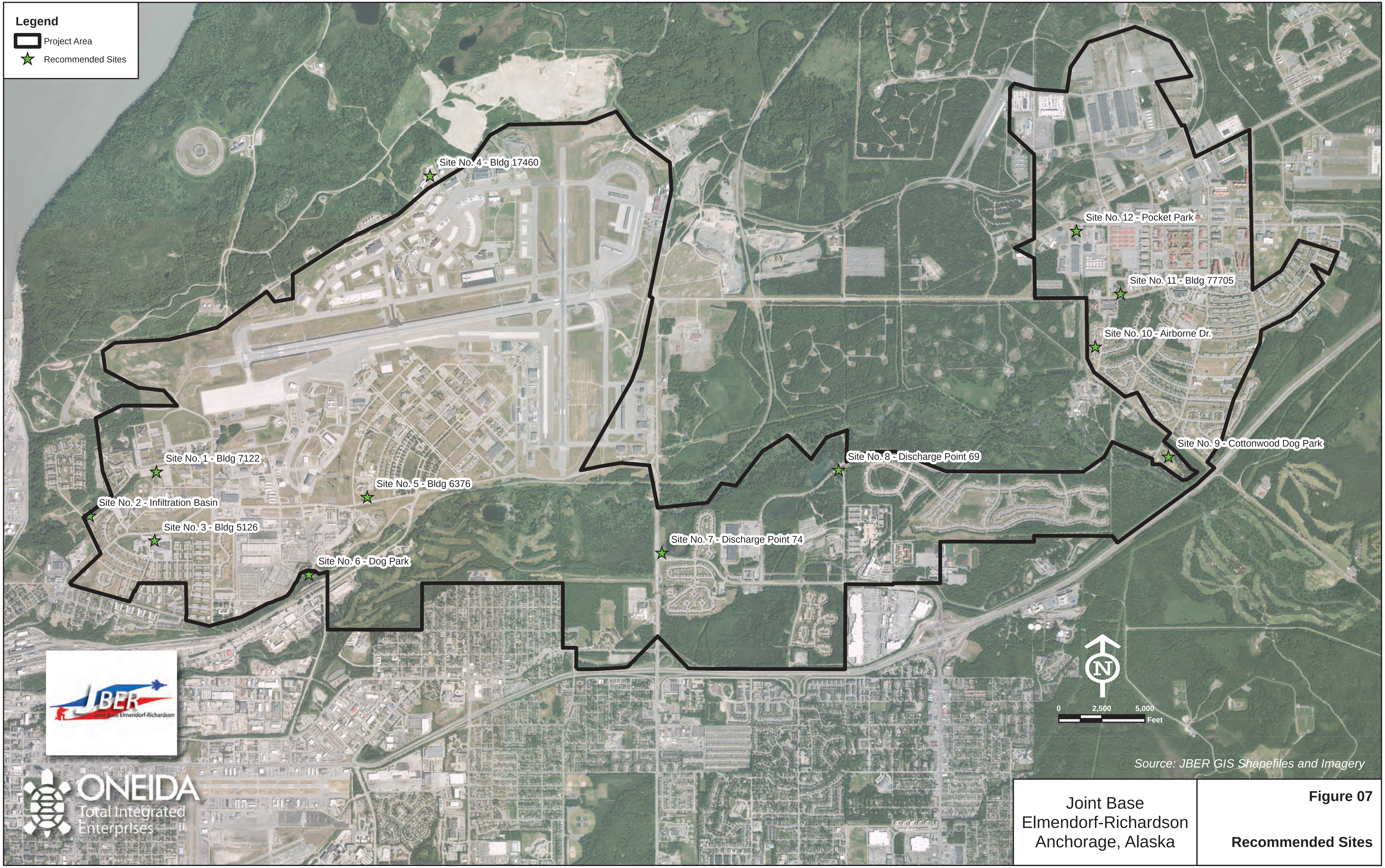
Joint Base Elmendorf-Richardson Anchorage, Alaska

Figure 05

Land Use



Legend
Project Area
Impervious Area
0
2,500
5,000
Feet
N
JBER
Joint Base Elmendorf-Richardson
ONEIDA
Total Integrated Enterprises
Source: JBER GIS Shapefiles and Imagery
Joint Base
Elmendorf-Richardson
Anchorage, Alaska
Figure 06
Impervious Area


Legend
Project Area
Recommended Sites
Site No. 1 - Bldg 7122
Site No. 2 - Infiltration Basin
Site No. 3 - Bldg 5126
Site No. 4 - Bldg 17460
Site No. 5 - Bldg 6376
Site No. 6 - Dog Park
Site No. 7 - Discharge Point 74
Site No. 8 - Discharge Point 69
Site No. 9 - Cottonwood Dog Park
Site No. 10 - Airborne Dr.
Site No. 11 - Bldg 77705
Site No. 12 - Pocket Park
N
0 2,500 5,000 Feet
Source: JBER GIS Shapefiles and Imagery
JBER
Joint Base Elmendorf-Richardson
ONEIDA
Total Integrated Enterprises
Joint Base Elmendorf-Richardson Anchorage, Alaska
Figure 07
Recommended Sites