Right Data, Right Time...

Leveraging Technology in a Team Approach to Runway Resilience

SAME Tri-Regional JETS 26 JUNE 2024

AUT VINCERE AUT MORI

AIR COMBAT COMMAND

LEAD THE WAY

633d CIVIL ENGINEER SQUADRON

GuernseyTingle

ARCHITECTURE | INTERIORS | PLANNING

NGS NuGLOBAL SOLUTIONS science for the next generation

ENGENUITY

COLLIER GEOPHYSICS Surface • Marine • Borehole

GET Solutions, Inc. A Terracon COMPANY

CONNICO

Kimley»Horn Expect More. Experience Better.

Presenters

Erin Stewart
Kimley-Horn

Jorgen Bergstrom
Collier Geophysics

Ryan Hill
Kimley-Horn

Learning Objectives

- Discover the key steps to delivering Airfield Resilience in coastal areas
- Learn how innovation can be achieved with a novel blend of existing techniques and new technology
- Explain how Initial Cost and Life Cycle Cost work together to support Course of Action selection
- Underscore the importance of full Stakeholder Engagement in infrastructure project development

Overview

- Langley History
- Military Resilience
- Identify Problem
- Teaming & Approach
- Technology & Timing
- Findings
- Courses of Action
- Q&A

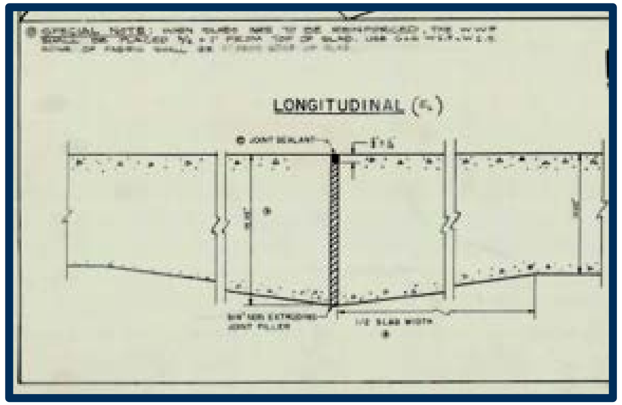
Langley Airfield History

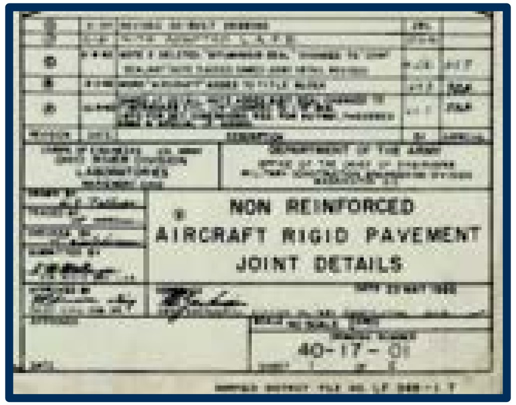
June 9, 1941 *From the Bruno Dall'Ava Collection*

Design aircraft **= B-17**

Built by Army Corps of Engineers

Current runway built ***83 years ago***

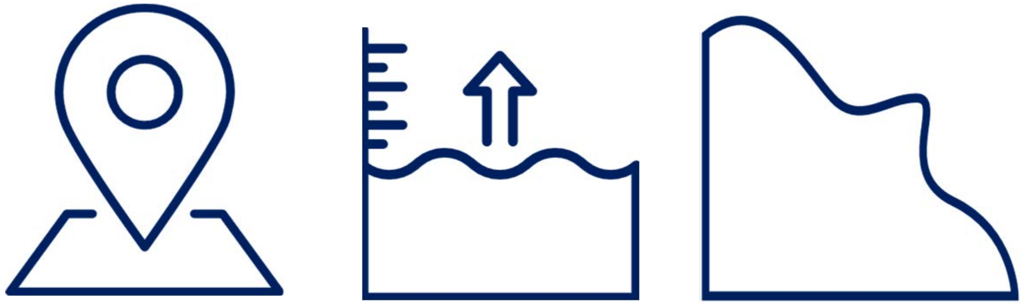




Current Mission and Operations

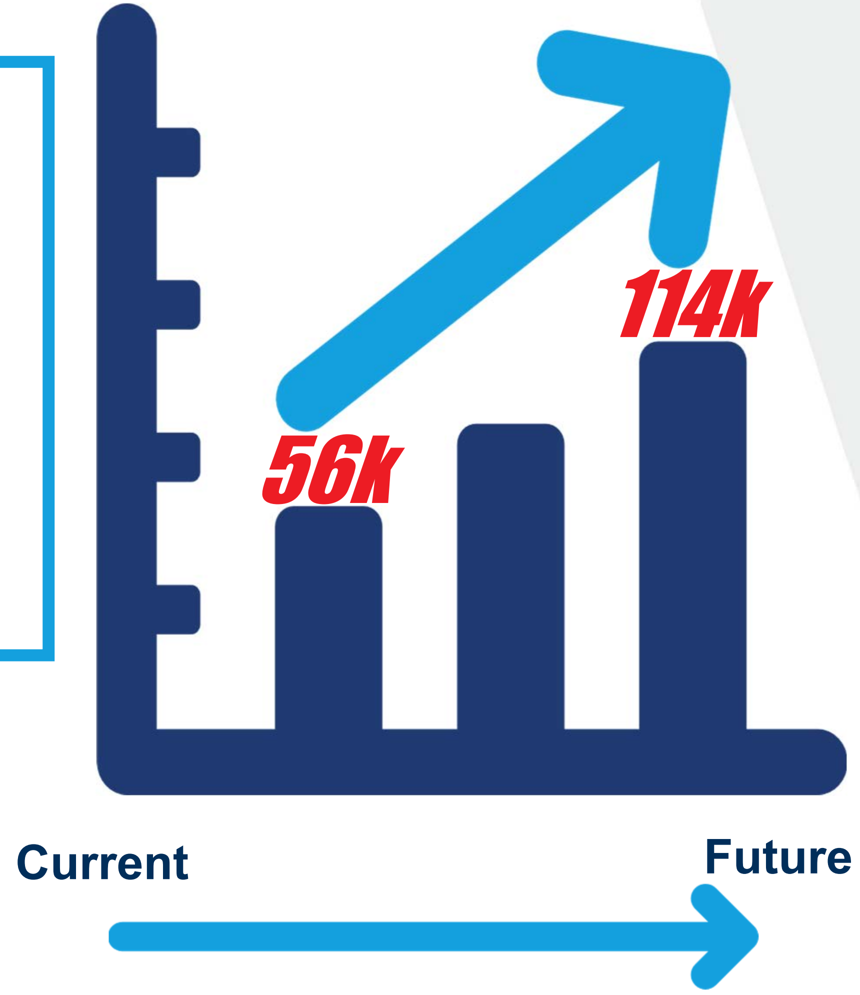
Joint Base Langley - Eustis

Threats/Challenges



Flat Topography | Sea Level Rise | Subsidence

Baseline Annual Airfield Operations



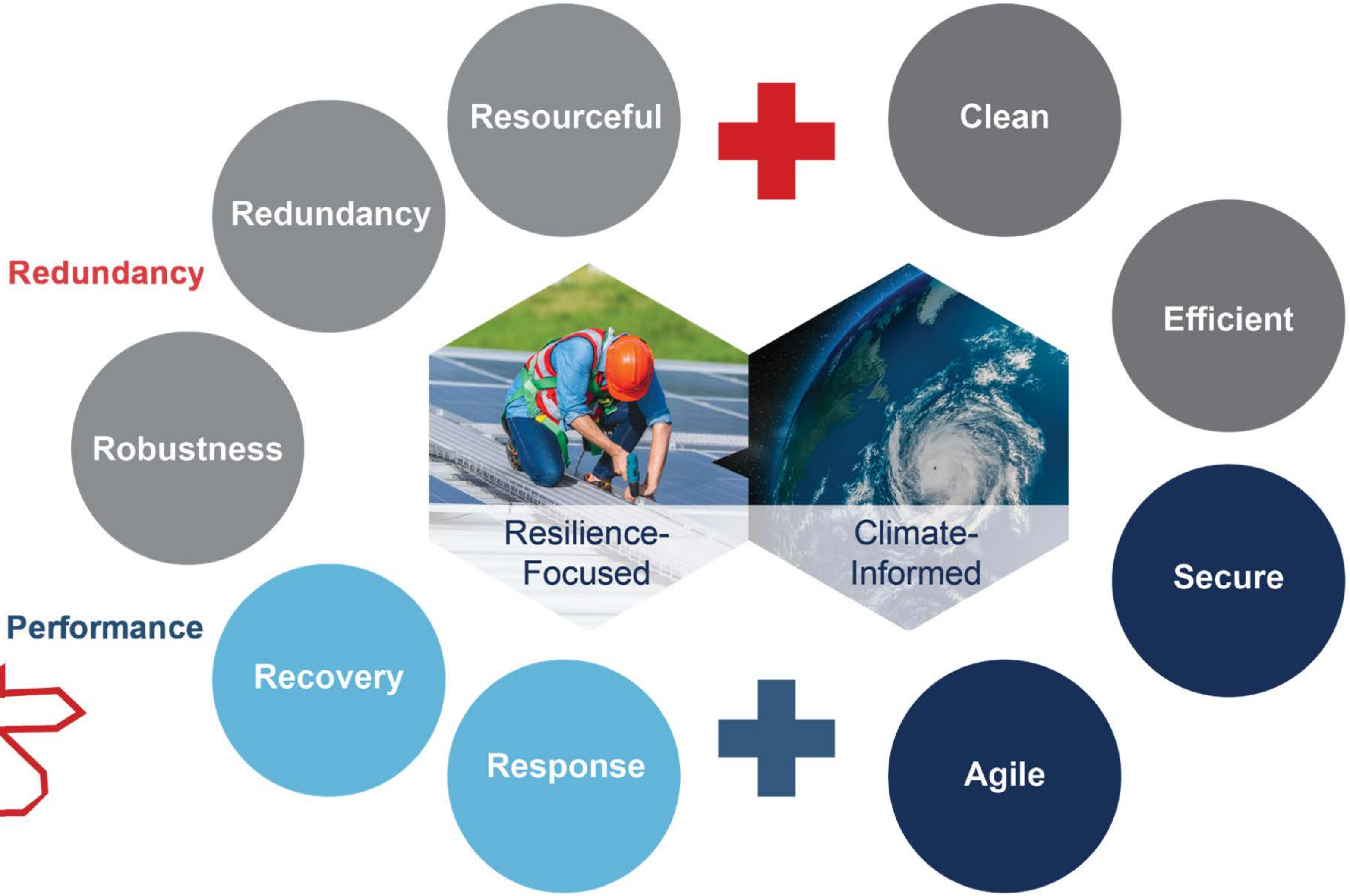
Why do this Project?

Spending **increasing amounts** on runway maintenance

Runway is **degrading faster** than it is being fixed

Need a **long-term plan** to guarantee future combat power projection

Military Installation Resilience



The Problem? Easy as … 1, 2, 3.

Airfield sinking approximately

1”

every 10 years

Water rising approximately

2”

every 10 years

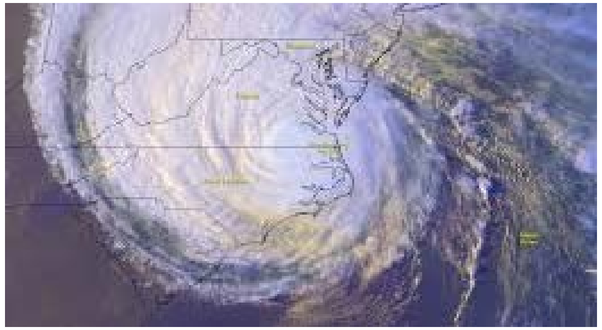
Groundwater is rising approximately

3”

every 10 years

(2-5’ below runway base depending on season)

The Problem



	1933 Unnamed	1999 Floyd	2003 Isabel	2009 Nor'easter	2011 Irene	2012 Sandy	2015 Joaquin	2016 Hermine	2016 Matthew
Water Level (ft)	8.9	6.3	7.9	7.6	7.5	6.9	6.5	6.12	5.78
Storm Wind (mph)	82	55	62	75	85	90	46	65	61
Damage ($)	No Data	No Data	146M*	44M*	1.5M*	40K*	6.5M*	9K*	168K*
Air Field Open	No Data	No Data	4 days	72 hrs	24 hrs	24 hrs	72 hrs	18 hrs	-
Base Open	No Data	No Data	1 Wk	48 hrs	24 hrs	24 hrs	72 hrs	-	-

$198M in damage between 2003 and 2016

Water Level Rise: +4.5 Feet

Current Resilience Status:

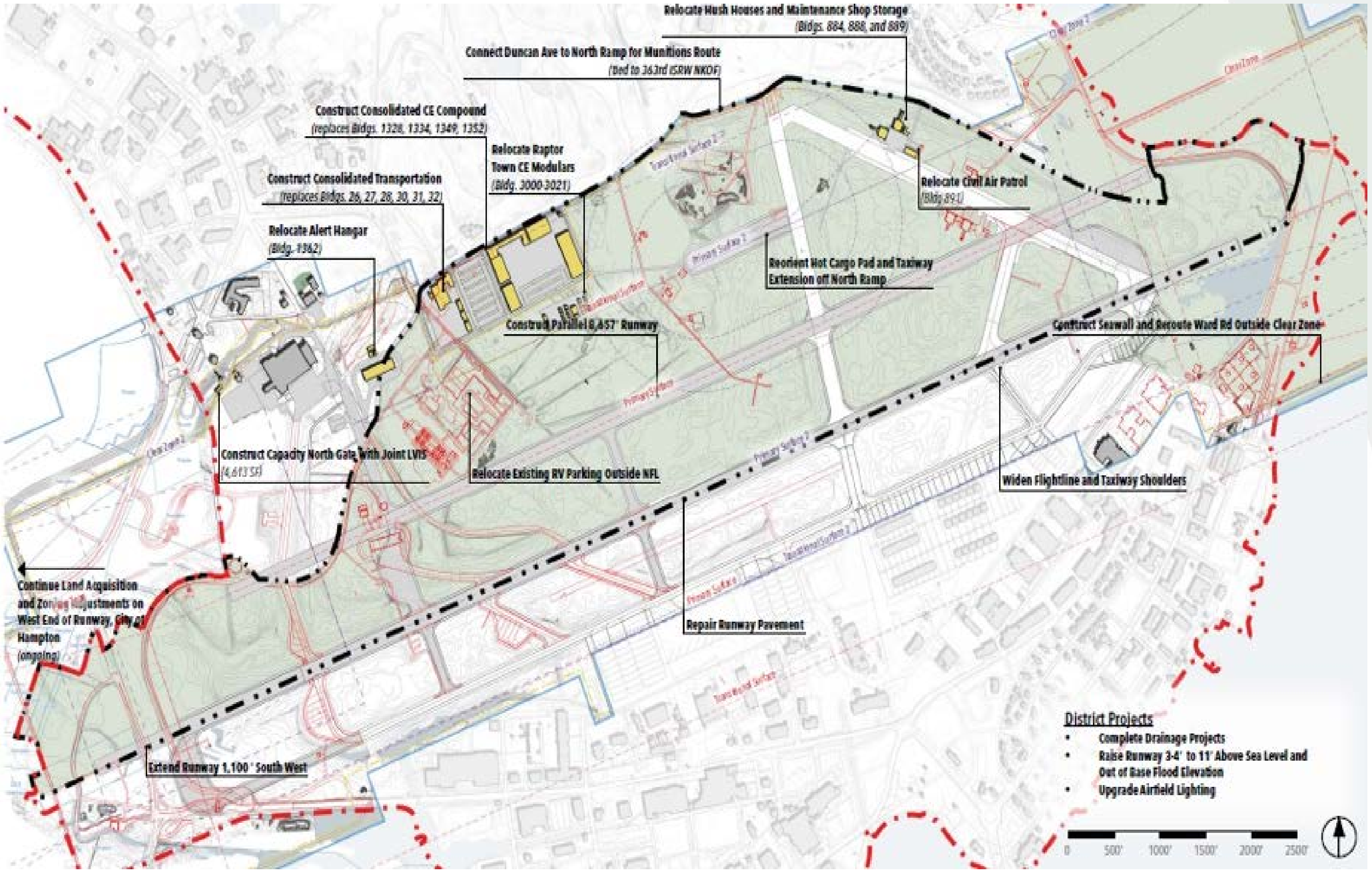
Action Plan

- Climate change mitigation planning ongoing for almost 10 years
- Protections already in place:
  - 85 Best Management Practice Structures
  - 112 Outfalls
  - 124,000 gallon/minute pumping station
  - 2 Miles of Living Shorelines
  - 3 Miles Sea Wall and Rip Rap
  - 5 Adaptively Designed Shoreline Water Barriers
- Protective effect degrades as tides rise, storms surge, and features become damaged and/or become submerged

Current Resilience Status: North Airfield District Master Plan

Graphic Legend

- Installation Boundary
- ADP Boundary
- Demolition
- Planned Facility
- Existing Facility
- Pavement and Sidewalk
- Elevation Contours (6")
- Airfield Imaginary Surfaces & OD Arcs
- Grass
- Trees
- Planned Pavement and Sidewalk
- Planned Fence
- Projects Outside District
- Proposed Airfield Imaginary Surfaces & OD Arcs

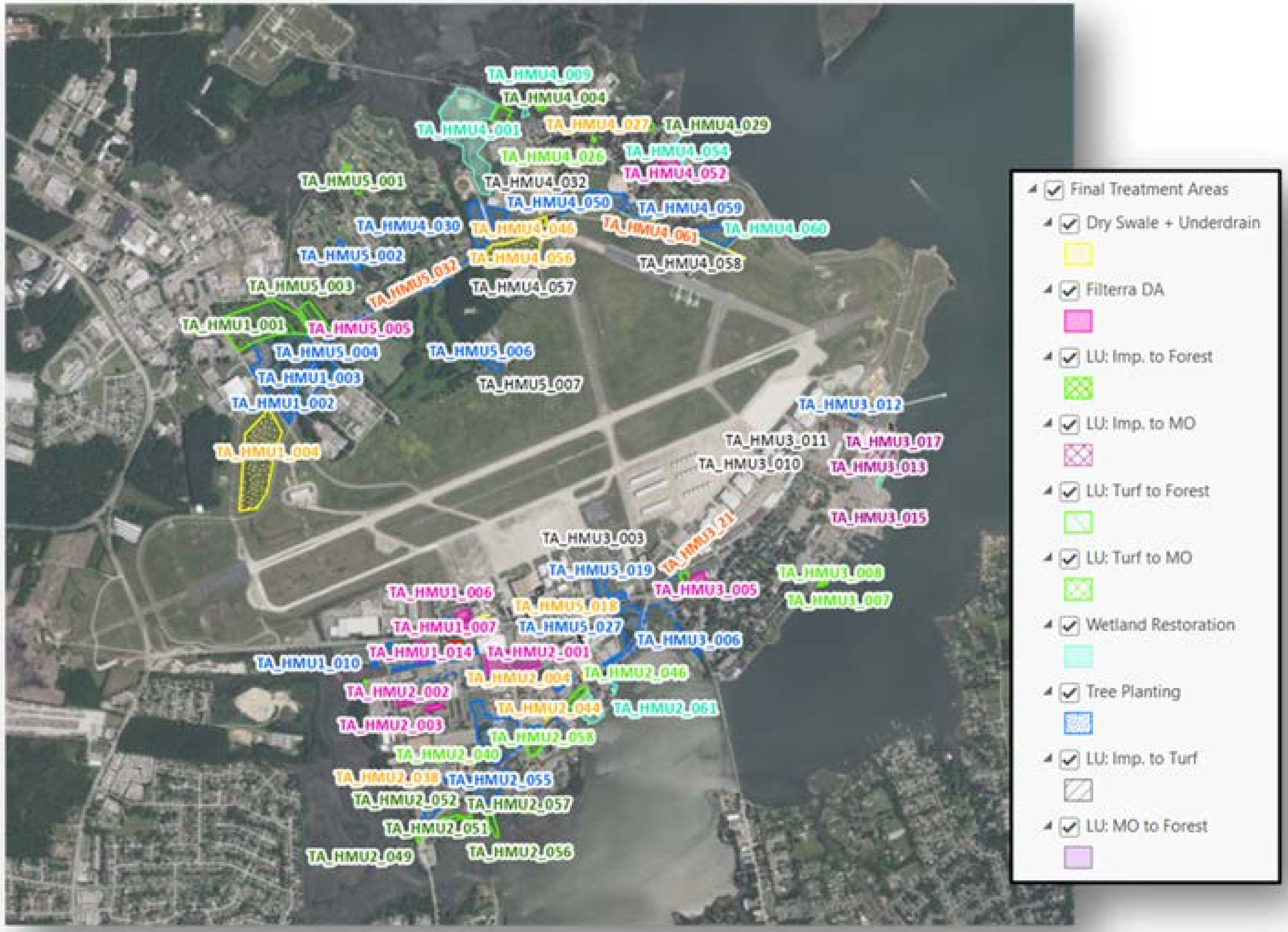


Resilience Status:

Future Plans

202

Stormwater Best Management Practices (BMP) designed, priced, and ready for construction



PROJECT APPROACH

> **"*We advance in specific fields by creating paradigms, which sometimes can make it very difficult to solve a problem within the domain in which it arose — but the problem may be resolved fairly easily within the paradigm of an adjacent domain.*"**

-Thomas Kuhn, *The Structure of Scientific Revolutions*

PROJECT APPROACH

Airfield sinking approximately

1”

every 10 years

Water rising approximately

2”

every 10 years

Groundwater is rising approximately

3”

every 10 years

(2-5’ below runway base depending on season)

PROJECT APPROACH

PROBLEM +	WHERE +	WHAT +	TEAM
	Above	Geospatial Subsidence	
	Around	Stormwater Conveyance Coastal Condition Integration w/ Resilience Plan	
	On	Pavement Surface Condition Repair History	
	In	Pavement Matrix Pavement Strength	
	Under	Geophysics	

+ TEAM

Above

Geospatial Runway Surface Subsidence → E059

Around

Stormwater Conveyance → Kimley-Horn

Coastal Condition → ENGenuity Infrastructure

Integration with Resilience Plan → NuGlobal

On

Pavement Surface Condition + Repairs → AFCEC / 633 CE Squadron

In

Pavement Matrix / Bearing Capacity → GET Solutions

Under

Geophysical Composition → Collier Geophysics

+ APPLICATION

Above

Geospatial Runway Surface Subsidence → E059

*inSAR**

Around

Stormwater Conveyance →
Kimley-Horn

Hydrologic & Hydraulic

Coastal Condition →
ENGenuity Infrastructure

Coastal studies

Integration with Resilience Plan →
NuGlobal

Resilience

On

Pavement Surface Condition + Repairs → AFCEC / 633 CE Squadron

*PCI**

In

Pavement Matrix / Bearing Capacity → GET Solutions

Geotechnical Studies

Under

Geophysical Composition → Collier Geophysics

*FDEM * & GPR**

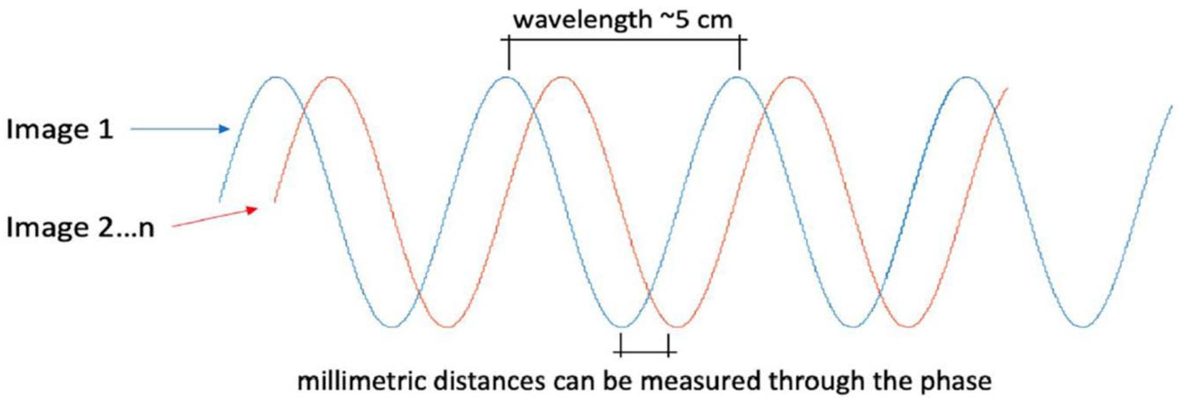
**Additional Info Coming Next…*

Translating Technology	
inSAR	**Interferometric Synthetic Aperture RADAR (inSAR)**
PCI	**2023 Air Force Civil Engineer Center Pavement Condition Index Report**
Field Data	Field Inspection and Repair Records from 633 Civil Engineer Squadron
Geotech	Core Samples from recent design/construction project Test pit data from recent projects
FDEM	**Frequency Domain Electromagnetic (FDEM)**
GPR	**Ground Penetrating RADAR (GPR)**
H&H	**Hydrology & Hydrography** Visual inspection of sheet flow and edge drain condition Capacity review of existing drainage network/model
Coastal Study	Engineering Inspection of coastal areas near airfield

InSAR (Interferometric Synthetic Aperture Radar)

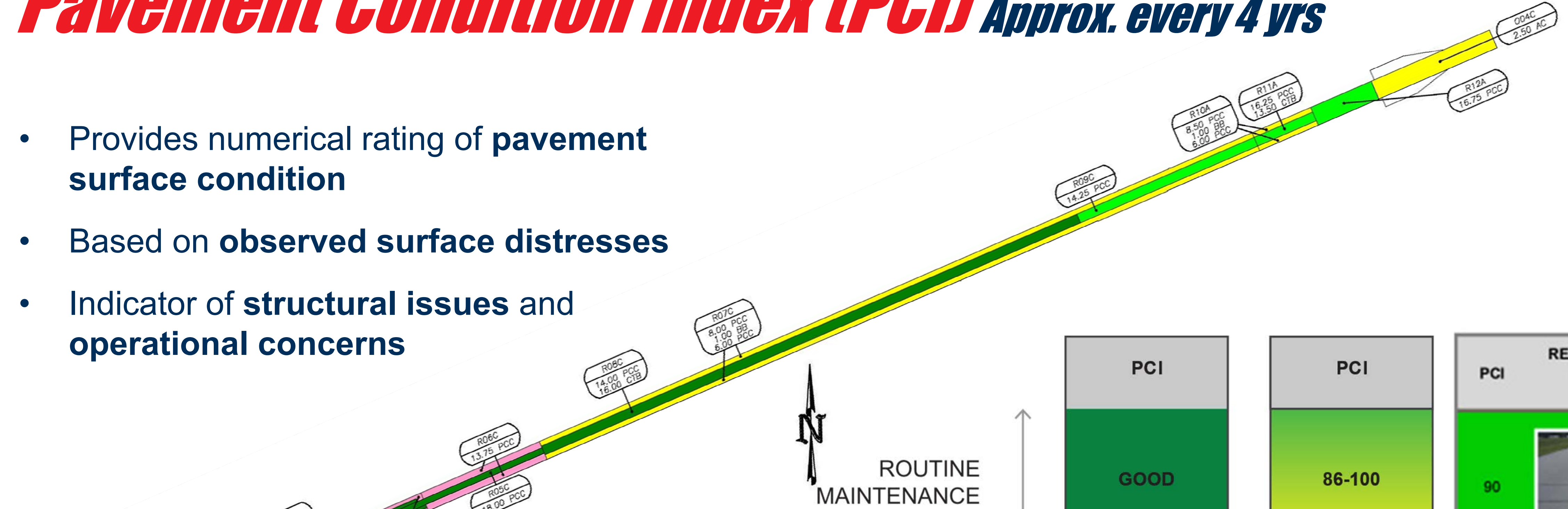
- **Satellite data** can be used to calculate measurements of millimetric **ground movements.**
  - By using long time series, **movements rates** and their **variations over time** can be calculated.

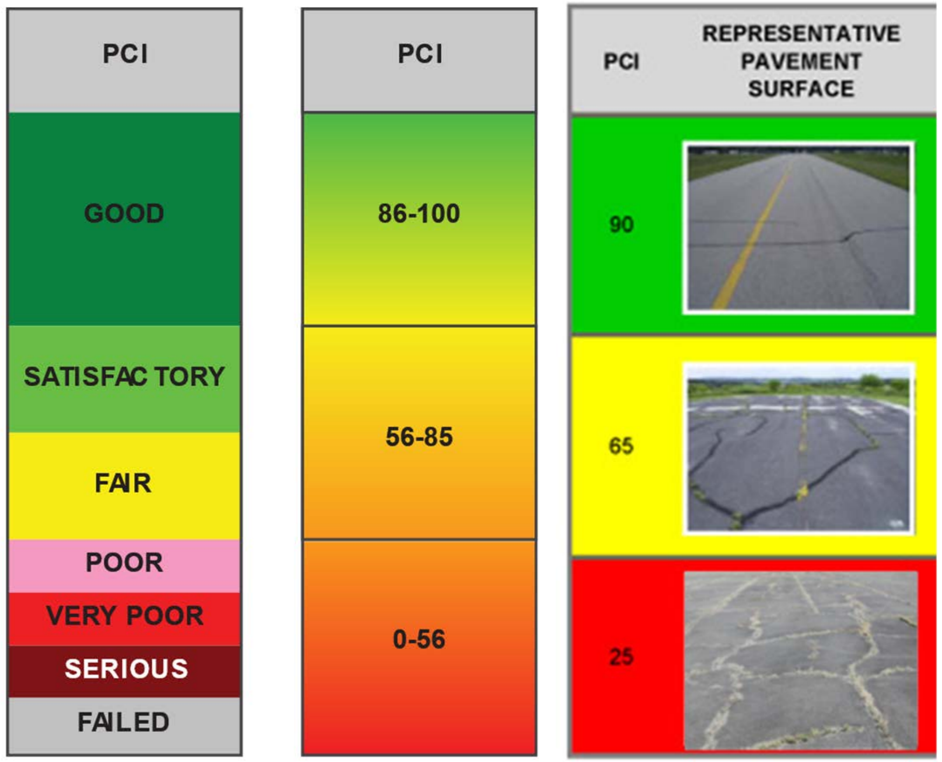
Figure 7 - Geometry of acquisition Ascending orbit in the area of interest.



Pavement Condition Index (PCI) Approx. every 4 yrs

- Provides numerical rating of **pavement surface condition**
- Based on **observed surface distresses**
- Indicator of **structural issues** and **operational concerns**





Frequency Domain Electromagnetic (FDEM)

- Electromagnetic energy directed down and **measures electrical properties of subsurface materials**
- Different materials (sand, silt, clay, water…) have different electrical characteristics

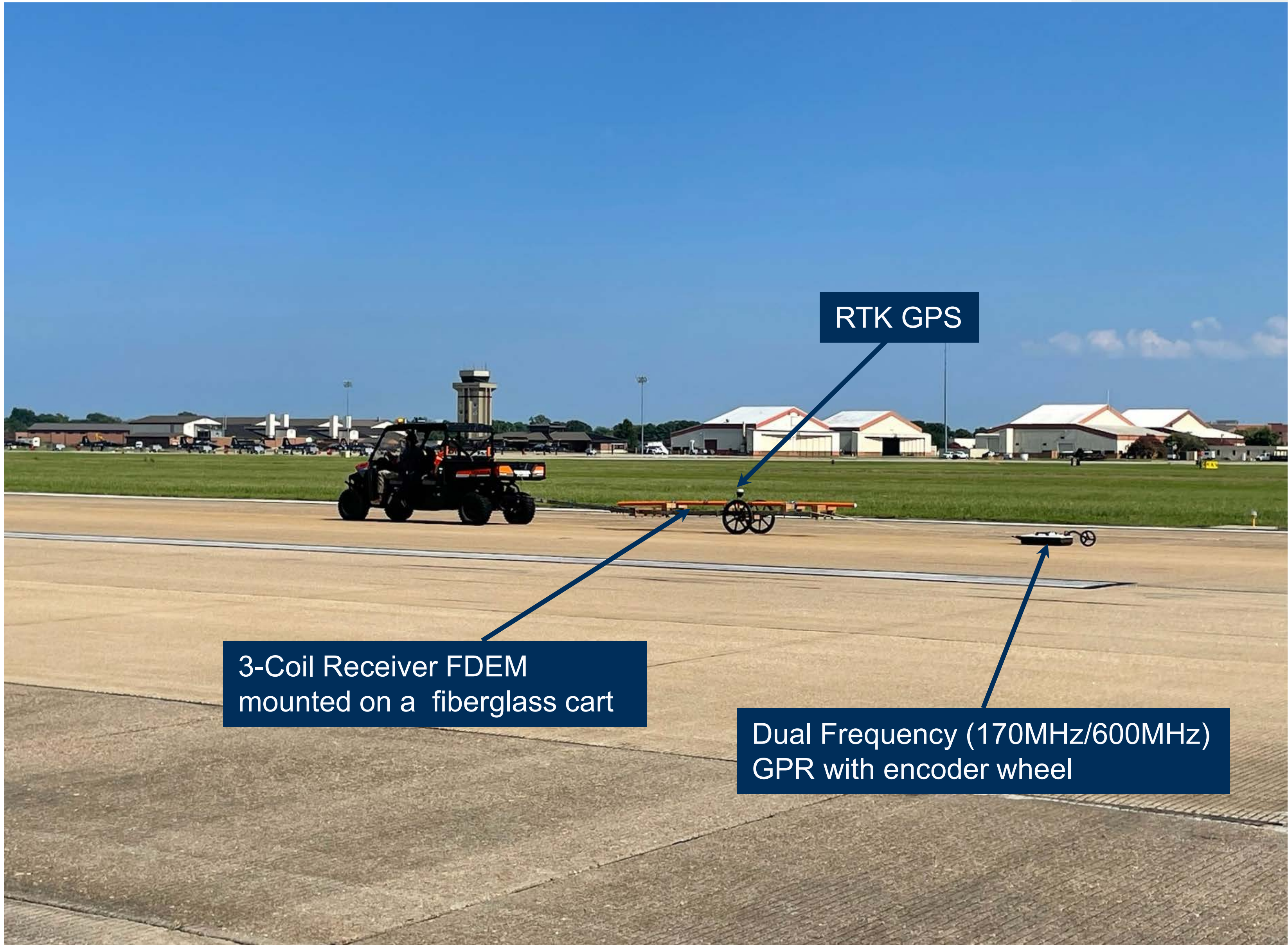
- Technology allows:
  - In-situ measurements of bulk ground conductivity and magnetic susceptibility
  - Can measure properties at **multiple depths**

Ground Penetrating Radar (GPR)

- GPR sends and receives high-frequency (10MHz-2,500MHz) electromagnetic waves to **detect buried objects** or structures
- Technology allows:
  - The detection of **metallic and non-metallic objects** as well as geologic boundaries, and **voids.**
  - Good estimation of depth to targets

FDEM and GPR Data Collection

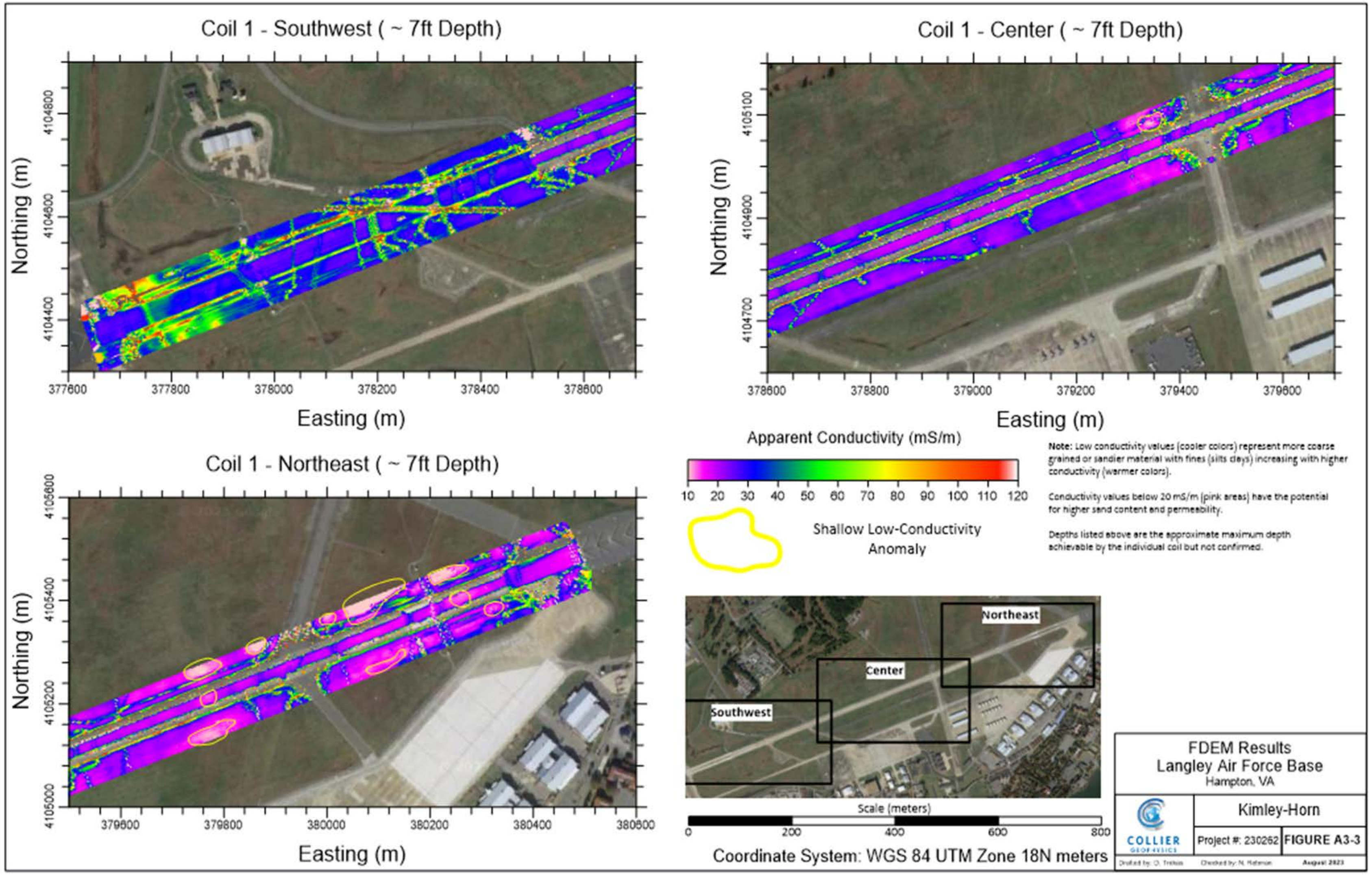
- FDEM and GPR Data collected with:
  - 5-foot profile spacing on the runway
  - 10-foot profile spacing in the wings



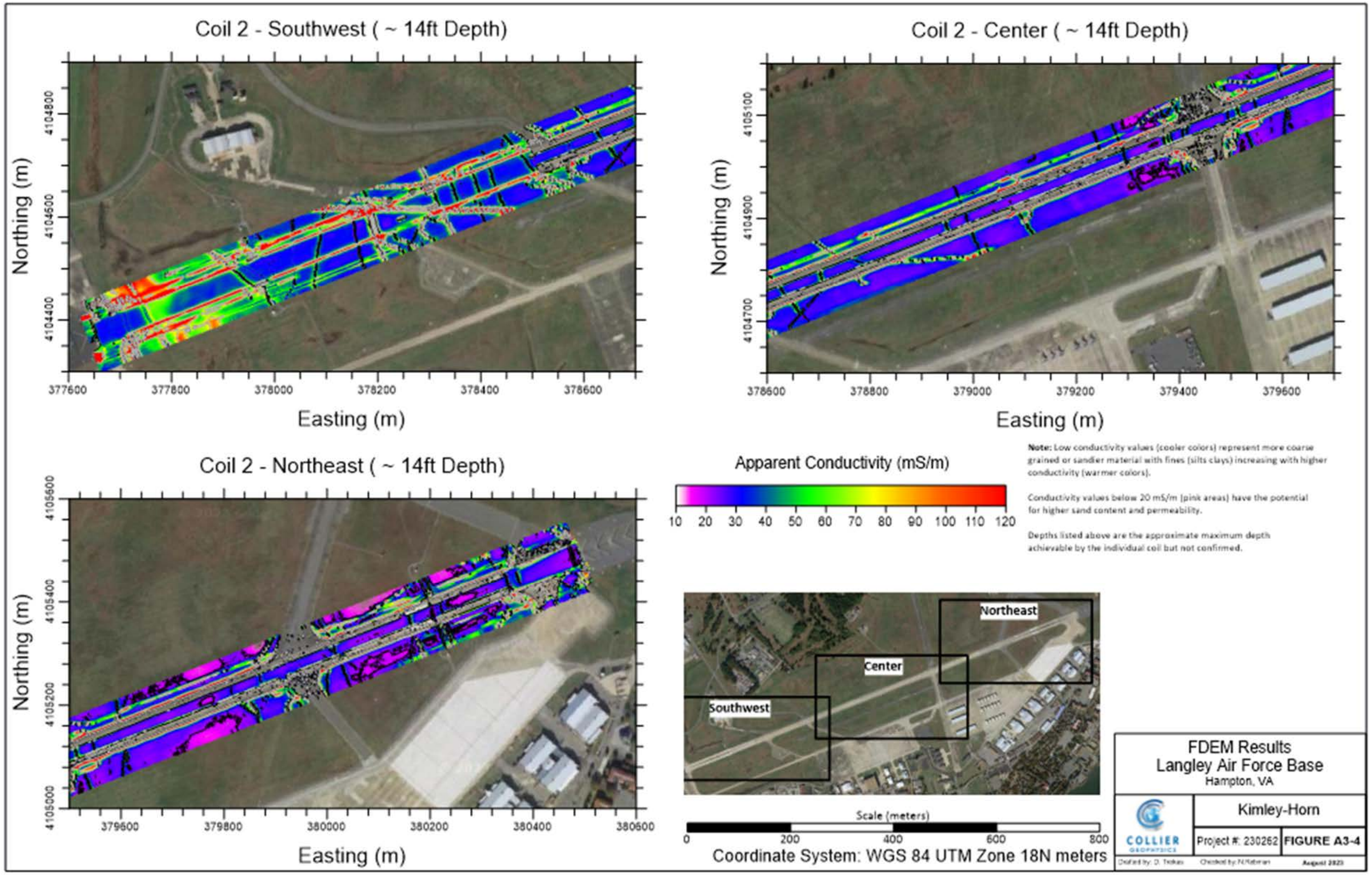
InSAR Results

- Subsidence = yellow/red “hot spots”
- Larger deformations @ R/W ends
- Largest subsidence nearest water
- This was a “quick look” study
- More detail can be made available during runway repair design phase

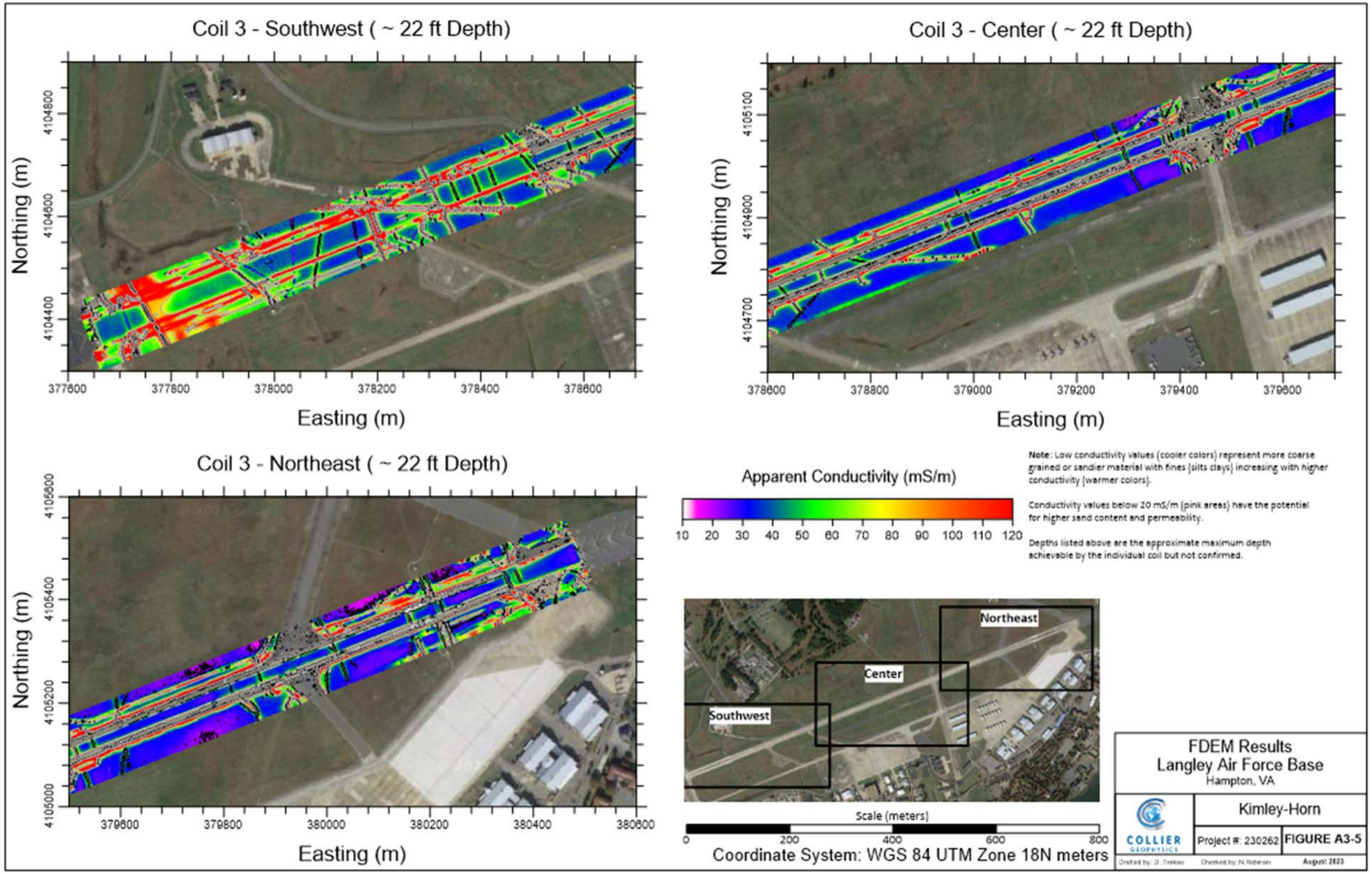
FDEM Results – Conductivity Shallow Sensor



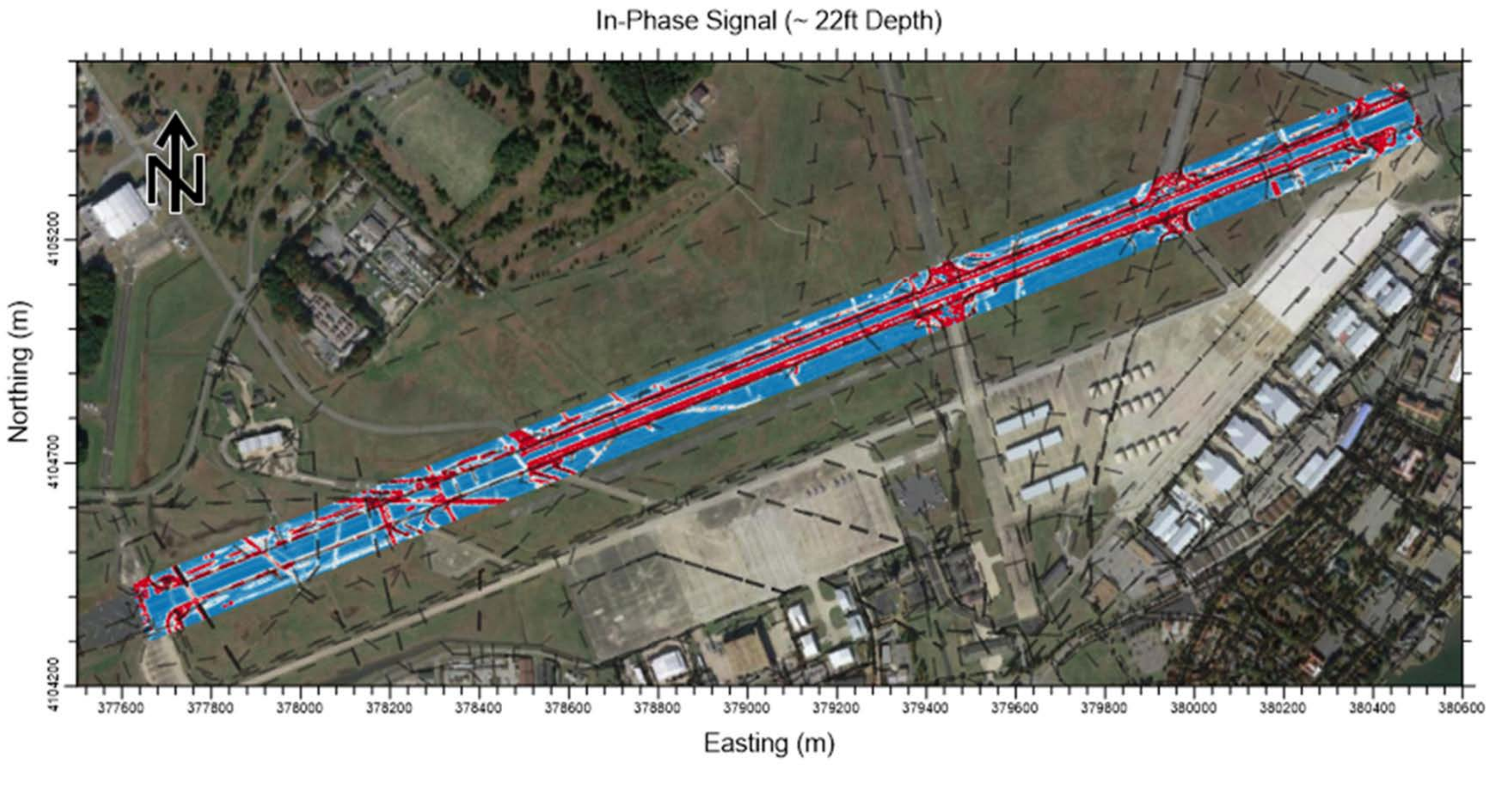
FDEM Results – Conductivity Mid Sensor



FDEM Results – Conductivity Deep Sensor



FDEM Results – In-Phase Deep Sensor



Note: Low conductivity values (cooler colors) represent more coarse grained or sandier material with fines (silts clays) increasing with higher conductivity (warmer colors).

Linear red features represent utilities and infrastructure.

Depth listed above are the approximate maximum depth achievable by the individual coil but not confirmed.

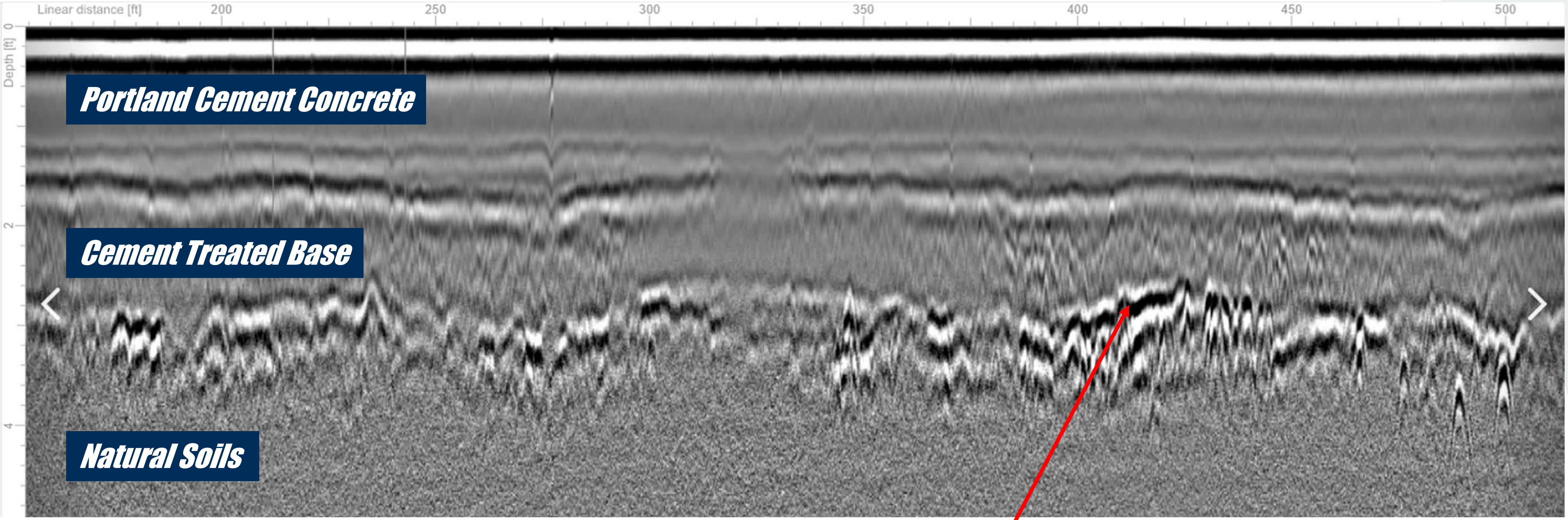
In-Phase FDEM Results
Langley Air Force Base
Hampton, VA

Kimley-Horn

COLLIER

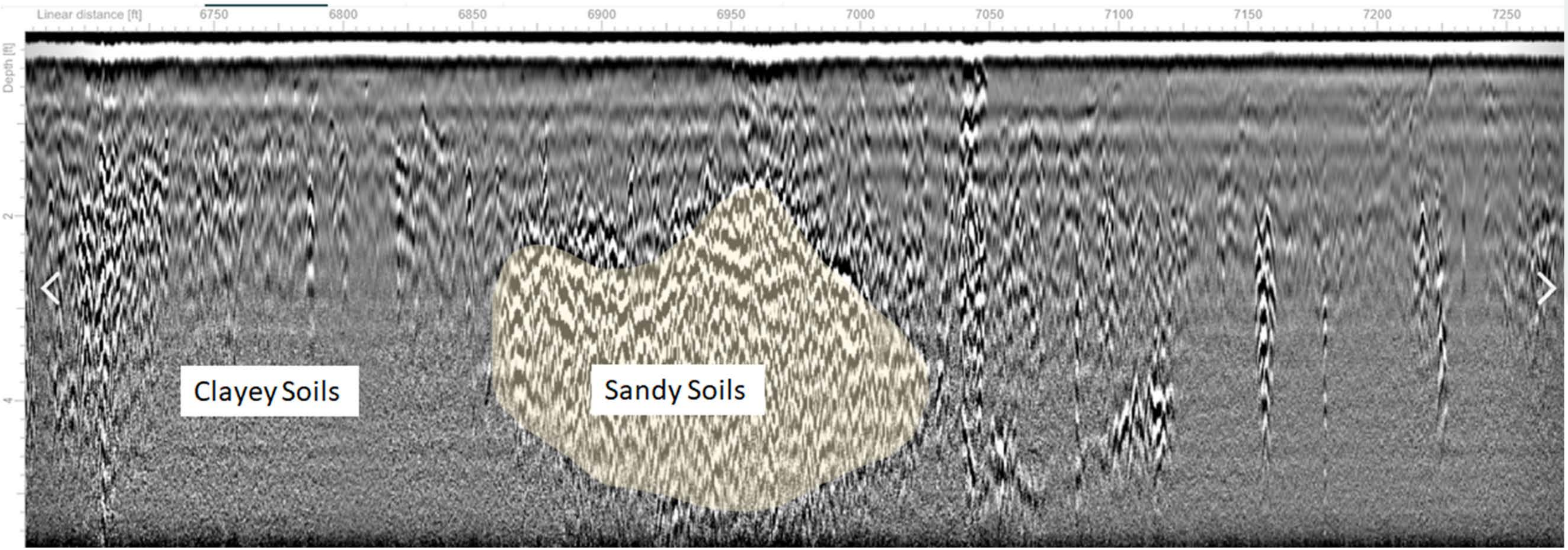
Project #: 230262 | Figure A3-6

GPR Data Example (600MHz Data)

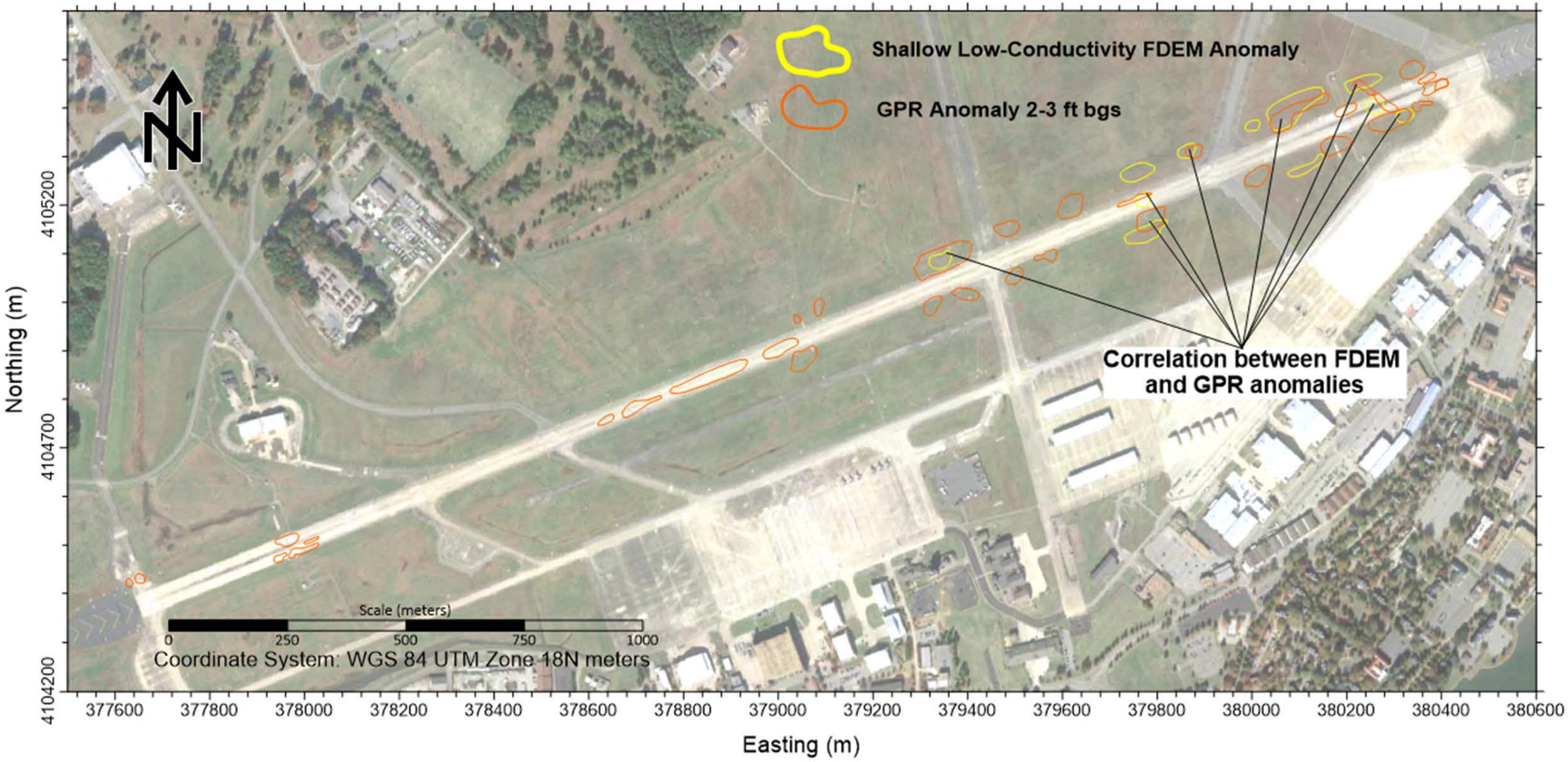


High amplitude reflections from this interface could be caused by sandier materials containing more water

GPR Data Example (600MHz Data) - Outside Runway

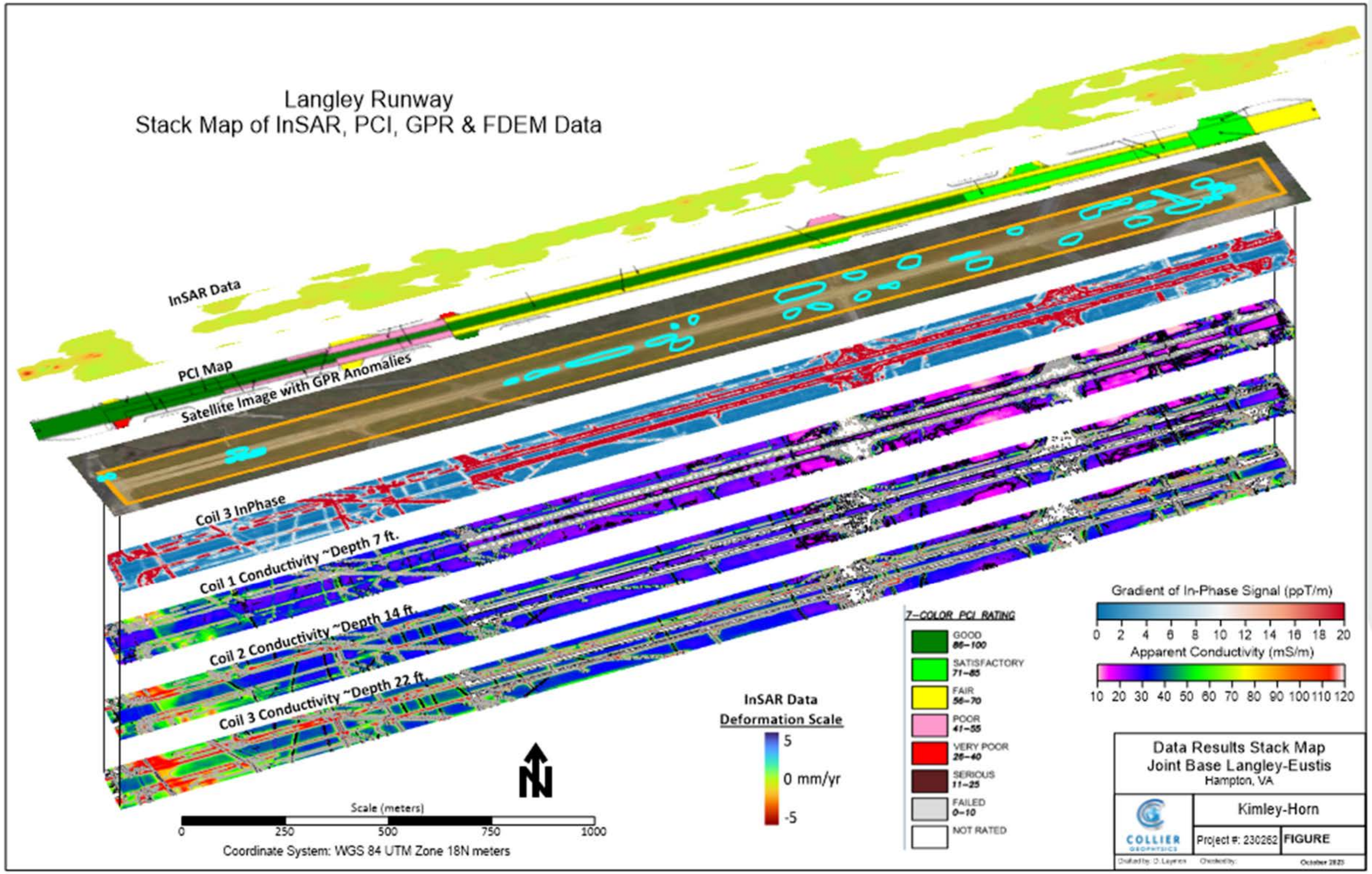


GPR and FDEM Anomaly Comparison



Findings: Viewing the Patient's "MRI"

- Taking all our research material and stacking it, we get a multi-method/multi-parameter "MRI" of the runway:
  - Pavement Condition Index
  - Subsidence
  - GPR Anomalies
  - FDEM Inphase
  - FDEM @ Appr. 7'
  - FDEM @ Appr. 14'
  - FDEM @ Appr. 22'



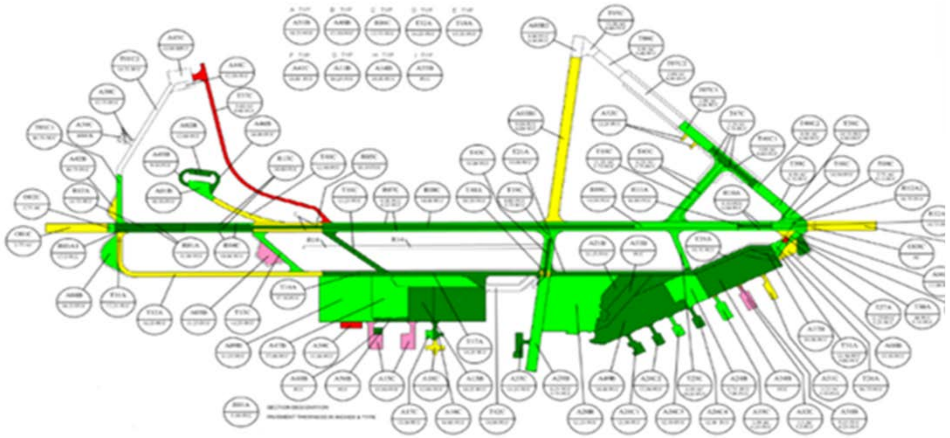
Findings:

Geophysical:

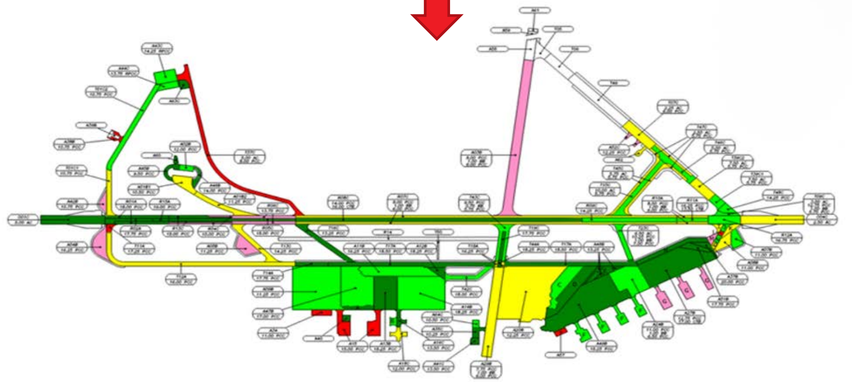
- No **significant internal issues** found in the concrete runway or the cement treated base
- Soil composition **varies greatly**.
- Sandier and higher water content soils appear to be more prevalent in the **eastern portion** of the runway.
- Sandier soils **may erode easier** and thereby **accelerate subsidence.**
- Not a focus of this investigation → **unknown utilities** were discovered below the runway

Findings:

- Runway concrete is **structurally sound**
- **Surface deterioration** rate is increasing
  - *See 2019 to 2023 comparison*
- **Deferred maintenance has compromised runway layers**
  - Stormwater + Storm surge + Ground water
- Continued water rise and subsidence will **accelerate deterioration**
- Repairs must establish
  - A **“tight roof”** (runway surface)
  - A **“dry basement”** (move water from base layers)



2019



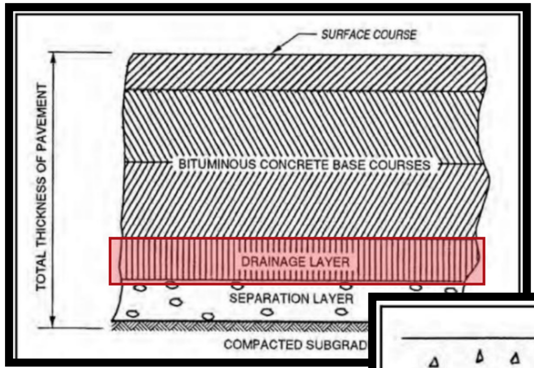
2023

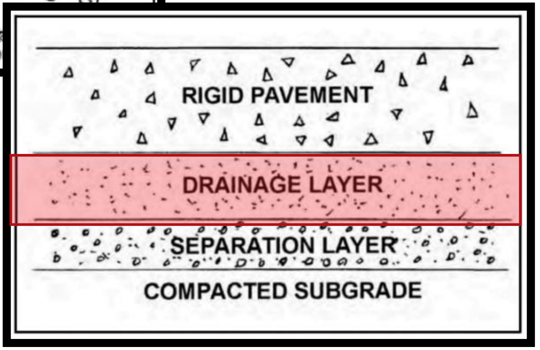
7-Color PCI by Section
- Good 86-100
- Satisfactory 71-85
- Fair 56-70
- Poor 41-55
- Very Poor 26-40
- Serious 11-25
- Failed 0-10
- Not Rated

Findings:

Achieving a "tight roof & dry basement"

- Stay above rising groundwater
  - **Raise runway elevation**
- Improve surface drainage
  - Provide proper **runway profile**
- Create a sub-surface drainage path for water
  - Add **drainage layer**
- Minimize effect of flooding
  - **Harden the airfield** against storm surge
- Defend from tidal influences
  - Utilize **gate valves and pumps**





Courses of Action (COAs)

COA Variables

- Sustain/Maintain/Modernize
- New location/Keep location
- Move North/Move West
- Asphalt/Concrete/Combo
- Same/New pavement section
- Same or higher elevation
- Cost / Schedule / Phasing

COA #	DESCRIPTION
0	CONTINUE ANNUAL MAINTENACE
1	REHABILITATE WITH NEW SHOULDERS
2	CONSTRUCT NORTH PARALLEL RUNWAY
3	UNBONDED CONCRETE OVERLAY
4	ASPHALT CONCRETE OVERLAY
5	RAISE RUNWAY IN PLACE (CONCRETE)
6	RAISE RUNWAY IN PLACE (ASPHALT)
7	RELOCATE RUNWAY TO WEST
8	RAISE RUNWAY AND RELOCATE WEST

HR0

COAs: Taking it to the Bank

It is DoD policy on large scale projects to consider just First cost, but also Life Cycle Cost (LCCA). Here's how our COAs stacked up:

COA #	DESCRIPTION	INITIAL COST	LCCA
0	CONTINUE ANNUAL MAINTENACE	$2M/YR-$4M/YR	$257M - $258M
1	REHABILITATE WITH NEW SHOULDERS	$38M - $42M	**$316M - $320M**
2	CONSTRUCT NORTH PARALLEL RUNWAY	$254M - $280M	**$446M - $472M**
3	UNBONDED CONCRETE OVERLAY	$97M - $107M	**$332M - $342M**
4	ASPHALT CONCRETE OVERLAY	$87M - $96M	**$328M - $337M**
5	RAISE RUNWAY IN PLACE (CONCRETE)	$252M - $278M	$257M - $283M
6	RAISE RUNWAY IN PLACE (ASPHALT)	$239M - $263M	$258M - $282M
7	RELOCATE RUNWAY TO WEST	$216M - $238M	$224M - $246M
8	RAISE RUNWAY AND RELOCATE WEST	$237M - $261M	$243M - $267M

Slide 39

HR0 part of the value of this is convincing senior leaders that this is a requirement.

The unrealized cost (hidden but actual) - TDY, mission

mission cost + COA cost.

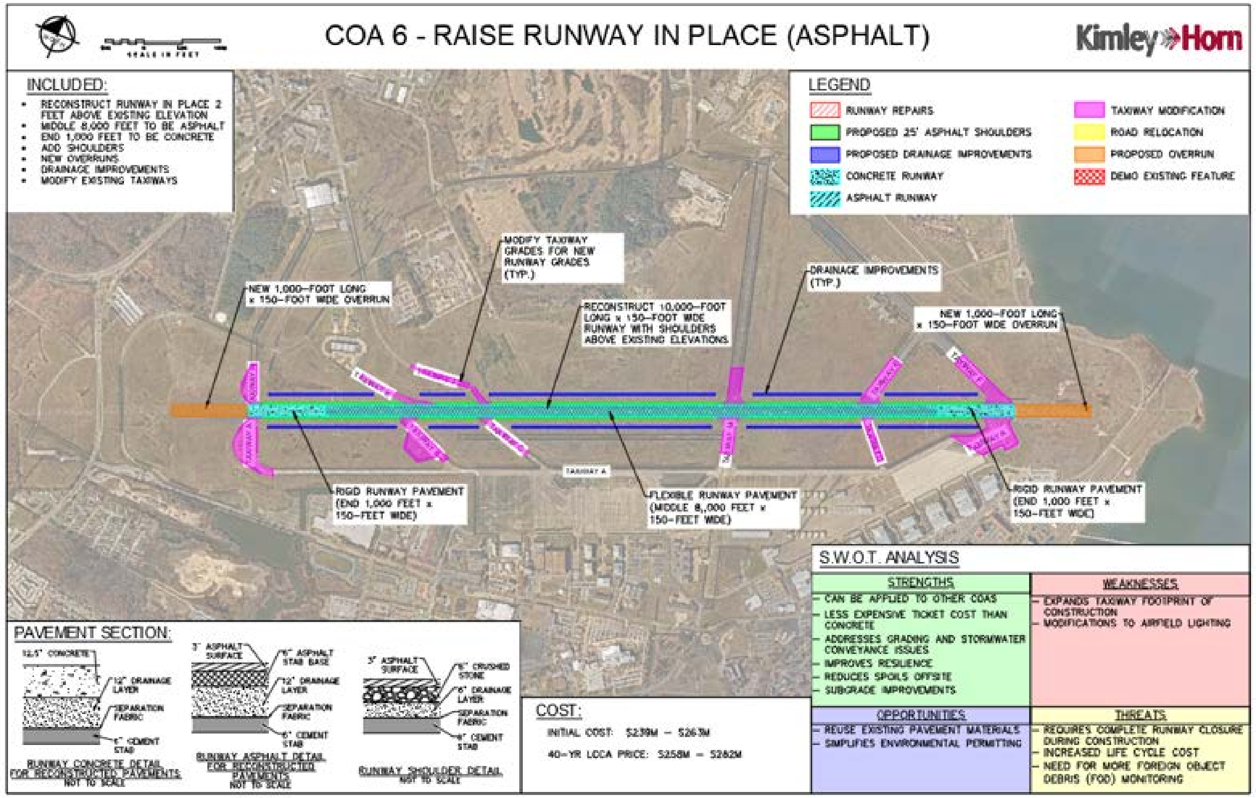
make sure to highlight flooding

proving that you need this is
Hill, Ryan, 2024-06-07T21:22:21.452

COAs: And Stakeholders Chose…

COA 6

- Keep runway location
- Rubblize existing runway
- Raise r/w elevation 24”
  - Improves surface drainage
  - Elevates above ground water for 50 years
- Create drainage layer
- Touchdowns = 1,000’ concrete
- Center = 8,000’ asphalt
- First cost $240-260M
- Phased construction
  - Full closure for center phase



Summary and Takeaways:

- Remember this is about ***launching combat jets***...
- Resilience should be a ***design metric*** and part of the ***Master Plan***
- The runway must be at the ***center*** of the master plan
- Use concept plans / feasibility studies ***BEFORE*** the planning charrette
- Life Cycle Cost will support (or sink) a COA...work hard on ***assumptions***
- Embrace new ***technology*** – but Engineers must ***lead the way***
- Work hard on an excellent one-page ***Executive Summary***

Let’s Make This Happen!

Q&A

The Team

Name	Affiliation	Project Role	Contact
Air Force (Partial List of Many More Stakeholders…)			
Bob Barrett	Engineer Flight Chief	Senior Executive	robert.barrett@us.af.mil
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