Nome Airport Rehabilitation

UAF ASCE Presentation

Project Team/Presenters

<u>Owner:</u>
Alaska Department of Transportation

<u>Design Consultant:</u>
R&M Consultants, Inc.

Brian Mullen, PE – *Project Geotechnical Engineer*

Matt Majoros, PE – *Project Civil Engineer*

Purpose and Need

Issue

The Nome Airport Runways were experiencing intermittent cracking and uneven settlement. This was due to continued thawing and consolidation of unstable foundation soils.

Objective

Rehabilitate both runways and design a long-term (20-year) solution to address settlement at the west end of RW 10-28.

History

R&M designed the Nome Airport Operating Settlement Repair (OME OSR, Stage I) project, which repaired five isolated settlement areas along the runway

R&M Work Synopsis

Performed

- Geotechnical investigation
- Design engineering
- Assistance during construction

Prepared

- Geotechnical recommendations
- Engineer's design report
- Construction safety and phasing plan
- Erosion and sediment control plan
- Plans specifications & estimate

Location surveyed in 2017

Advertised for bids July 2020

Construction began in 2021

Construction completed in 2022

Runways

RW 10-28

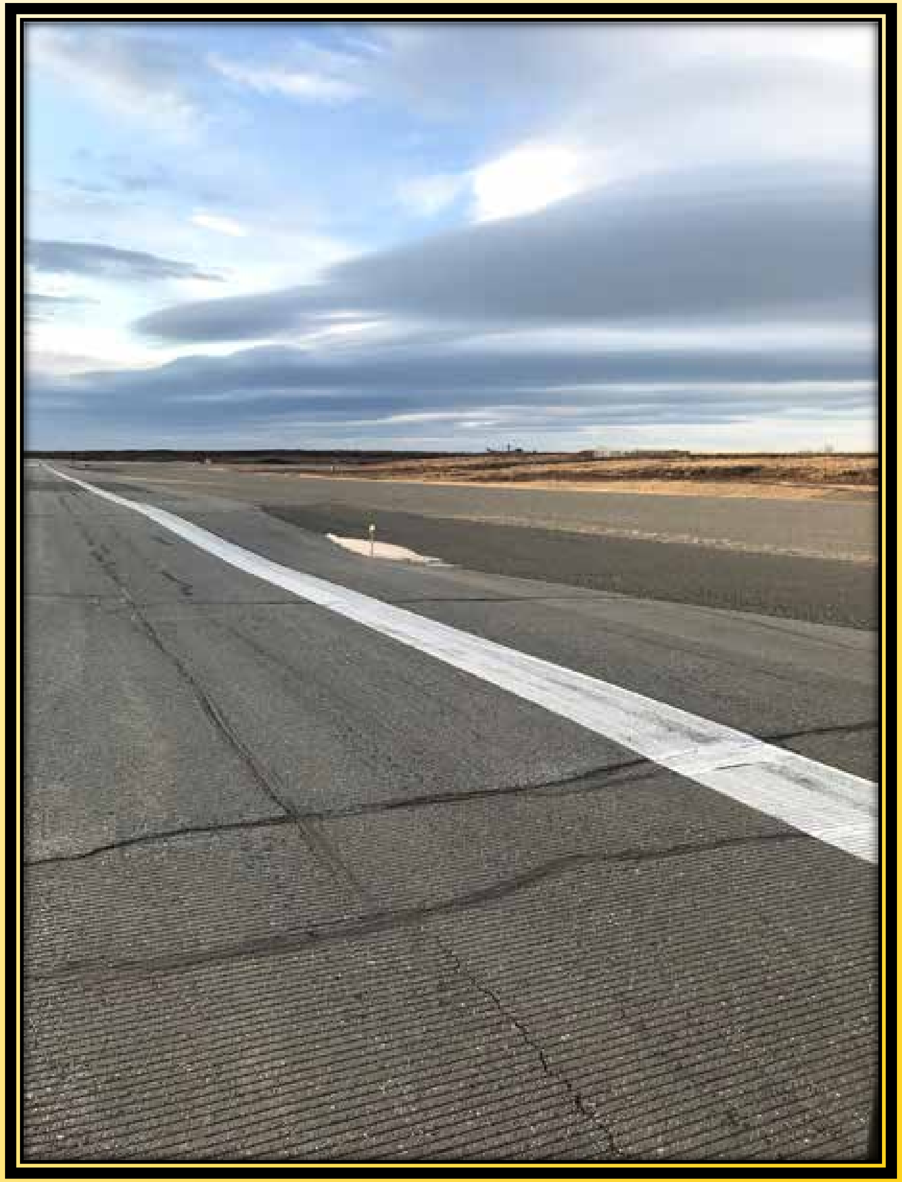
- Main runway (East-West)
- 6,009’ long x 150’ wide
- 25’ wide paved shoulder

RW 3-21

- Crosswind runway (North-South)
- 6,176’ long x 150’ wide
- Widened to 25’ paved shoulder
- Displaced threshold

Pre-Repair Photos : RW

Main runway depression & ponding



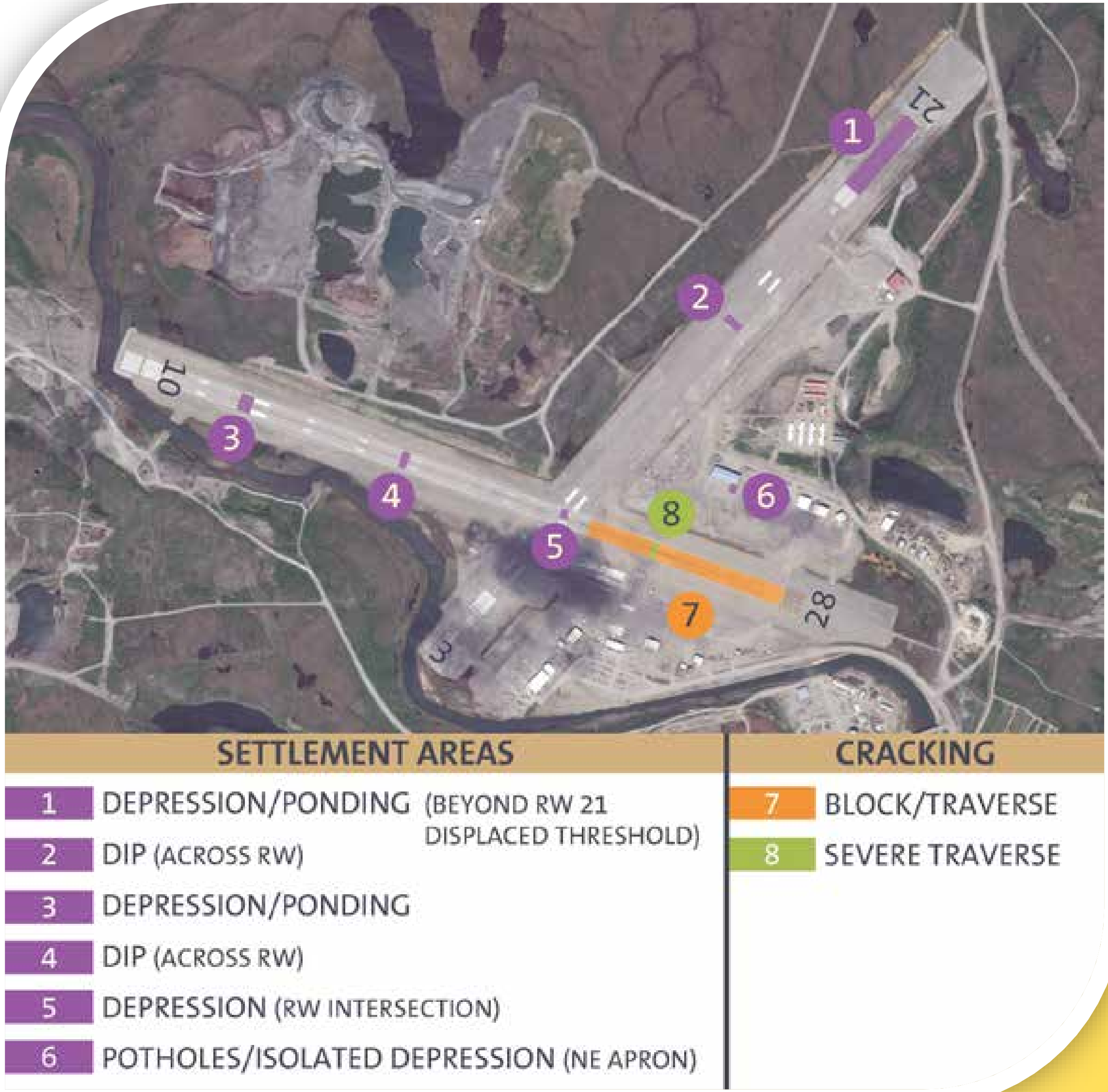
Crosswind runway dips in shoulder

Pre-Repair Photos : Apron/Cracks

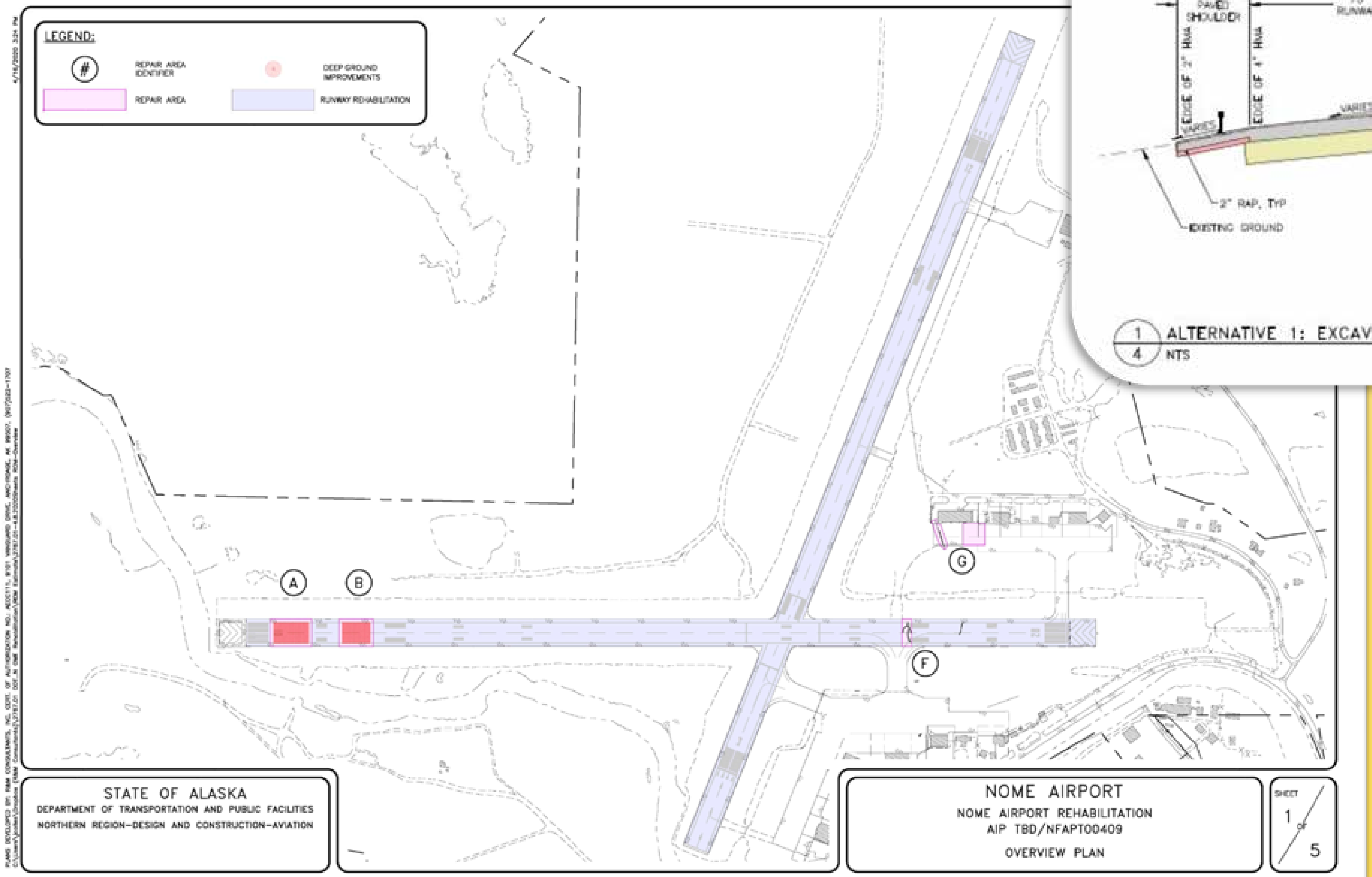
Main runway transverse crack

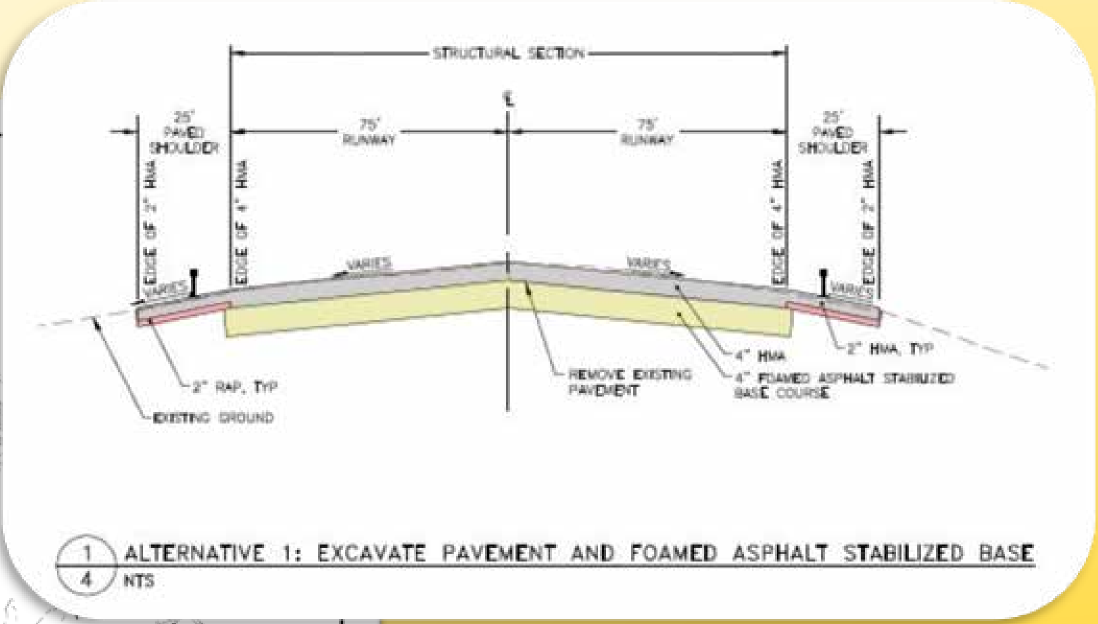
Apron depression & ponding

Distress Areas (from OSR, Stage 1)



Scope – Nome Airport Rehabilitation



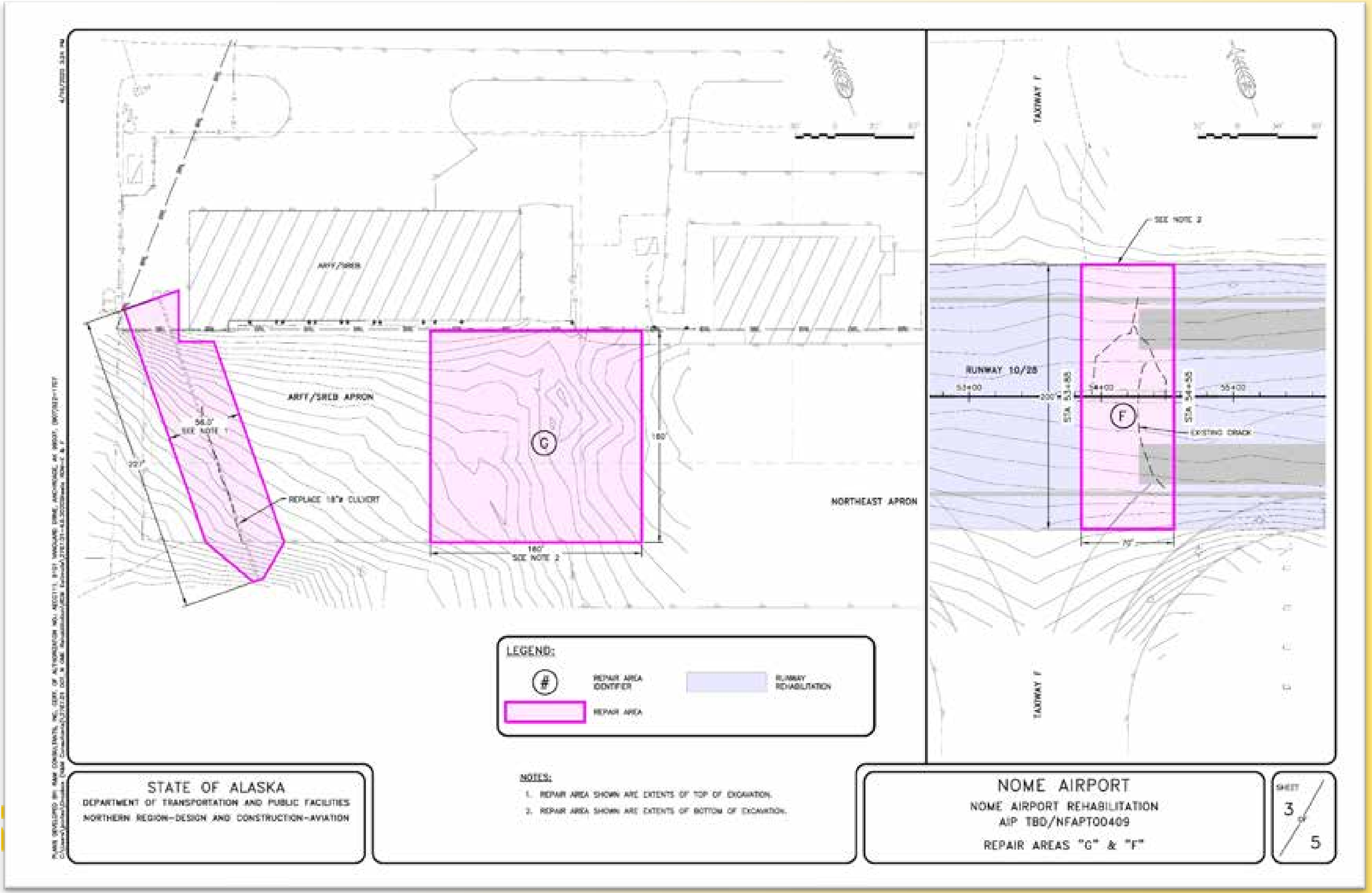


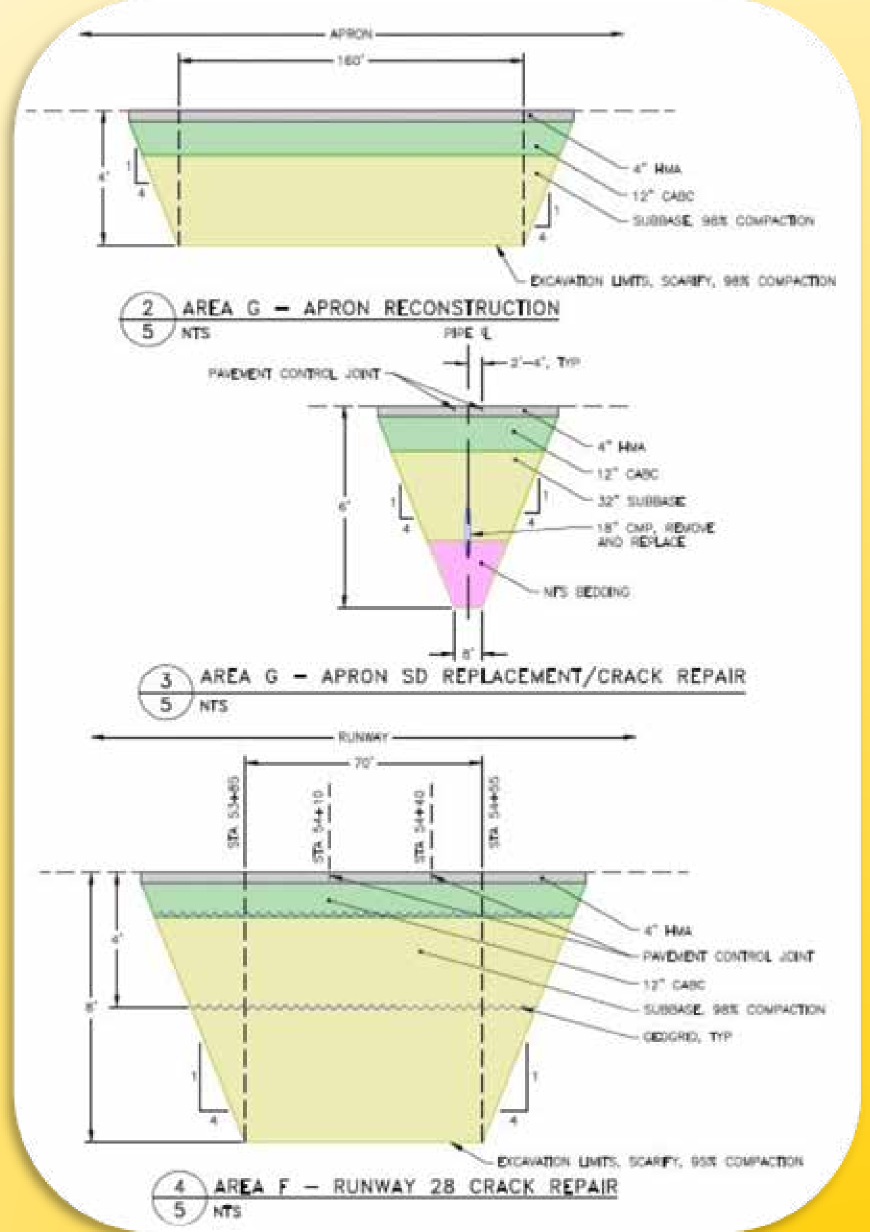
- Rehabilitate all of RW 10-28 and 3-21 pavement. Rehabilitation = new asphalt pavement + base course

- Repair Areas – deeper embankment/subgrade improvements

Apron/Crack Repair

Area G – Storm drain pipe replacement, ARFF apron repair
Area F – Severe RW transverse crack repair





Design Standards

Airport Component	Standard	Existing	Proposed
Airport Reference Code	C-III	C-III	C-III
RW Width	150 ft	-	-
RW 10-28 Width	-	150 ft	150 ft
RW 3-21 Width	-	150 ft	150 ft
Shoulder Width	25 ft	-	-
RW 10-28 Shoulder Width	-	25 ft	25 ft
RW 3-21 Shoulder Width	-	20 ft	25 ft
RSA Width	500 ft	-	-
RW 10-28 Width*	-	500 ft	500 ft
RW 3-21 Width*	-	500 ft	500 ft

Design Aircraft/Critical Aircraft

- The existing design aircraft is the Boeing 737-700 (C-III)
- AC 150/5000-17 requires 500 annual operations of the critical aircraft

Pavement Design

Stabilized base course is an FAA requirement for large aircraft (>100,000 pounds)

Used FAA's FAARFIELD pavement design software

Fleet Mix

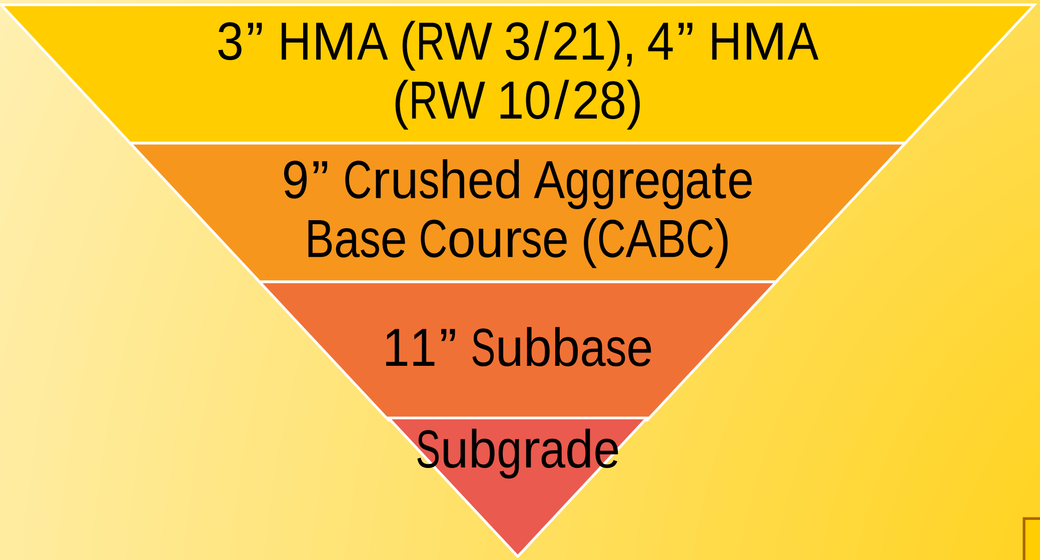
Aircraft	Gross Weight (lbs.)	2018 Annual Departures	w/ 20% Contingency	Annual Growth
SuperKingAir-B200	12,590	2,660	3,192	0.6%
B737-100	111,000	210	252	0.6%
B737-300	140,000	77	93	0.6%
B737-400	150,500	43	52	0.6%
B737-700	155,000	753	904	0.6%
B737-800	174,700	190	228	0.6%
GrnCaravan-CE-208b	8,750	3,868	4,642	0.6%
Navajo-C	6,536	1,143	1,372	0.6%
Stationair-206	3,612	1	2	0.6%
MD83	161,000	80	96	0.6%
DC9-32	109,000	54	65	0.6%
C-130	155,000	173	208	0.6%
S-20	16,976	811	974	0.6%
D-15	15,000	4	5	0.6%
	TOTAL:	10,067	12,085	

Source: Department of Transportation, Bureau of Transportation Statistics T-100 databank (https://www.transtats.bts.gov).

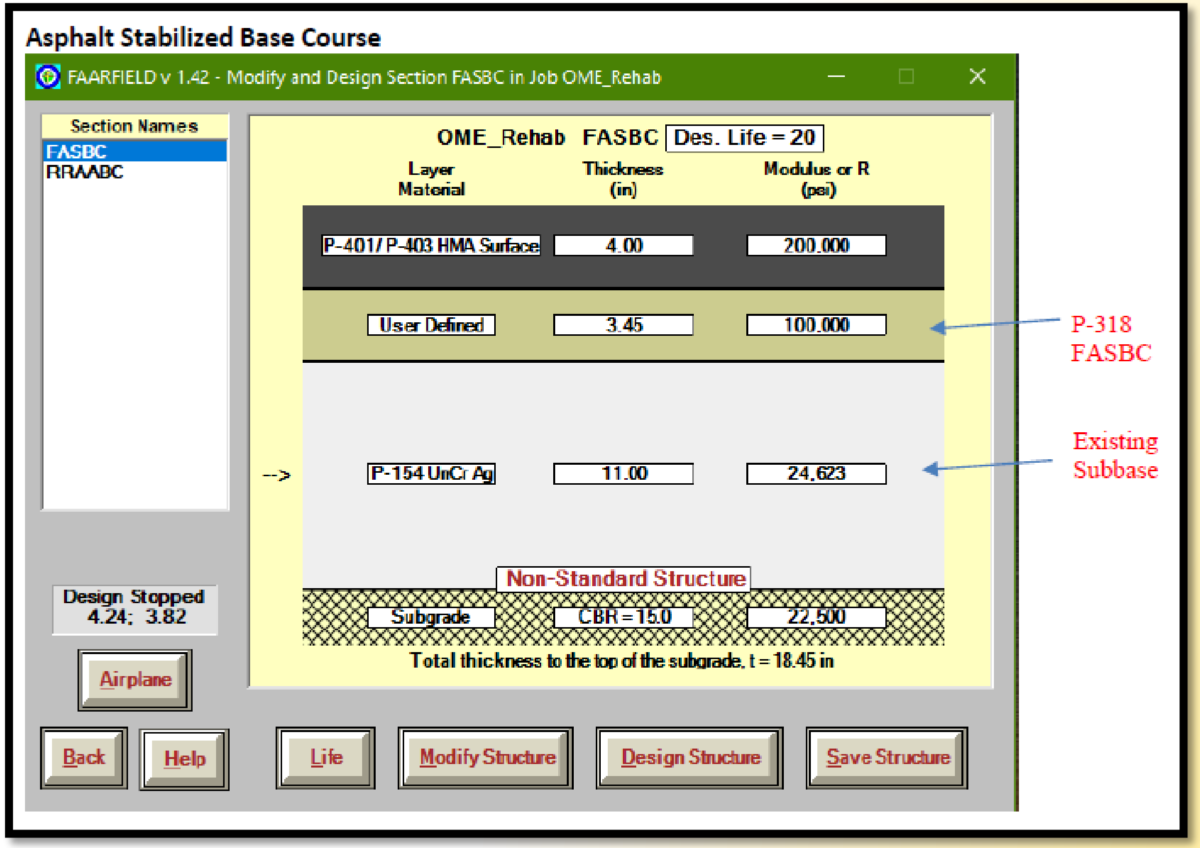
Material Strength Input Parameters:

- FASBC: Modulus = 100,000 psi
- CABC: Modulus = 75,000 psi
- Subbase: 35,000 psi
- Borrow: 25,000 psi
- Subgrade: CBR = 15

Existing Section (as-builts):



Pavement Design

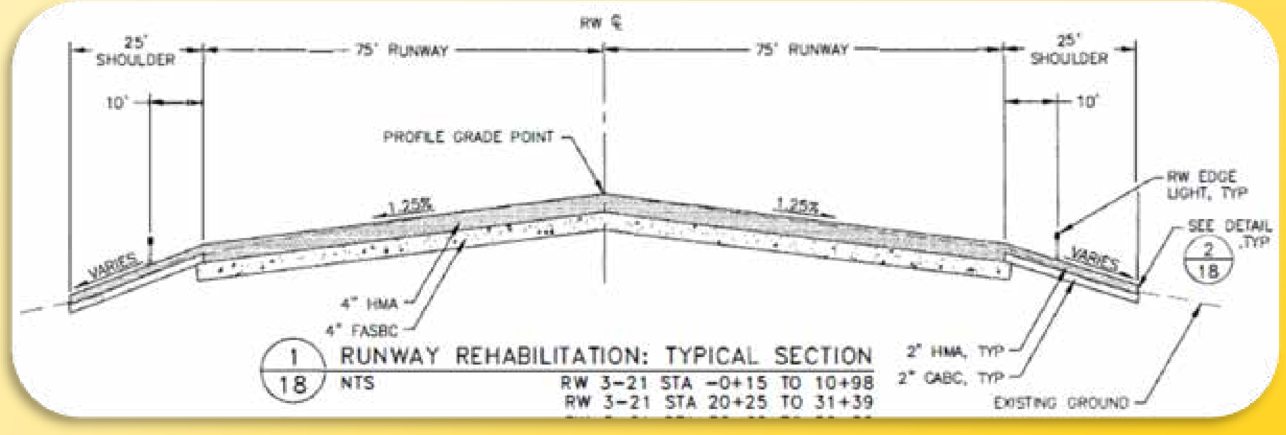


Results

4” P-401 HMA Pavement Surface

4” P-318 Foamed Asphalt Stabilized Base Course (FASBC)

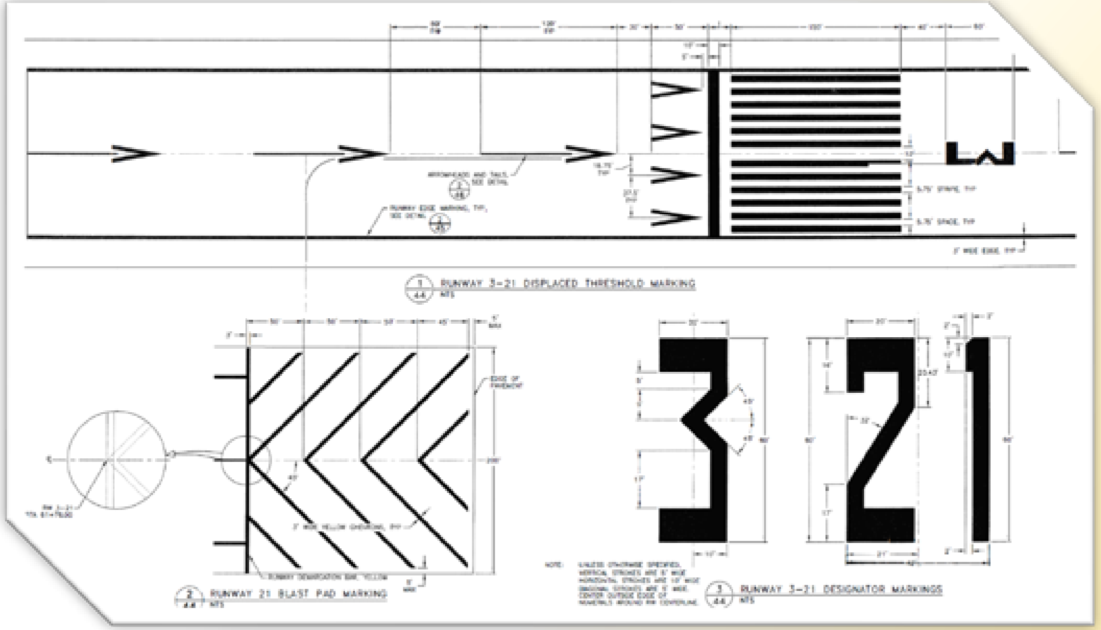
Existing structural section (subbase/borrow)



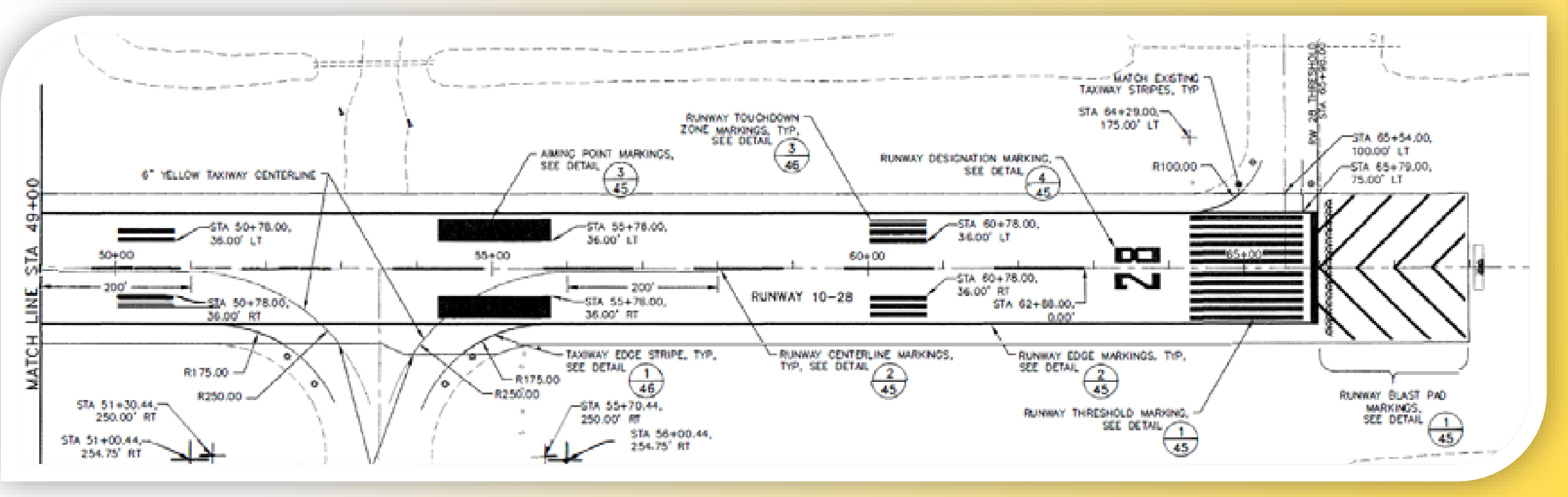
RW Rehab

- Mill-off existing pavement
- Foamed Asphalt – inject small amount of water and asphalt binder at high temperature and mix with aggregate. Can be performed in place with reclaimer machine, to stabilize the base course under pavement
- Pave, install lighting, groove and stripe

Runway Markings



- Markings are dependent on runway approach instrument type (visual, non-precision, precision)
- Airport markings are white or yellow and contain reflective glass beads
- Comply to FAA Advisory Circular (AC) 150/5340-1M *Standards for Airport Markings*



Construction Phasing

Cannot close the airport

- It is an essential lifeline to the community

Close one runway at a time

Half-width runway phasing for intersection rehab

CONSTRUCTION PHASE SCHEDULE

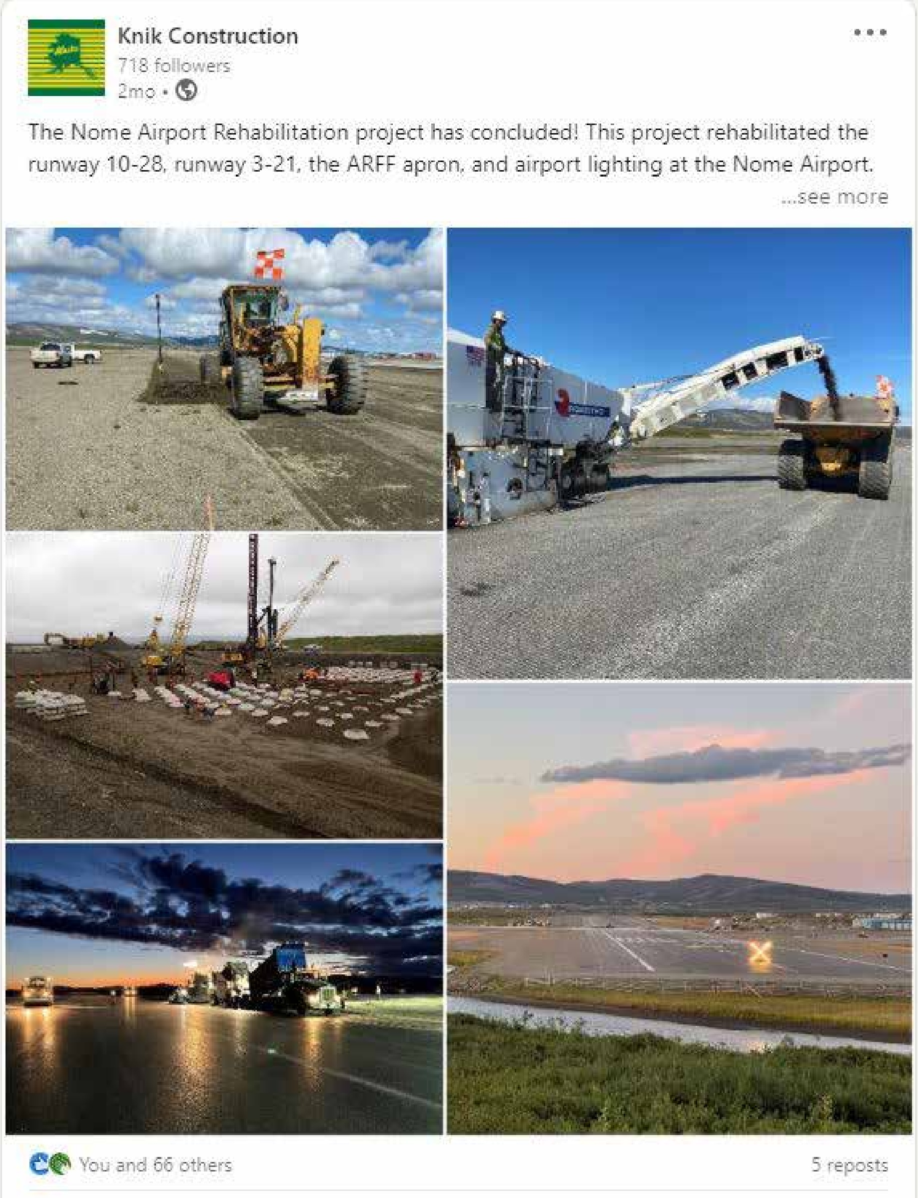
PHASE	WORK AREAS	DURATION	CONCURRENT WITH PHASE	CLOSURES
1A	REHABILITATE RW 3-21	60 DAYS		RW 3-21 (FULL), TW's D, E, H
2A	REHABILITATE RW 10-28	60 DAYS		RW 10-28 (FULL), TW F
2B	DEEP GROUND IMPROVEMENTS	38 DAYS	2A	RW 10-28 (FULL)
2C	DEEP GROUND IMPROVEMENTS	30 DAYS	2A	RW 10-28 (FULL)
2D	CRACK REPAIR	10 DAYS	2A	RW 10-28 (FULL), TW F, G
2E	REHABILITATE HALF OF INTERSECTION	12 DAYS		RW 10-28 (HALF-WIDTH), RW 3-21 (FULL)
2F	REHABILITATE HALF OF INTERSECTION	12 DAYS		RW 10-28 (HALF-WIDTH), RW 3-21 (FULL)
2G	INTERSECTION & RW 10-28 GROOVING, FINAL COAT OF MARKINGS ON RW 10-28 & 3-21	21 DAYS		NIGHTLY AIRPORT CLOSURE
3	ARFF/SREB APRON	10 DAYS	N/A	N/A

Cost

Project Cost: $27,921,522

- 2.4 miles of repaving
- 286,850 SY of pavement removal & repaving
- 57,590 tons of hot mix asphalt placed

Completed Construction Photos



Design and Construction of the Nome Airport Pile Supported Embankment

UAF ASCE Presentation

April 20th 2023

Brian Mullen, PE, AM ASCE

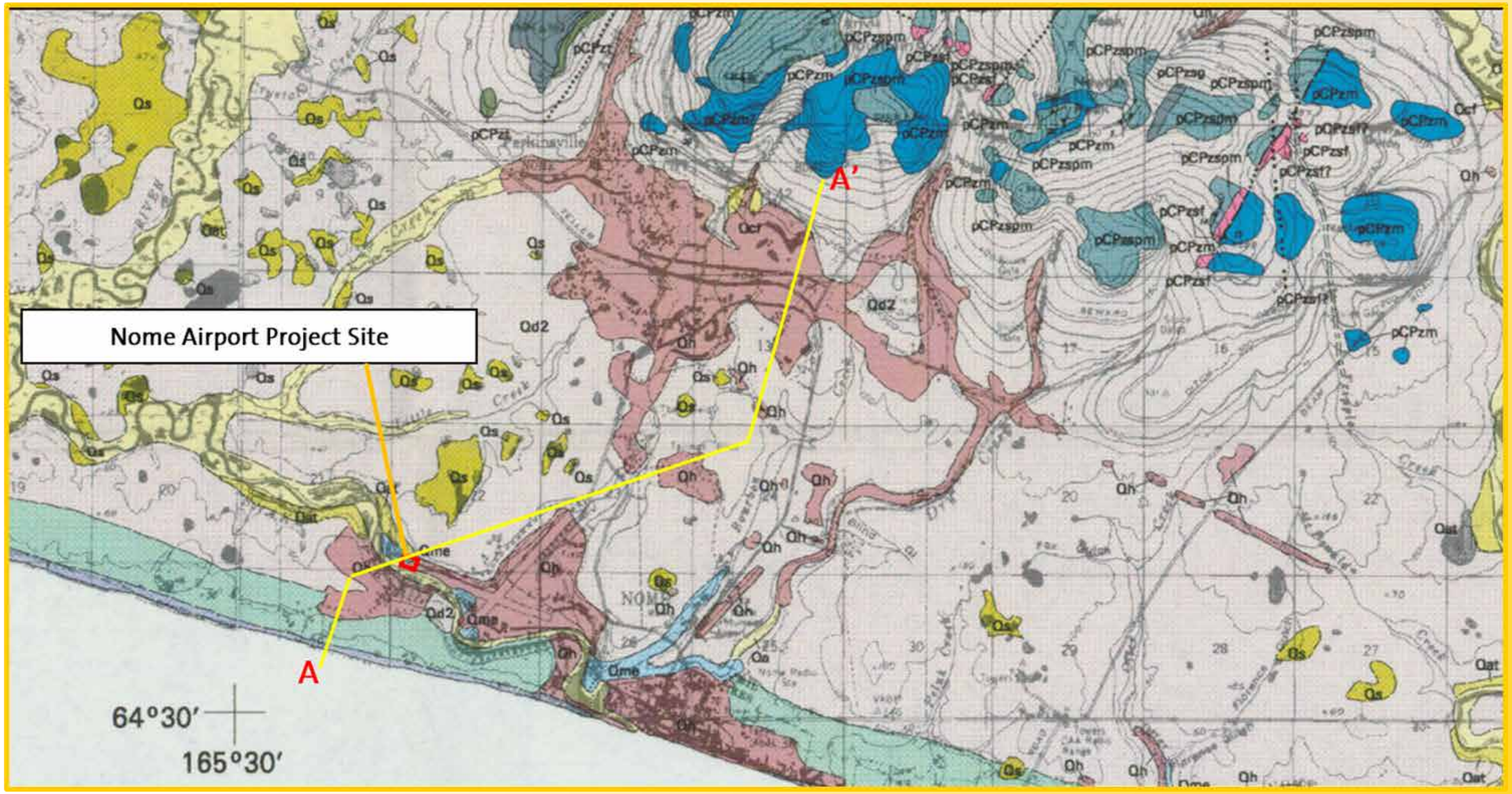
Presentation Outline

- PROJECT BACKGROUND
- GEOTECHNICAL INVESTGATION
- DEEP GROUND IMPROVEMENT METHODS
- PILE SUPPORTED EMBANKMENT DESIGN
- PILE SUPPORTED EMBANKMENT CONSTUCTION
- CONCLUSIONS

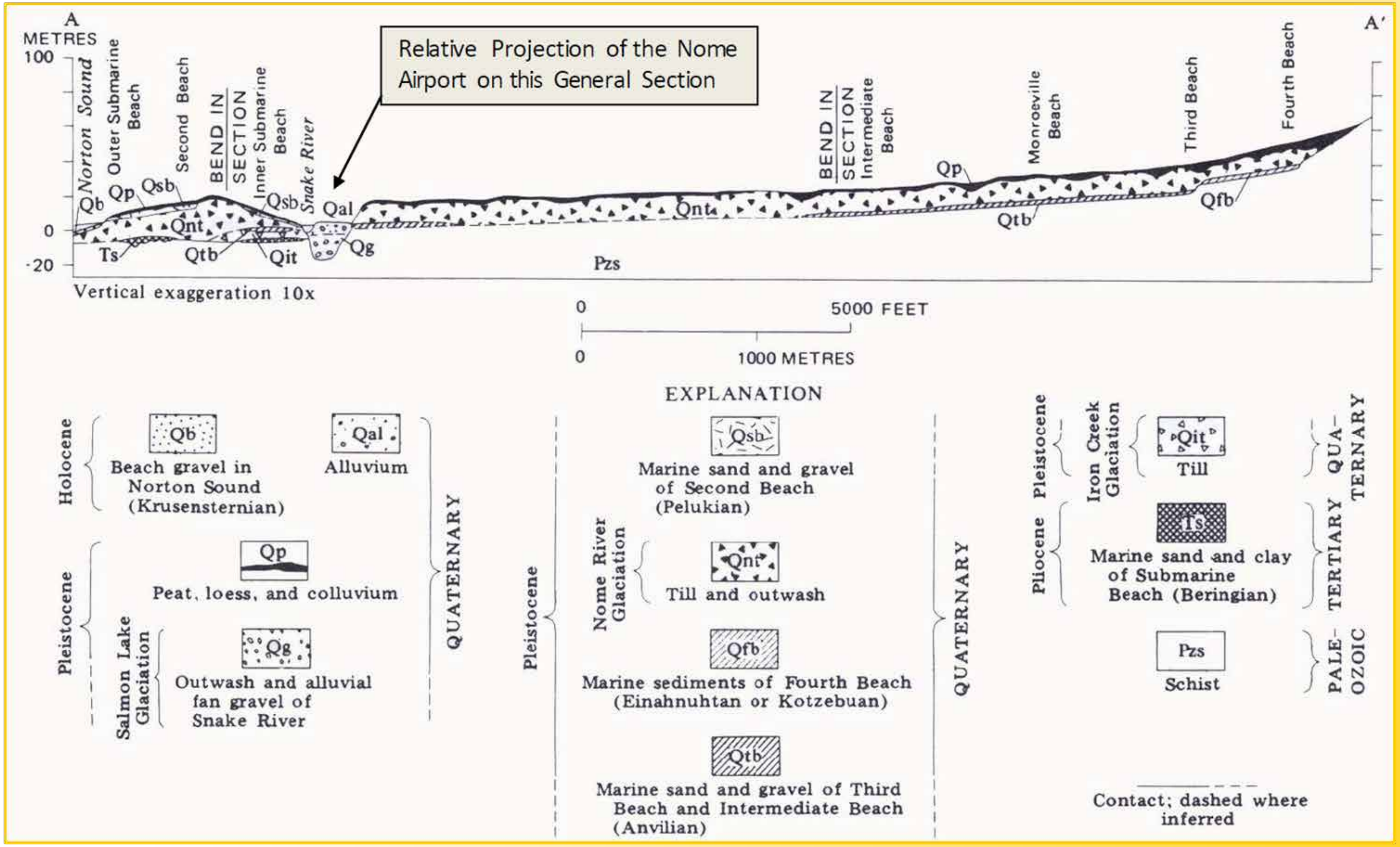
Nome, Alaska, USA

Nome Airport Vicinity

Research: Nome Area Surficial Geological Mapping (Bundtzen et al., 1994)



Research: Geological Cross Section (Péwé, 1975)

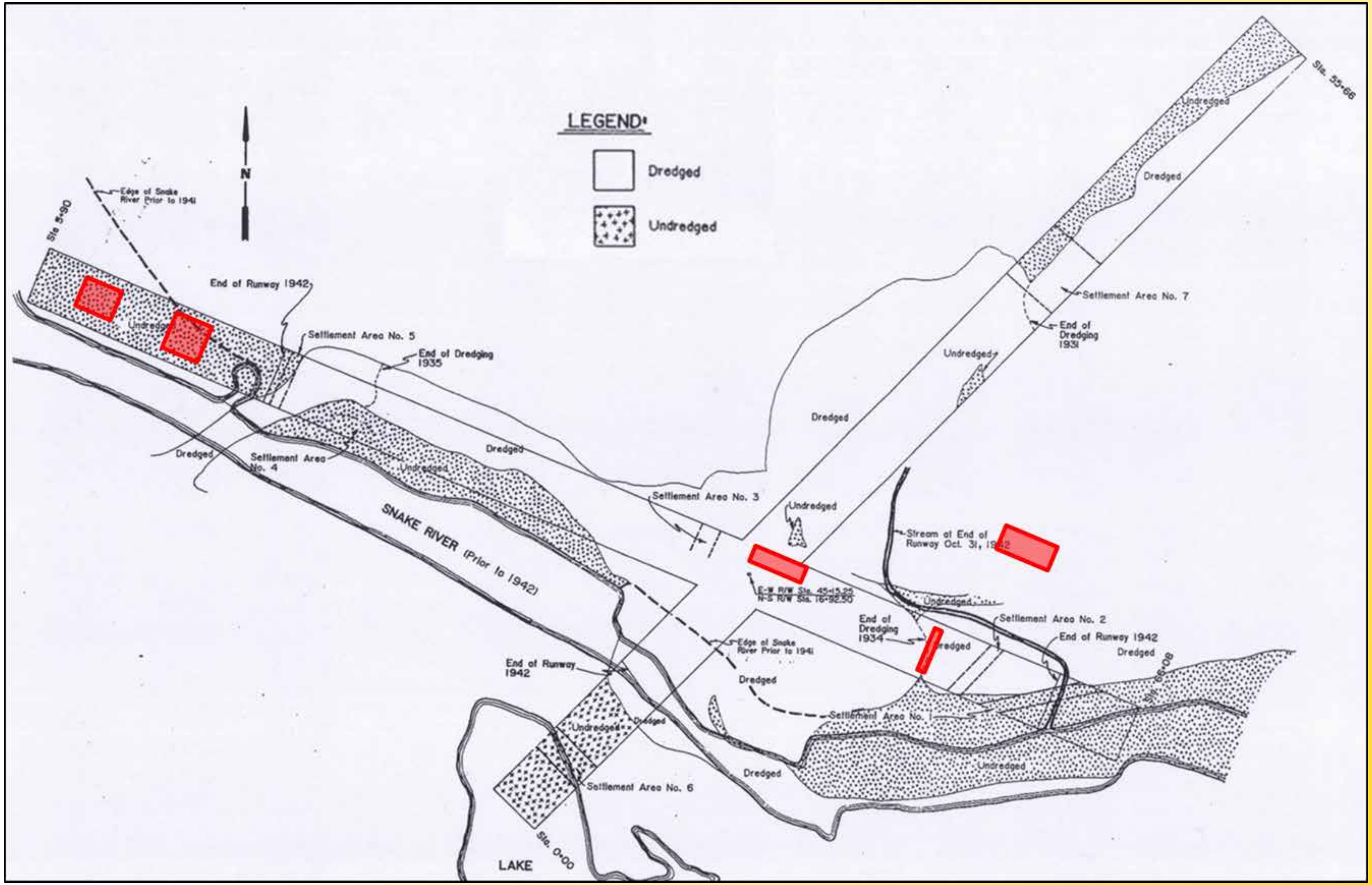


Nome Airport (OME) History

Maintenance and operations problems stemming from poor geotechnical conditions at location selected for the airport

- 1930's: Pre-airport gold dredging
- 1940's: Original airport construction and Major Snake River Realignment
- 1950's: First Asphalt Pavements on Runways
- 1960's: Pavements are performing poorly w/settlement and cracking. Particular distress areas appear requiring more frequent repairs.
- Circa 1975, 1990, 2000, 2008, 2012, 2019, 2022: Major reconstruction/repairs projects
- 2017: Nome OSR Project, extra attention to ditress areas and request for long lasting mitigation to most problematic distress areas at west end of RW 10-28

Research: Dredge Tailings (1930's) and River Realignment (1940's)



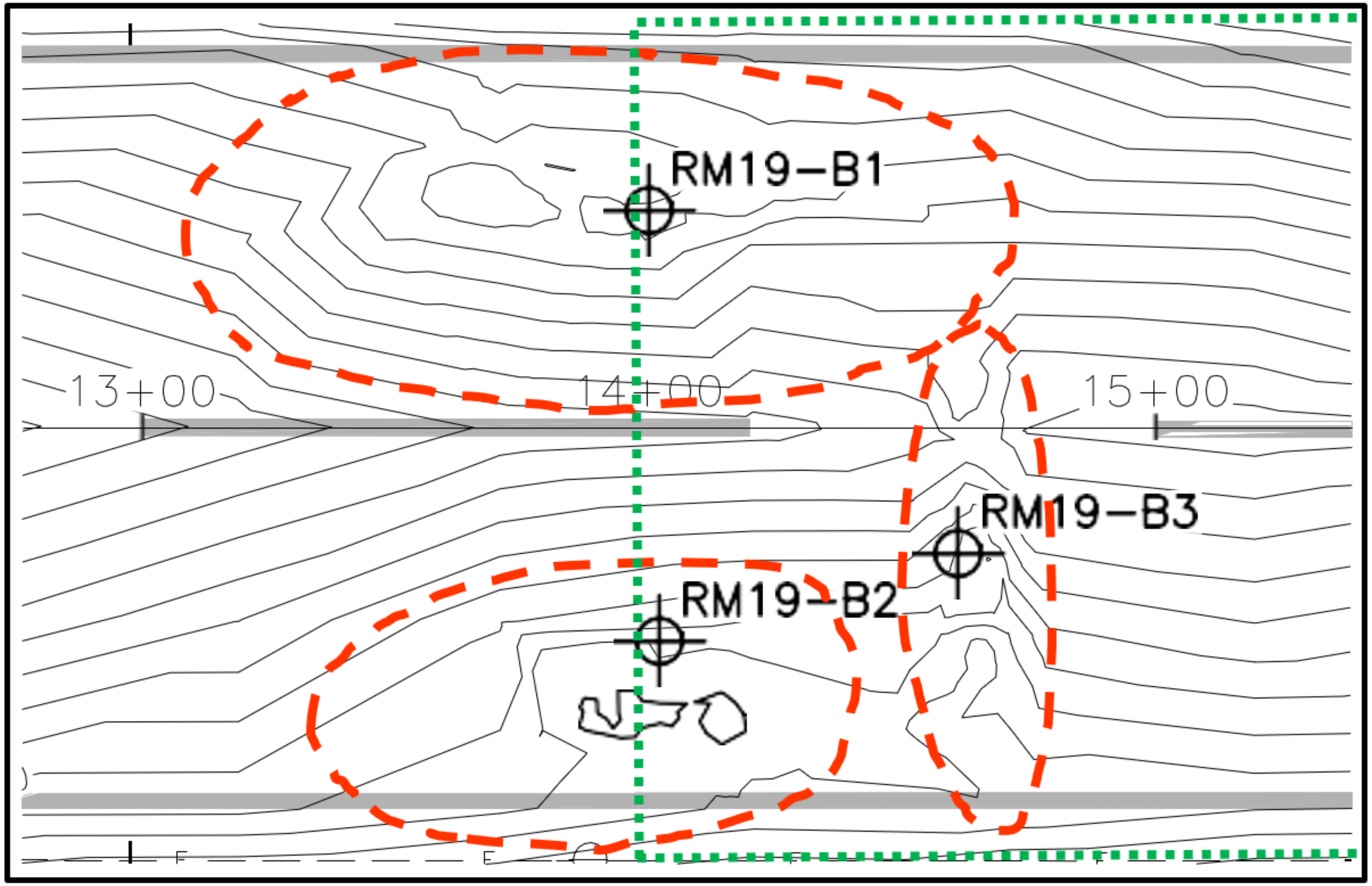
Geotechnical Investigation/Recommendations Timeline/Scope

- 2017: Define distress areas, field reconnaissance with airport manager, new topographical survey.
- 2018: Cont. evaluate history and existing information.
- 2019: Perform new geotechnical investigations and evaluate failure mechanisms (compare new vs. old)
- Jan 2020: Present deep ground improvement methods alternatives recommendation to DOT&PF
- June 2020: Pile supported embankment selected
- July 2020: Final Design Recommendations Pile Supported Embankment, Final Plans and Specs to DOT&PF
- Aug 2020: Project construction contract awarded
- 2022: Project construction completed by KNIK, STG

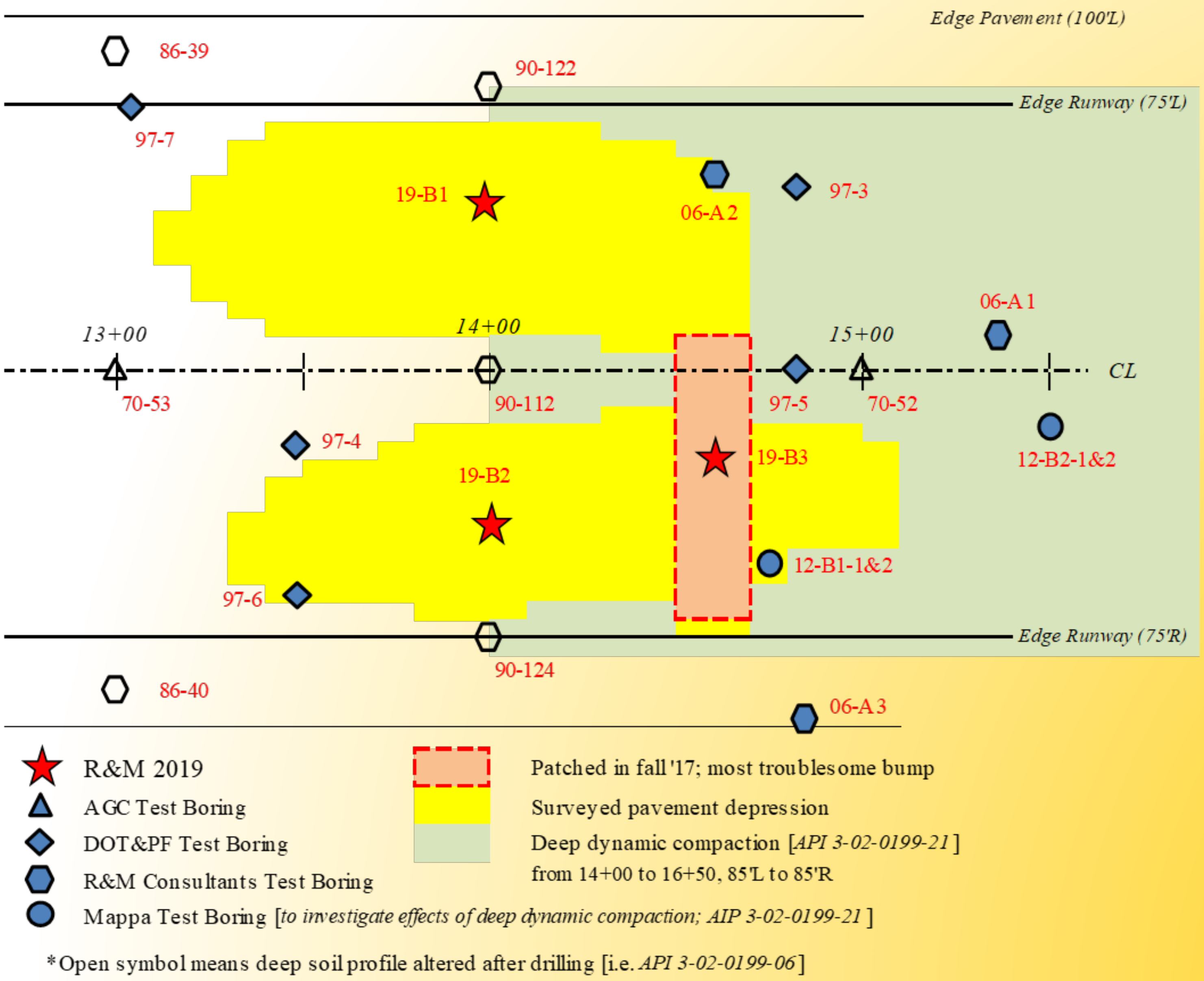
Nome OSR Distress Areas (2017 Reconnaissance by R&M)

Nome OSR Distress Areas (2017 Reconnaissance by R&M)

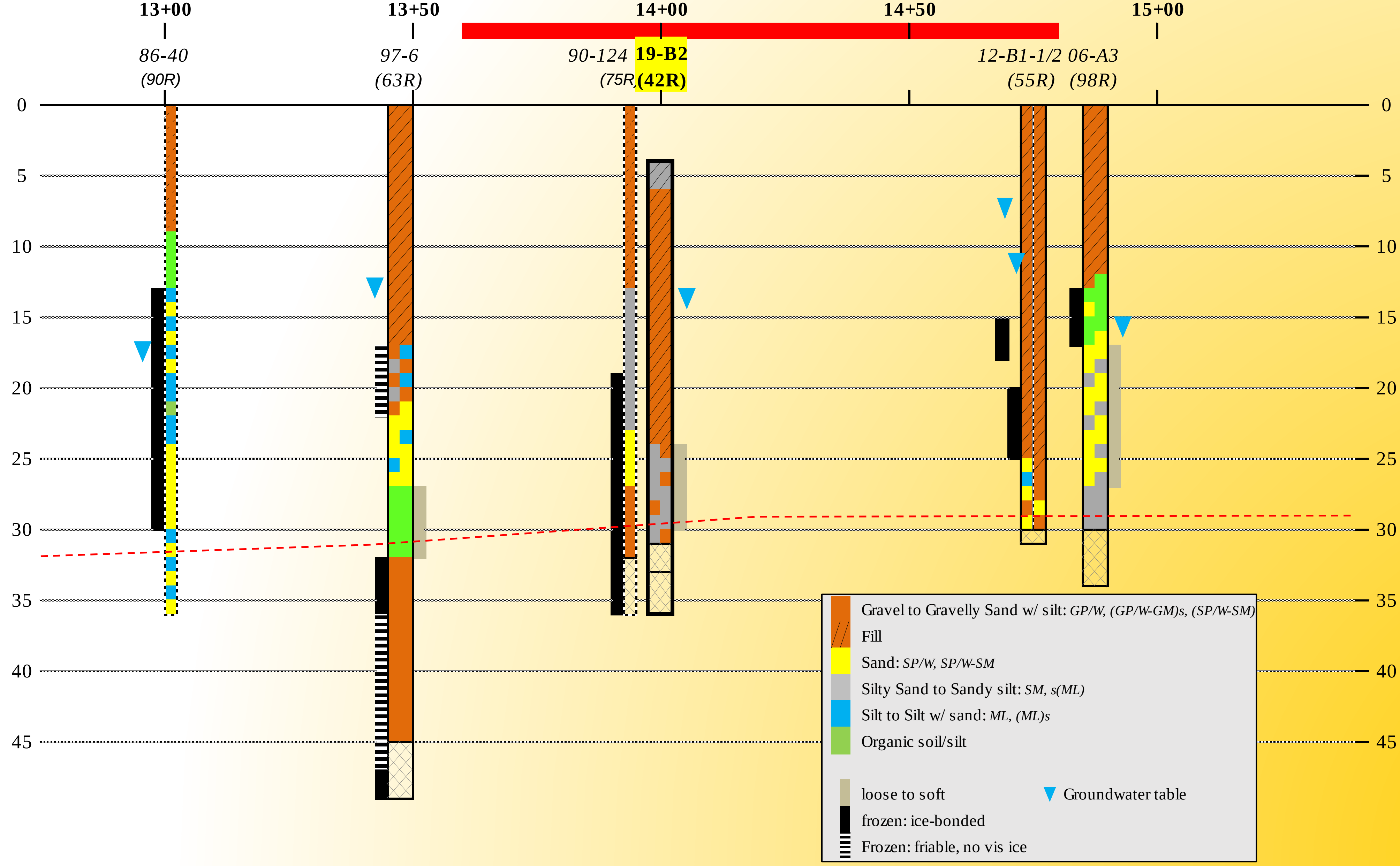
2017 Topographical Survey: Distress Area B



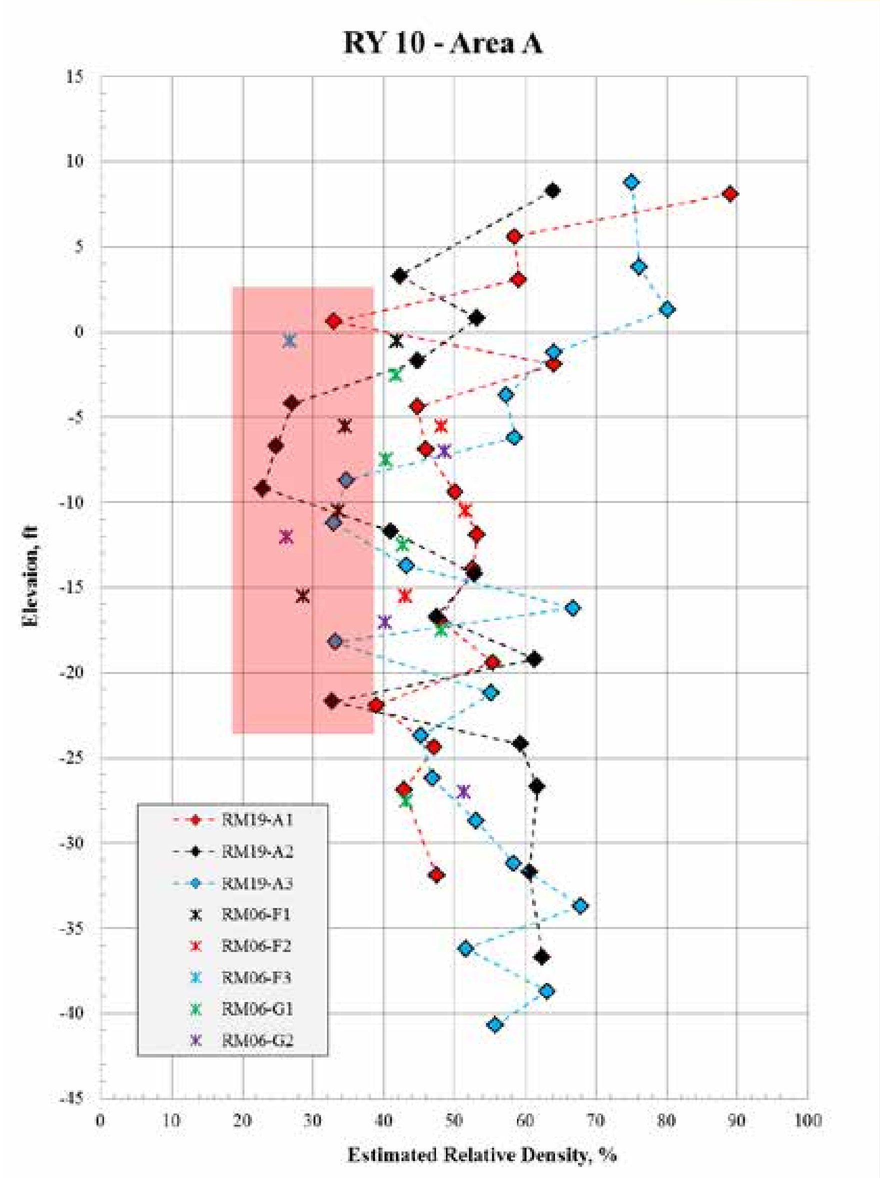
2019 Geotechnical Investigation: Distress Area B

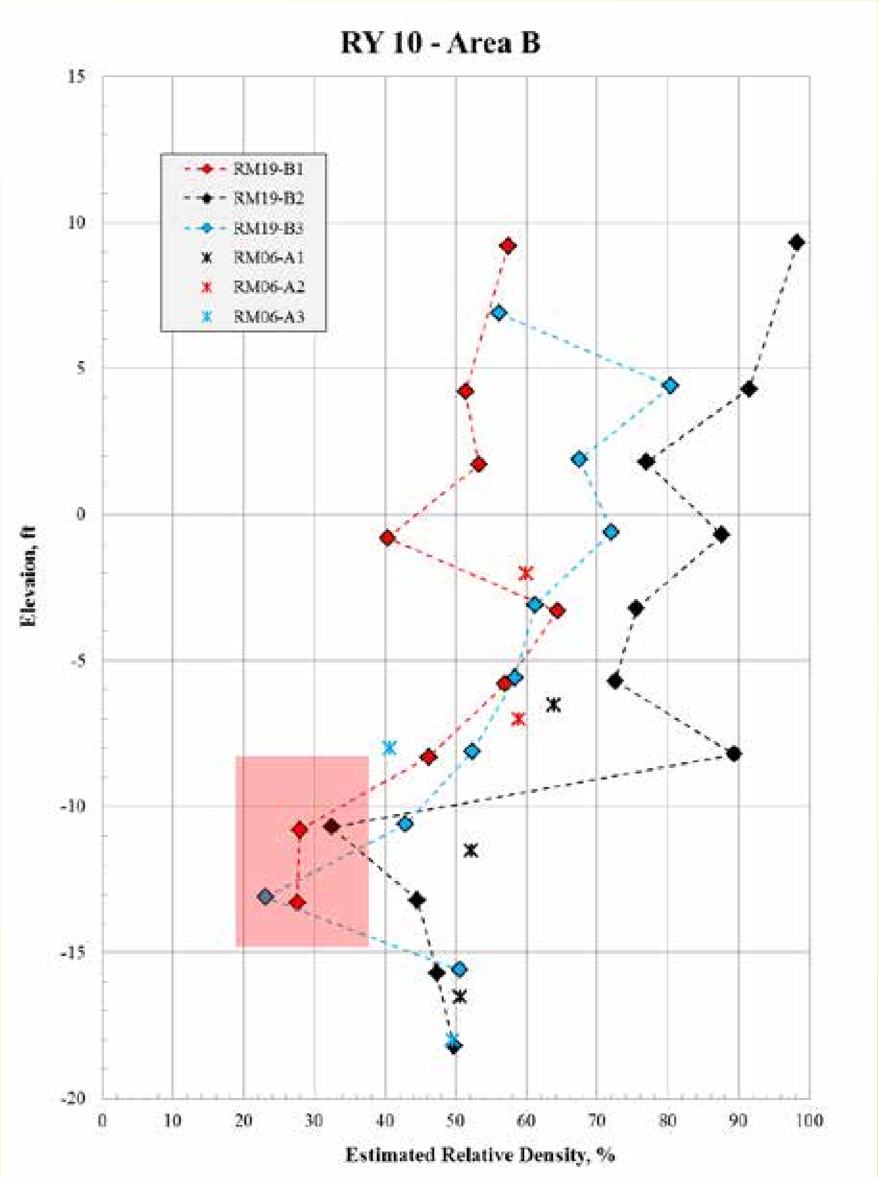


2019 Geotechnical Investigation, Schematic Profile ± 50-75' Rt



Evaluate Settlement Mechanisms





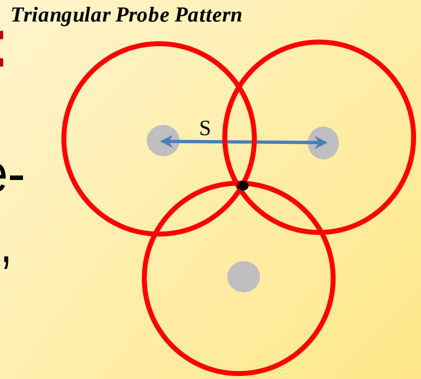
Jan 2020: Geotechnical Recommendations to DOT&PF

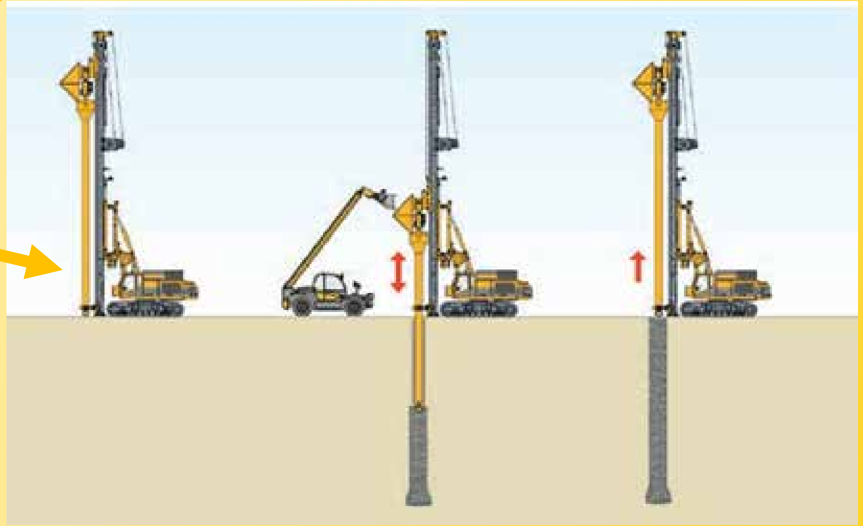
Work areas underlain by loose unfrozen, and/or high thaw-strain permafrost soils:

1. Eliminate poor/undesirable foundation soils (pre-thaw and surcharge, or over-excavate & replace), OR

2. Apply Deep Ground Improvement Methods (*in order of increasing cost*)

   - Deep Dynamic Compaction
   - Vibro-Compaction/Replacement
   - **Aggregate/Cement-treated Soil Columns**
   - **Pile Supported Embankment**
   - Permeation Grouting





June 2020: DOT&PF Selects Pile Supported Embankment

Preferred because:

- PSE and ATSC both well suited to globally mitigate range of settlement mechanisms occurring in the distress areas.

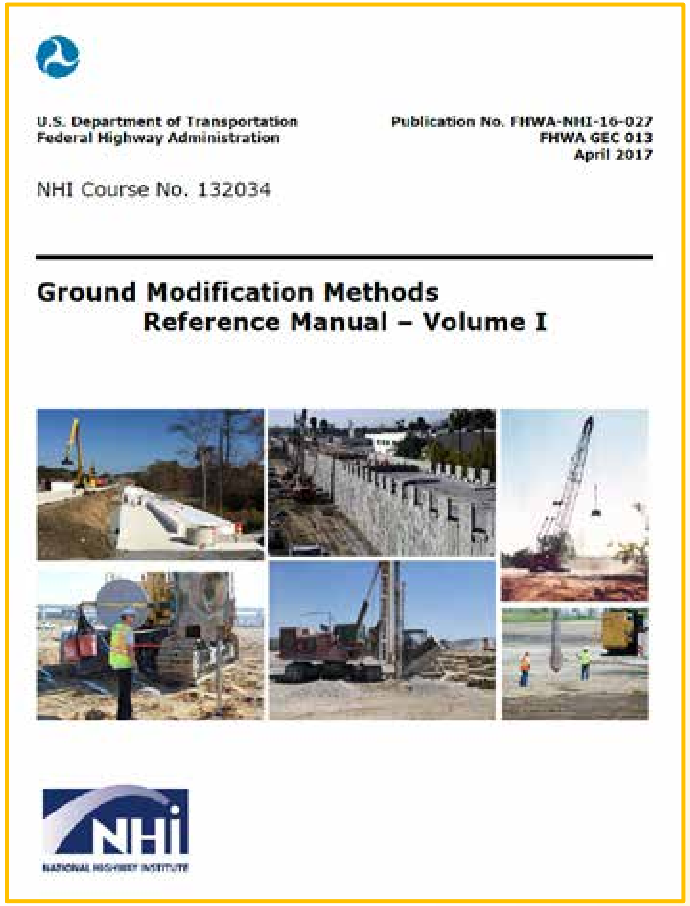
- ATSC perceived more expensive, or higher cost risk due to cement cost in Nome, large specialized equipment needed, and greater uncertainty with cost for non-traditional construction methods.

- ATSC would additionally require a significant testing effort upfront, potential conflict with project schedule and airport operations.

- PSE can be installed by Alaska contractors with existing equipment. Conventional method used in an unconventional application.

June 2020: Design Pile Supported Embankment

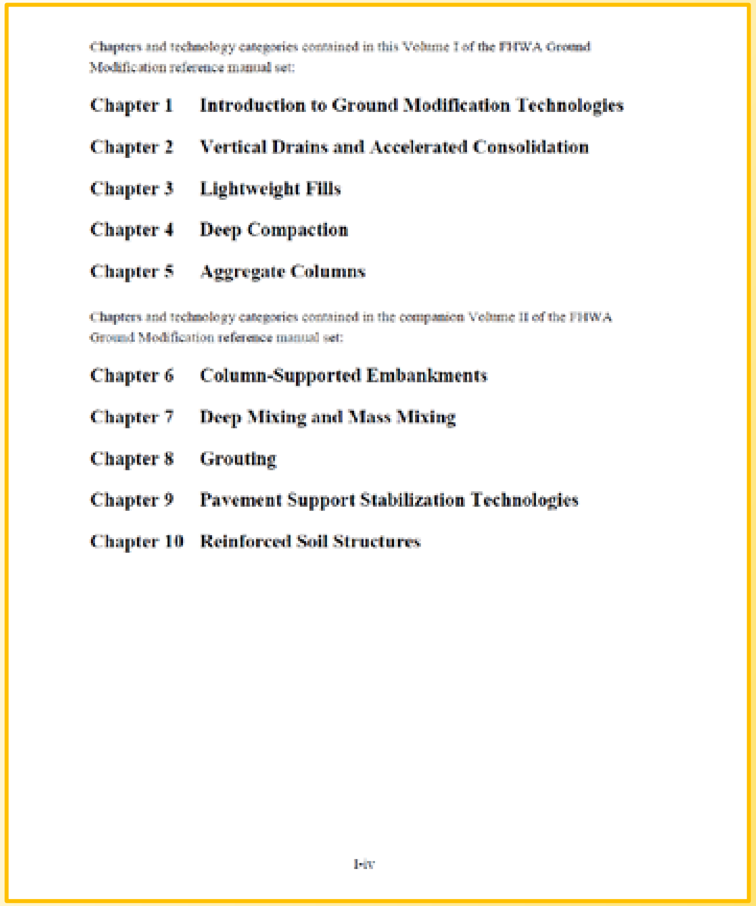
Primary Reference for Design Methodology:


U.S. Department of Transportation
Federal Highway Administration

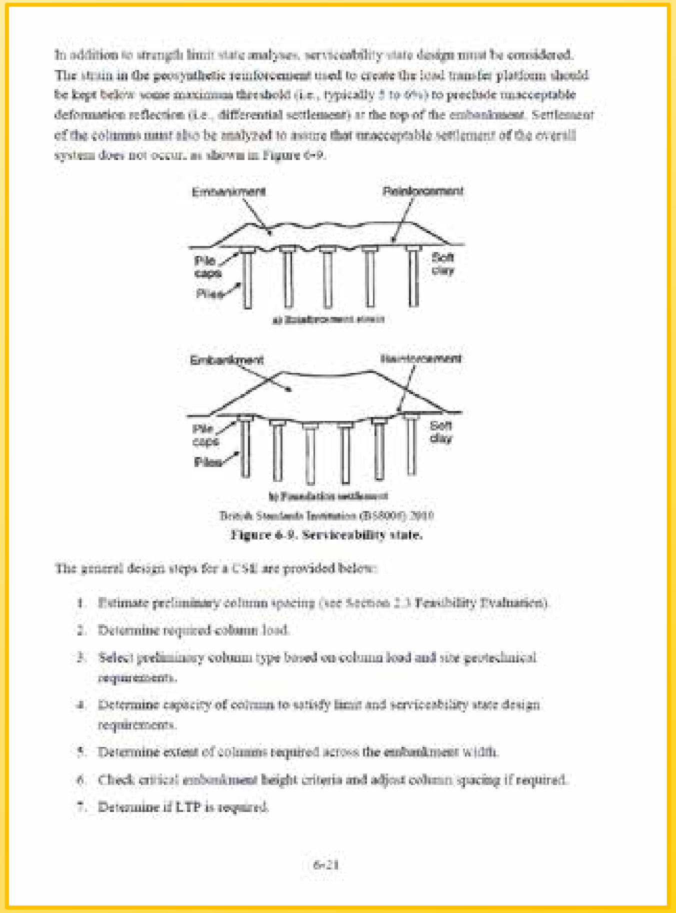
Publication No. FHWA-NHI-16-027
FHWA GEC 013
April 2017

NHI Course No. 132034

Ground Modification Methods Reference Manual – Volume I


Chapters and technology categories contained in this Volume I of the FHWA Ground Modification reference manual set:

Chapters and technology categories contained in the companion Volume II of the FHWA Ground Modification reference manual set:


In addition to strength limit state analyses, serviceability state design must be considered. The strain in the geosynthetic reinforcement used to create the load transfer platform should be kept below some maximum threshold (i.e., typically 5 to 6%) to preclude unacceptable deformation reflection (i.e., differential settlement) at the top of the embankment. Settlement of the columns must also be analyzed to assure that unacceptable settlement of the overall system does not occur, as shown in Figure 6-9.

British Standards Institution (BS8006) 2010

Figure 6-9. Serviceability state.

The general design steps for a CSE are provided below:

1. Estimate preliminary column spacing (see Section 2.3 Feasibility Evaluation).
2. Determine required column load.
3. Select preliminary column type based on column load and site geotechnical requirements.
4. Determine capacity of column to satisfy limit and serviceability state design requirements.
5. Determine extent of columns required across the embankment width.
6. Check critical embankment height criteria and adjust column spacing if required.
7. Determine if LTP is required.

June 2020: Design Pile Supported Embankment

1. **Maximum pile spacing** correlates directly with embankment thickness above pile tops.
2. **Piles are designed** to support full embankment load plus down-drag forces from future consolidation, installed on grid pattern optimized to limit future differential settlement.
3. **Overexcavate** from surface grade to base depth of future load transfer platform.
4. **Drive piles** through compressible strata completing on a sufficient bearing strata at depth. **Verify pile capacity.**
5. **Place pile caps** and **install load transfer platform.**
6. **Backfill overexcavation** and **construct pavement section.**

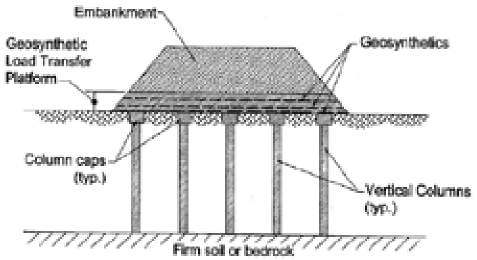


Figure 6-5. CSE with column caps.

The caps usually consist of either cast-in-place or precast concrete. Reinforcing steel may be required. Currently there is little information on the design of column caps. Design issues for column caps are focused on the connection between column and cap, with respect to lateral loads and bending moments (i.e., how are lateral loads determined, where are they applied).

3.2 Load Transfer Platforms

The LTPs covered in this manual consists of select granular structural fill either non-reinforced or reinforced with one or more layers of geosynthetic reinforcement or in situ unreinforced cohesionless soil.

3.2.1 Materials

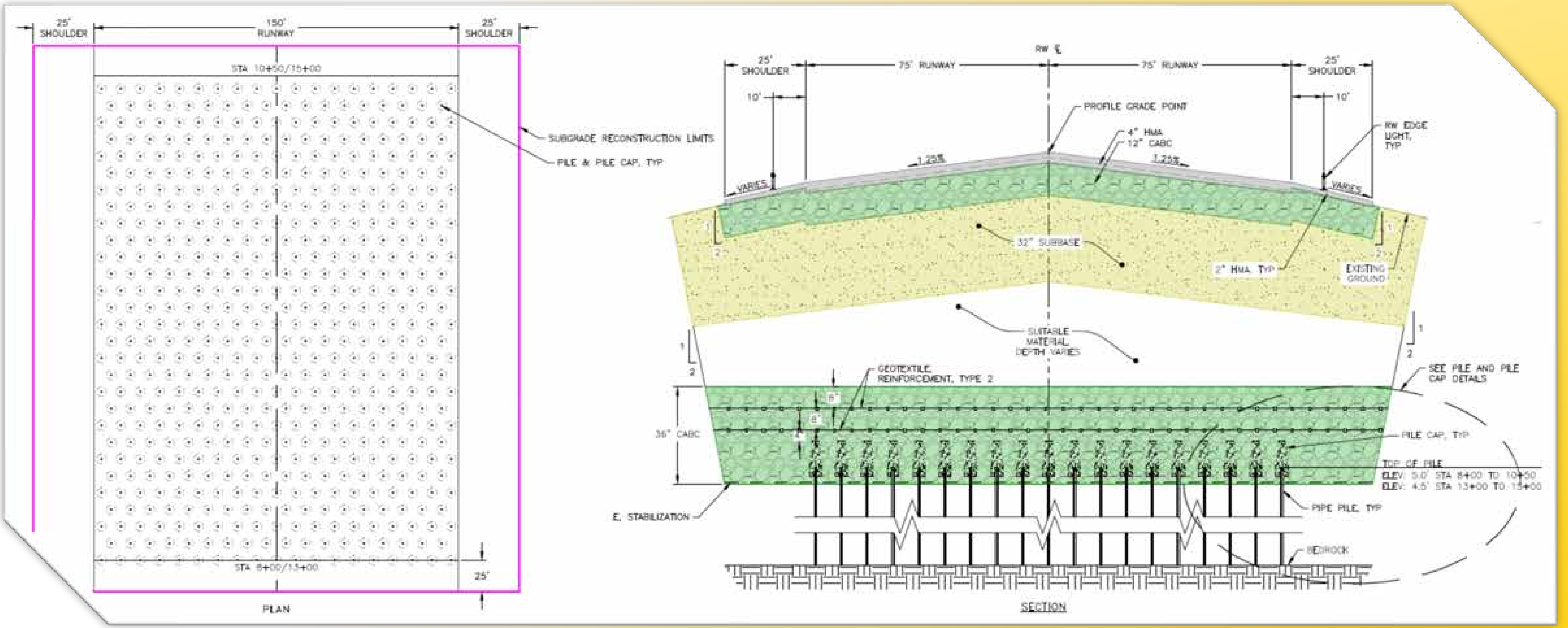
3.2.1.1 Granular Material

If there is a layer of soil just below the ground surface that is stiff enough and has adequate depth, this layer may act as the LTP. Characteristics of the soil layer and its ability to act as an LTP will be covered in detail in Section 4. If in situ soil at the surface does not have sufficient properties to act as the LTP then backfill material will be necessary to create the LTP. Arching in the LTP soil above the columns is considered an integral component in the transfer of stress from the embankment to the columns. It is, therefore, important that the soils in the zone where the arch is formed be frictional material with high shear strength. Well graded granular fill is considered an ideal material for constructing the LTP. Above the platform, a non-select fill may be used to construct the remainder of the embankment.

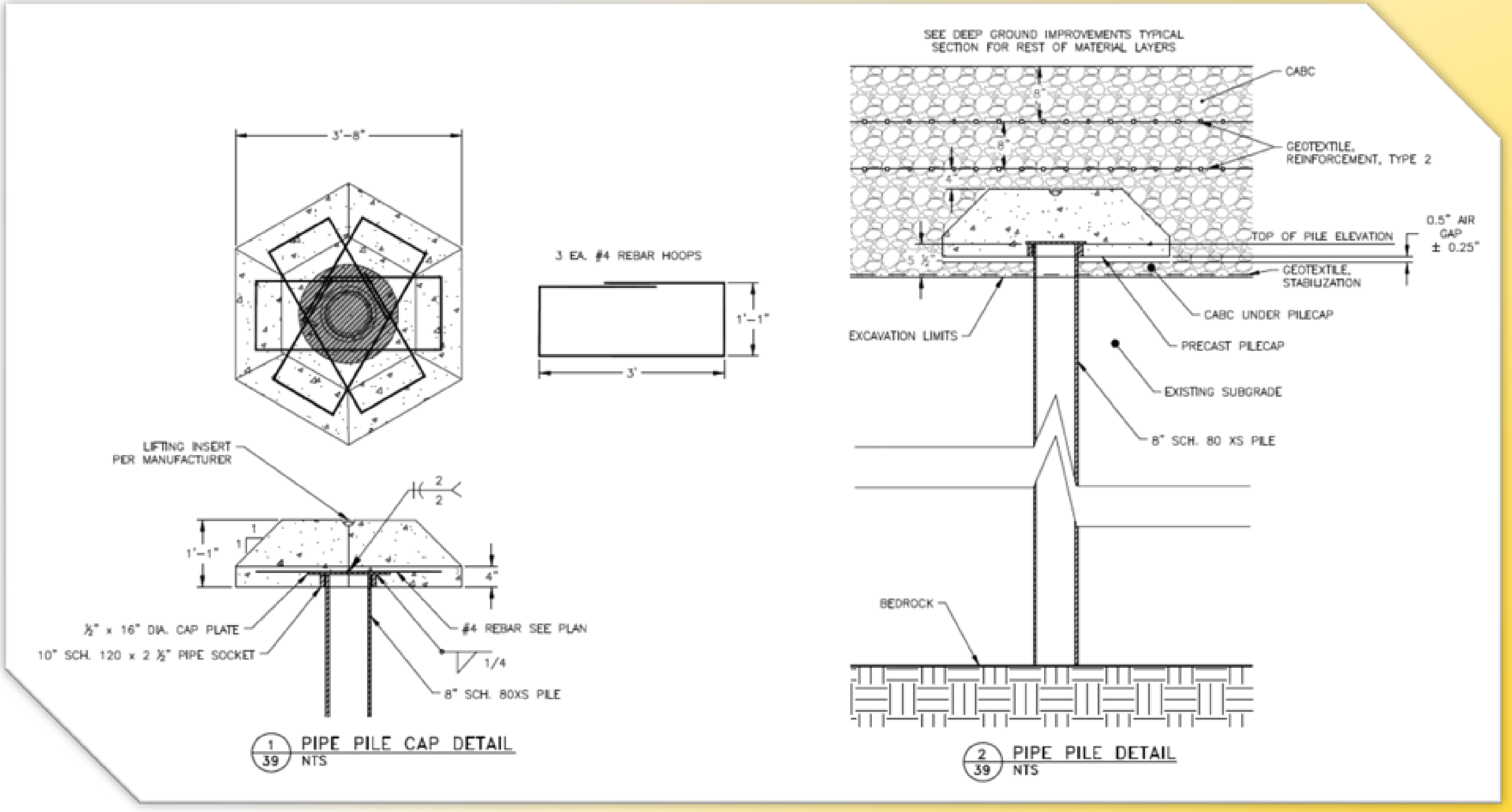
6-16

June 2020: Design Pile Supported Embankment

- 1,222 8” dia. XS steel pipe piles, installed on an 8’ triangular grid
- Seated into bedrock, designed to support the entire load of overriding embankment DL + LL + DD

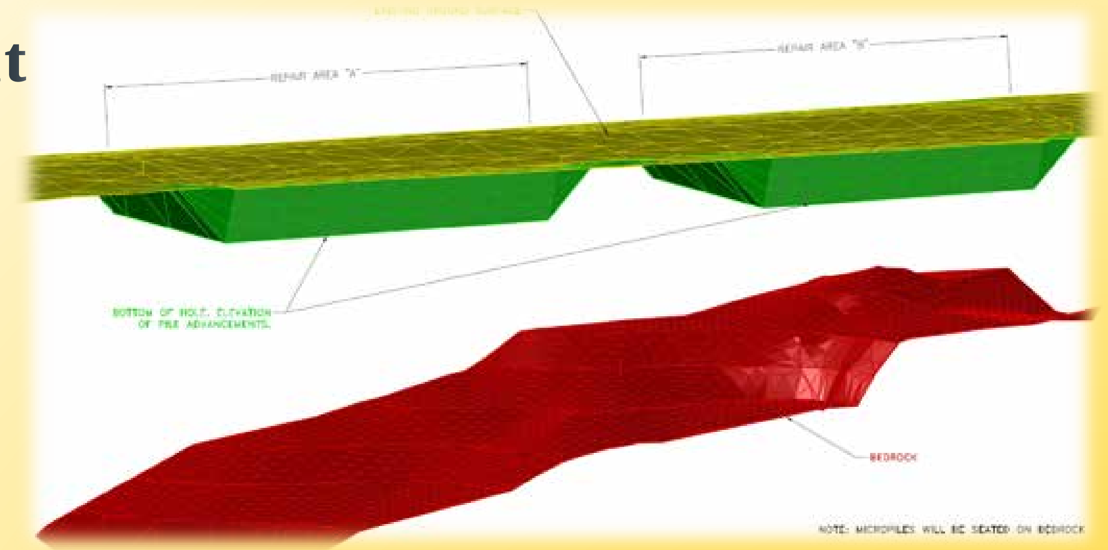


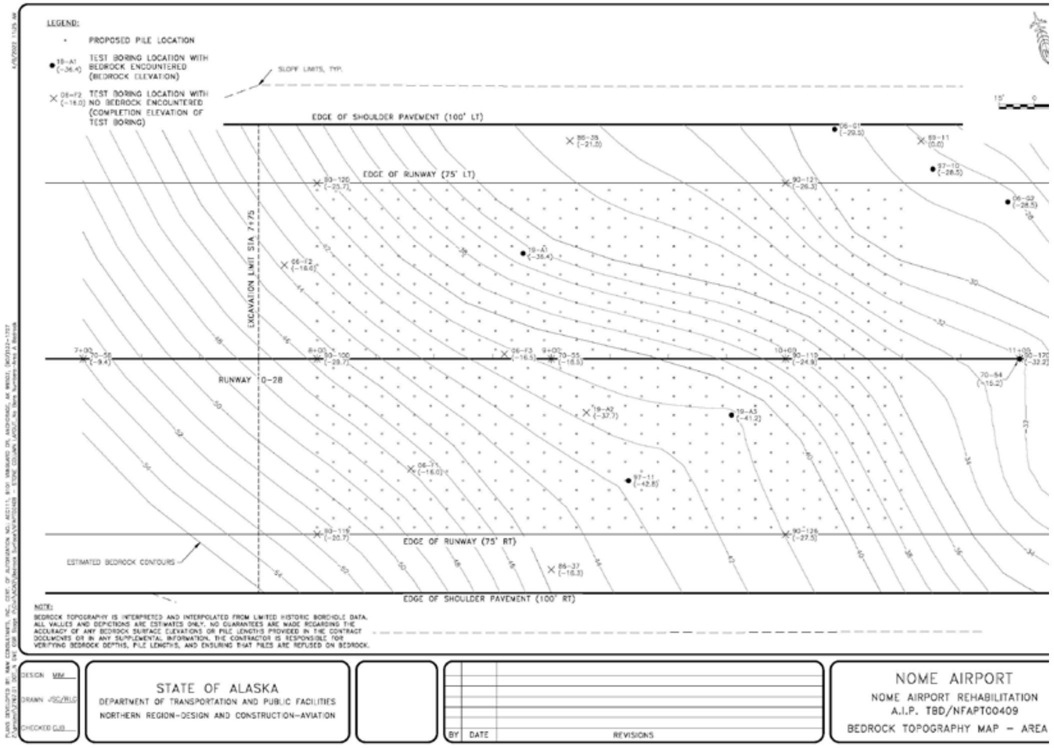
June 2020: Design Pile Supported Embankment

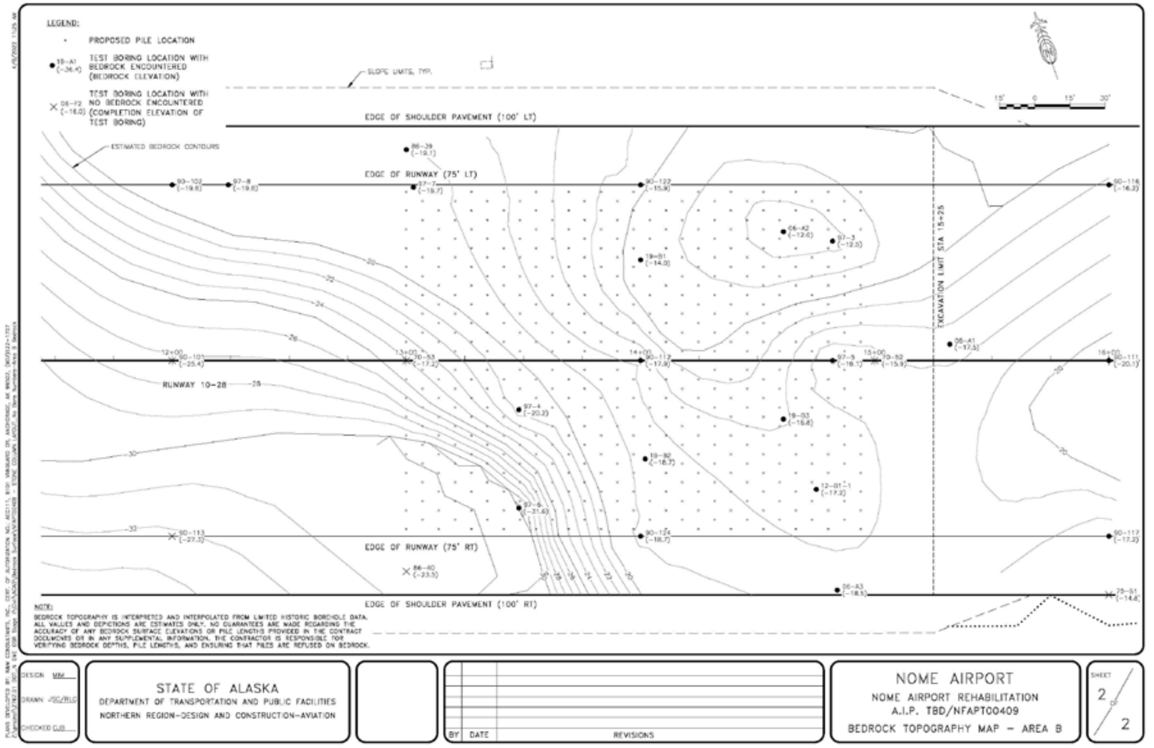


June 2020: Design Pile Supported Embankment

- 51,560 linear feet of pile estimated
- Estimated pile lengths to bedrock ranged from 20-60 feet





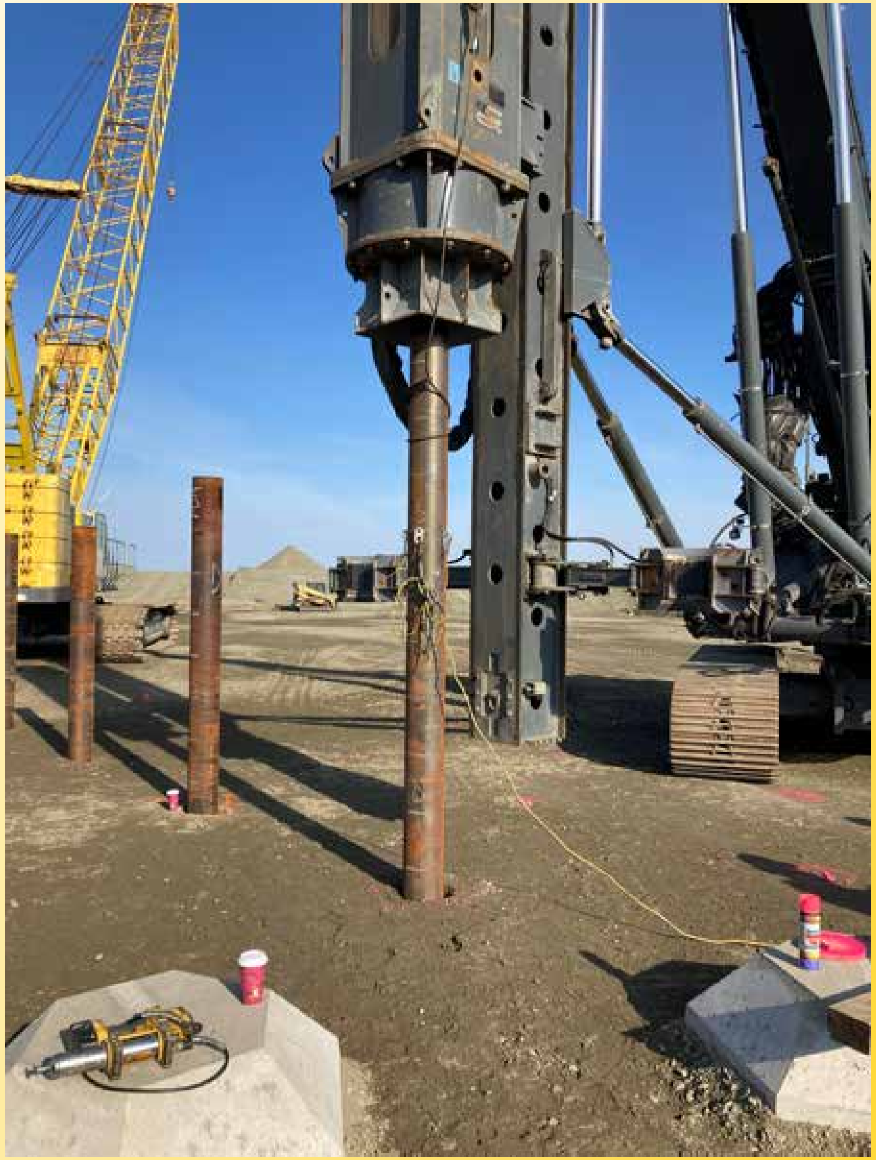


Summer 2022 Construction

Summer 2022 Construction

Summer 2022 Construction

Summer 2022 Construction



Summer 2022 Construction

Summer 2022 Construction

Summer 2022 Construction

Summer 2022 Construction

Summer 2022 Construction

Conclusions

- A thorough understanding of construction history, geology, and geotechnical conditions is paramount for solving complicated geotechnical problems (no such thing as too much data in design, more borings/testing would reduce risk/stress).
- There are many Deep Ground Improvement Methods available, varying in cost, complexity, and applicability to the problem at hand (deciding what to do was the hardest part)
- Professional contractors are very good at what they do, and their ability to innovate and solve problems is critical for projects (oversight required)
- Pile Supported Embankments construction at Nome **and** airport setting is now proven technique (finished on schedule, no significant change order).
- Results of this application are good thus far (time will tell).

Questions/Comments

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