Geotechnical Asset Management (GAM) Framework Development and Pilot Study

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Presentation Outline

- Overview of Alberta's Geohazard Risk Management Program
- Geotechnical Asset Management Framework Development (based on NCHRP Report 903)
- Pilot-Scale Implementation Results and Next Steps

Overview of Alberta's Highway Network

Pavement Rehabilitation Program

- More that 28,300 kilometres of paved highways (the equivalent of 60,700 lane kilometres)

Bridge Rehabilitation and Replacement Program

- Approximately 4,500 bridges

Geotechnical Risk Management Program (GRMP)

- ~500 geotechnical sites, including natural hazards and constructed earth works

Alberta Government

Geohazard Risk Management Program (GRMP)

- Peace Region:
- North Central Region:
- Central Region:
- Southern Region:

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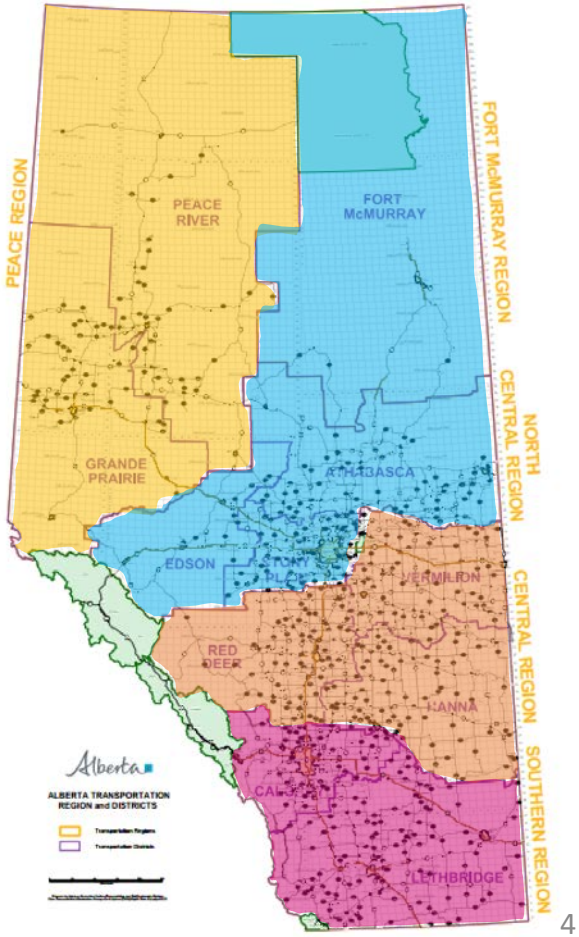


Geohazard Risk Management Program (GRMP)

The Ministry of Transportation and Economic Corridor's strategic mandate is to "provide a **safe** and **efficient** transportation system to support Alberta's economic, social and environmental vitality."

(a) Soil Slope (b) Rock Slope (c) Embankment (d) Retaining Wall (e) Subgrade

Objectives for GAM Pilot Study

Defining and Locating Assets:

- Develop a **taxonomy** that can be applied for consistent classification of AT's geotechnical assets / geohazard sites.

Current Condition and **Performance** Measure:

- Develop a risk-based rating system that incorporates measures of **asset condition and (monetized) consequences** of failure.

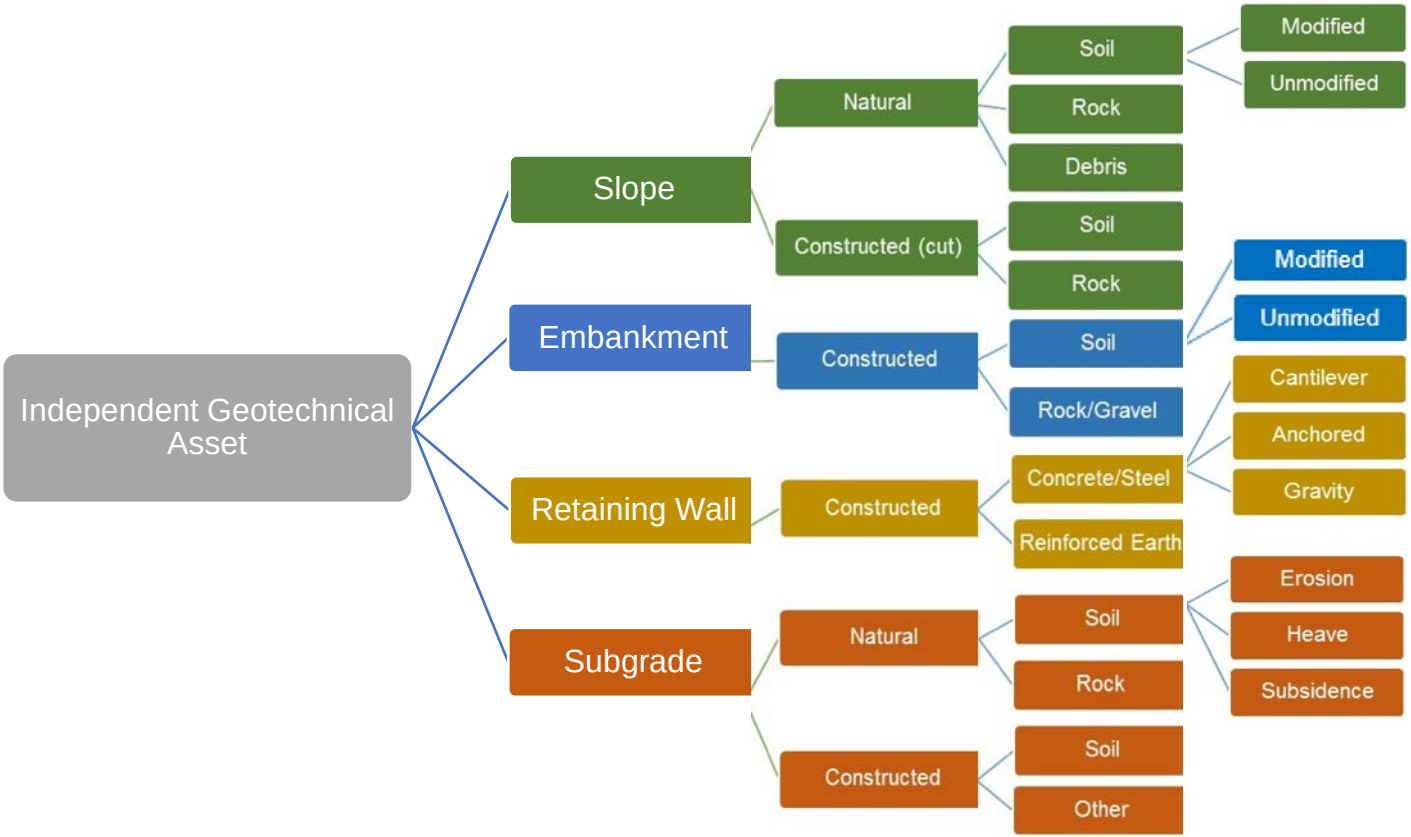
Investment Analysis:

- Recommend deterioration models and unit treatment costs, for **forecasting** future inventory condition and associated funding requirements.
- Develop decision making tools for **prioritization** of projects (e.g. BCR) across multiple portfolios.

NCHRP. 2019. Research Report 903.

Alberta Government

Taxonomy of Geotechnical Assets



Classification: Public

Taxonomy modified from Anderson et al. (2016)

Current Condition

Asset Condition Rating

Risk = **Probability** x Consequence

Mean Time Between Adverse Events:				
> 20 years	**20 – 10 years**	**10 – 5 years**	**5 – 2 years**	**2 – 0.5 years**
Very Good	**Good**	**Fair**	**Poor**	**Very Poor**
				
Any **defects are minor** and within the normal range for newly constructed or fabricated elements.	**Low to moderate extent of low-severity distress.** Distress present does not compromise the element function or asset performance.	Evidence of **widespread low-severity distress or localized medium-severity distress**, that may compromise performance in the medium-term.	**Widespread medium-to-severe distress**. Marginally-functioning, severely distressed elements threaten overall asset integrity.	**Widespread high-severity distress**. The asset is no longer functioning as intended, and may result in a service disruption at any time.
Probability of Disruption:				
Rare (< 5%)	**Unlikely (5 - 10%)**	**Possible (10 - 18%)**	**Probable (18 – 39%)**	**Imminent (39 – 85%)**

Annualized Probability of Disruption $= 1 - e^{(-1/t)}$

Assess Performance

Asset Consequence Rating

Risk = Probability x **Consequence**

Consequence:				
Negligible	**Minor Delay**	**Moderate Delay**	**Major Delay**	**Detour**
1 - 2	**3 - 4**	**5 - 6**	**7 - 8**	**9 - 10**
				
Routine maintenance required on an as-needed basis (cleaning ditches, sealing cracks).	Minor repairs required based on industry standard practices (pavement patching, off-highway work within ROW).	Significant repairs required to single lane of a multi-lane corridor.	Rehabilitation or reconstruction to one direction of the highway required.	Rehabilitation or reconstruction to full width of highway required.
		Vehicle damage possible.	User injury or environmental impacts possible.	User injury or fatality, or environmental impacts likely.
Speed restrictions or single lane closure for up to 0.5 day.	**Speed restrictions or single lane closure for up to 2 week.**	**Speed restrictions or single lane closure for up to 30 days.**	**Alternating traffic for up to 60 days.**	**Full closure with traffic detour for up to 90 days.**

Monetizing the Risk

$Risk = %Probability x $Consequence

$**Risk** = **Probability** (%, annual likelihood of occurrence) x **Consequence** ($, for users and owner)

Consequence
Negligible
Minor
Moderate
Major
Critical

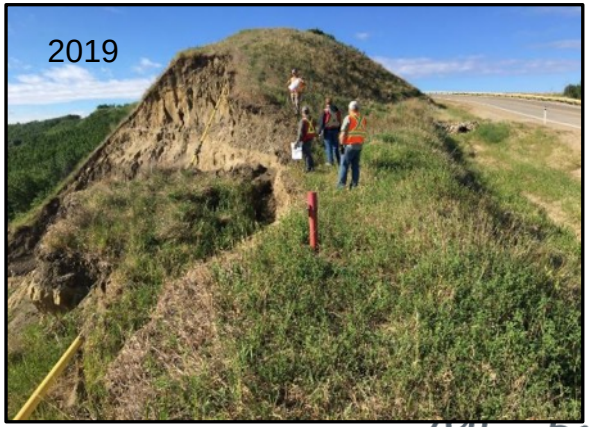
Agency Consequence

Restore Activity	Agency ($)
Maintain	$29,685
Maintain	$29,685
Rehab	$210,025
Rehab	$210,025
Reconstruct	$2,121,408

User Consequence

Impact Type	Impact Duration (days)	User ($)
No Impact	0.5	$127
Shoulder	2	$509
One Lane	30	$69,045
One Direction	60	$232,830
Both Direction	90	$3,051,882

Deterioration of Geotechnical Assets



Classification: Public

Deterioration Models

Probabilistic Approach– simplified geohazard deterioration models can be developed using expert judgement and accumulated experience.

e.g. from Alaska DOT's Geotechnical Asset Management Plan: $p_{jj} = 0.5^{\left(\frac{1}{t}\right)}$

Where j = condition state (before and after 1 year)
t = transition time in years

After Thompson (2017)

Soil Slopes	Starting Condition State				
	Very Good	Good	Fair	Poor	Very Poor
Transition time (years)	55.0	23.1	12.6	7.6	—
Same-state probability	0.9875	0.9704	0.9465	0.9128	1.0000
Next-state probability	0.0125	0.0296	0.0535	0.0872	0.0000

Investment Analysis

Site-Level Decision Framework (BCR)

AssetID	Asset Type	AADT	Percent Commercial	Highway Class	Detour Length (km)	Probability Level	Consequence Level	Rec Treatment	Recommended Treatment PV Cost	PV $Benefits in Reduced $Risk	PV $Benefits over Recommended Treatment PV Cost	50-Year BCR Priority Rank
GP004	Slope	1180	32.2	Arterial	90.2	Very Poor	Major	Rehab	$551,776	$13,413,172	24	1
NC011	Slope	1240	25.5	Arterial	167.1	Very Poor	Major	Rehab	$979,230	$19,381,970	20	2
C018	Slope	290	8.7	Park Access	29.0	Very Poor	Major	Rehab	$526,332	$9,057,137	17	3
GP028	Embankment	7220	34.6	Principal Arterial	347.8	Poor	Moderate	Reconstruct	$767,711	$10,943,083	14	4
GP029	Slope	4050	21.8	Arterial	26.0	Poor	Major	Reconstruct	$1,353,425	$18,652,949	14	5


GP004

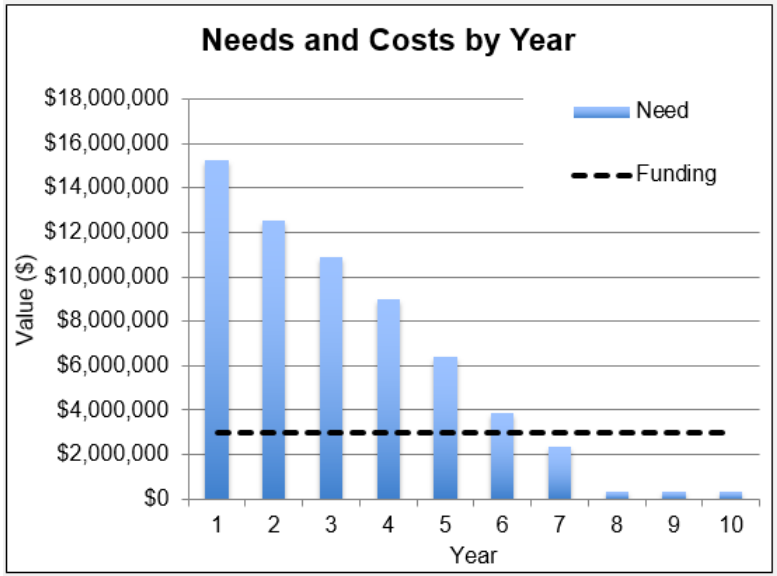

NC011

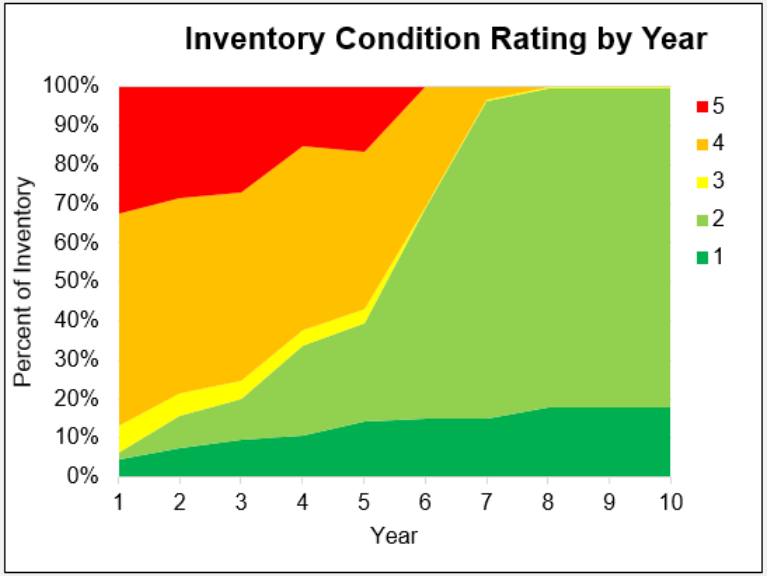

C018


GP028


GP029

Inventory-Level Forecasting





Customized GAM Planner Excel Workbook Tool

Alberta Transportation
Geotechnical Asset Management Planner

Based on NCHRP Project 24-46 GAM Planner

Alberta Transportation | TETRA TECH

Protect | Unprotect

MAIN MENU

DATA TABLES

Inventory	Opens the **Inventory Table** to enter or edit information for the inventory of assets.
Inspection	Opens the **Inspection Table** containing Inspections database.
Treatments	Opens the **Treatments Table** containing Available Treatments database.
Treatments History	Opens the **Treatments History Table** database to add completed treatments.
Instruments	Opens the **Instruments Table** database to add Instruments.

ASSET MODEL ADMINISTRATION

Create Asset Model	Create a new Asset Model based on **Asset Model Builder**.
Edit Asset Model	Open and Edit an existing Asset Model Worksheet.
Delete Asset Model	Select an existing Asset Model to Delete.
Build and Solve Asset Specific Models	Build Asset Specific Models for all Assets in **Inventory Table**.
Asset Models	Open the list of Asset Models built using the **Build Asset Models** for individual AssetID.

GAM FRAMEWORK PARAMETERS

Taxonomy	View or update the **Taxonomy**.
Probabilities	View or update **Markov Deterioration Models** and **Adverse Event Rates**.
Probabilities and Consequence Levels	View or update **Probabilities Condition** and **Consequence Levels.**
User Costs Model	View or update **User Costs** Model.
50-Year Monetized Risk Model	Opens the **Monetized Risk Calculation Model.**
Asset Model Builder	Asset Model Builder is the template model used to create new models.

PROVINCE INVENTORY POPULATION TABLES

Traffic Volume	Opens the **Traffic Volume Table.**
Detour Length	Opens the **Detour Length** Table.
Hwy Service Classification	Opens the **Hwy Service Classification** Table.
Highway Contract Maintenance Area	Opens the **Highway Contract Maintenance Areas** Table.

FIELD INSPECTION REPORT

Field Inspection Report	Open **Field Inspection Report**
Create Blank Field Inspection Reports	Prepare Empty **Field Inspection Reports** for Inspection by Selecting **'Yes'** in Export Column of Inspection Table.
Import Filled Field Inspection Reports	Import Filled **Field Inspection Reports** after Inspection to **Inspection Table.**

PROGRAM SIMULATION

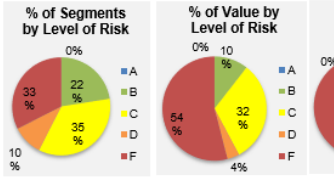
Summary Results	Opens the **Summary Results** worksheet to enter budgets by year and view summary results.
Detailed Results	Opens the **Detailed Results** worksheet to show details on a selected asset.
Dashboard	Opens the **Dashboard** worksheet.

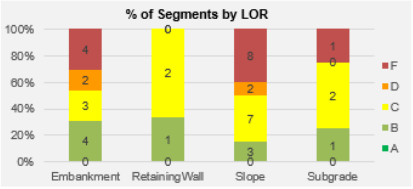
Note: To use the tool, it is necessary to enable macros. Also, the Excel Solver must be installed. The Excel Solver is a plug-in provided with Excel.

SUMMARY STATISTICS

ASSET DATA		ANALYSIS RESULTS	
No. of Asset Models:	9	Initial Needs:	$27,761,953
Number of Assets:	40	Spent Over 10 Years:	$35,370,796
Number of Sites:	38	Remaining Backlog:	$11,195,734
Asset Reconstruction Value:	$96,697,445		
Asset $Risk Value:	$28,193,303		

Risk Level ($Risk)	Assets	Reconst Value	Current $Risk	Embankment	RetainingWall	Slope	Subgrade
A	0	$0	$0	0	0	0	0
B	9	$10,186,784	$20,512	4	1	3	1
C	14	$30,638,845	$188,753	3	2	7	2
D	4	$3,634,860	$287,243	2	0	2	0
F	13	$52,236,956	##########	4	0	8	1





Conclusion and Next Steps

Where we are:

Geohazard Risk Management Program (GRMP)

- Partial inventory of provincial geohazard sites (primarily soil slopes and embankments).
- Relative prioritization of geohazard sites for mitigation.
- Very limited ability to simulate future conditions and advocate for needed funding.
- No cross-asset comparison with bridge or pavement projects vying for funding.
- Antiquated data management system (TIMS).

Where we're going:

Geotechnical Asset Management Framework:

- Comprehensive inventory of natural and constructed geotechnical assets.
- Risk rating system applicable to the full range of geotechnical assets, with probability of failure and monetized consequences.
- Deterioration models to forecast future inventory condition and funding needs.
- Evidence-based performance measures and targets.
- Improved GIS-based tools, including mobile field inspection forms.

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Thank you

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