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SUCCESSES AND LESSONS LEARNED FROM 5 YEARS OF MONITORING RIVERBANK BIOENGINEERING PROJECTS IN CALGARY

SOURCE TO STREAM CONFERENCE

MIKE GALLANT, MSCE, P.ENG., CPESC

March 27, 2024



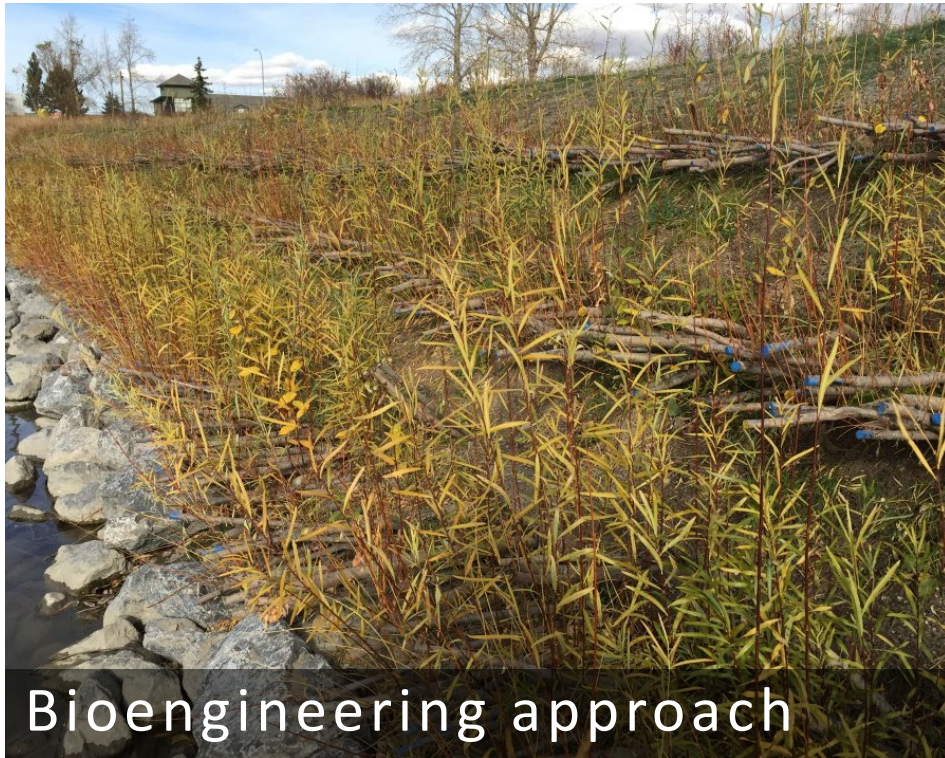
TOPICS

- Context City of Calgary Riparian Monitoring Program
- Effectiveness Monitoring Objectives
- What is a Bank Effectiveness Site?
- Bank Effectiveness Approaches & Methods
- Top 5 Results
- Summary
- Acknowledgements & Questions



RIVERBANK BIOENGINEERING

*Soil and water bioengineering is the use of living plant materials to perform some engineering function, usually **slope stabilization, erosion reduction, and vegetation establishment.***



Bioengineering approach



Conventional approach

BIOENGINEERING TRENDS

- Increase in use
 - Resurgence since the 1990's (Evette e
 - The green infrastructure sector in Ontario (2018):
 - Contributes ~\$4.64 billion in GDP
 - directly employs 84,400 people
 - potential to grow by 22% to 73% by 2030

Green Infrastructure Ontario Coalition, 2020

- Increase in funding
 - GC Nature Smart Climate Solutions Fund
\$4.7B over the next ten years (2021-2030)



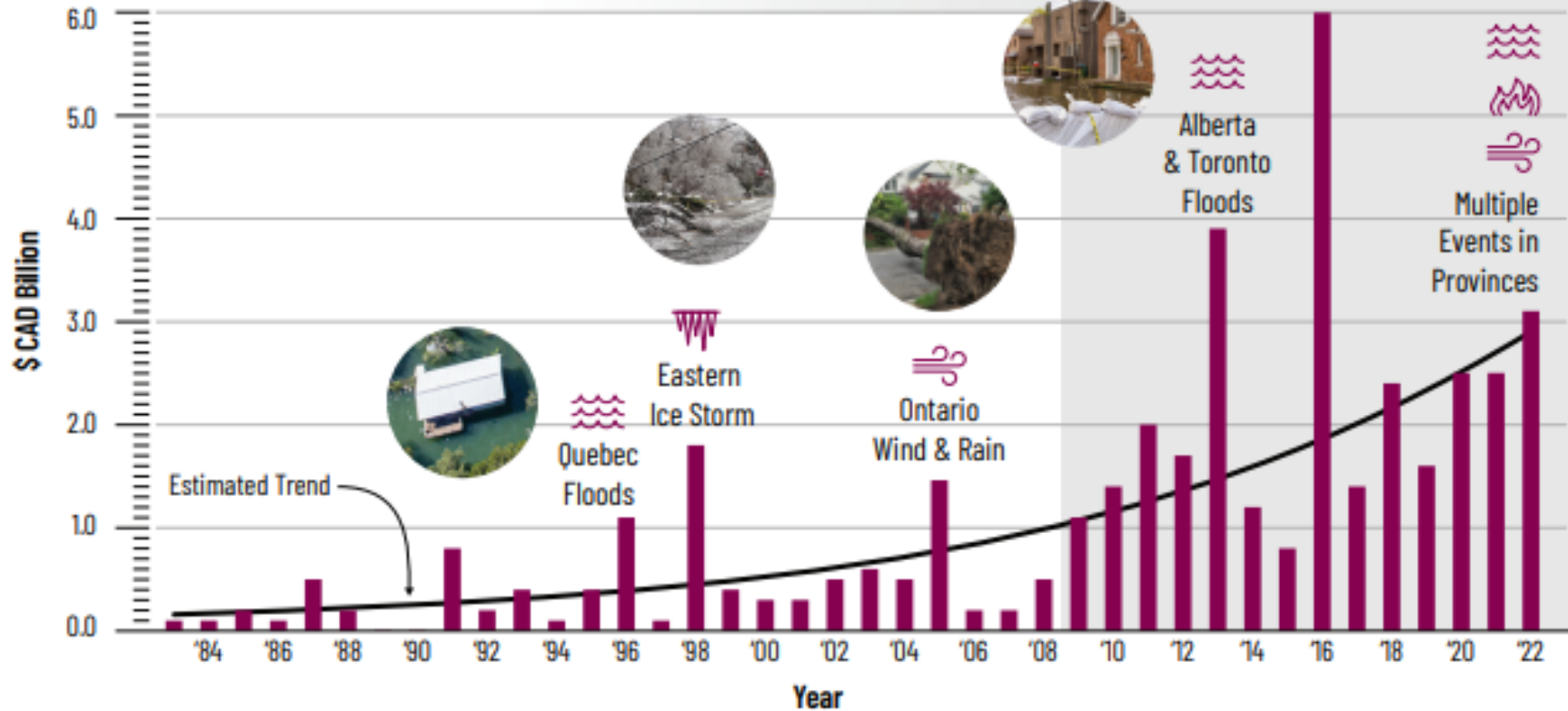
INCREASE IN NEED FOR BIOENGINEERING

Costs of Extreme Weather: Catastrophic Insurable Losses

\$ = \$\$\$\$

\$1 insured loss

\$3-4 uninsured losses incurred by government, business, individuals





PERFORMANCE MONITORING DATA GAP

“Long-term multi-year monitoring programs are needed to demonstrate performance over time and build confidence in Nature based Solutions”

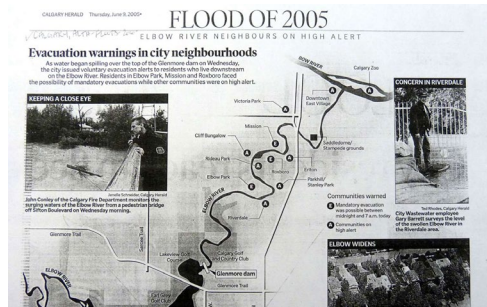
CSA Group. April 2023. Managing Flooding and Erosion at the Watershed Scale to Support Governments Using Nature Based Solutions

“Monitoring longevity and efficacy of engineering structures and material over time is one of the ten key issues facing riparian practitioners.”

Stokes et al. 2014. Ecological mitigation of hillslope instability: Ten key issues for researchers and practitioners. Plant and Soil.



DEVELOPMENT OF A MONITORING PROGRAM – CALGARY EXPERIENCE



2005 FLOOD

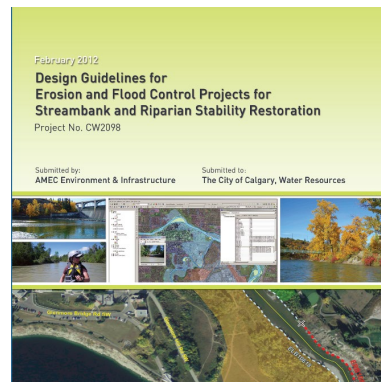


2013 FLOOD

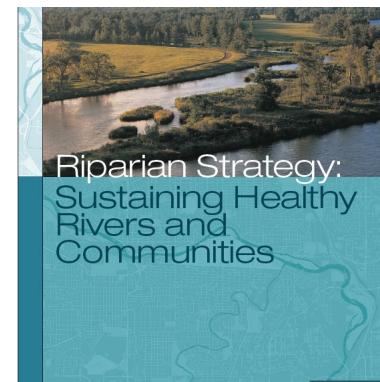


2016 – RIPARIAN ACTION PLAN

2012 – CITY OF CALGARY DESIGN GUIDELINES



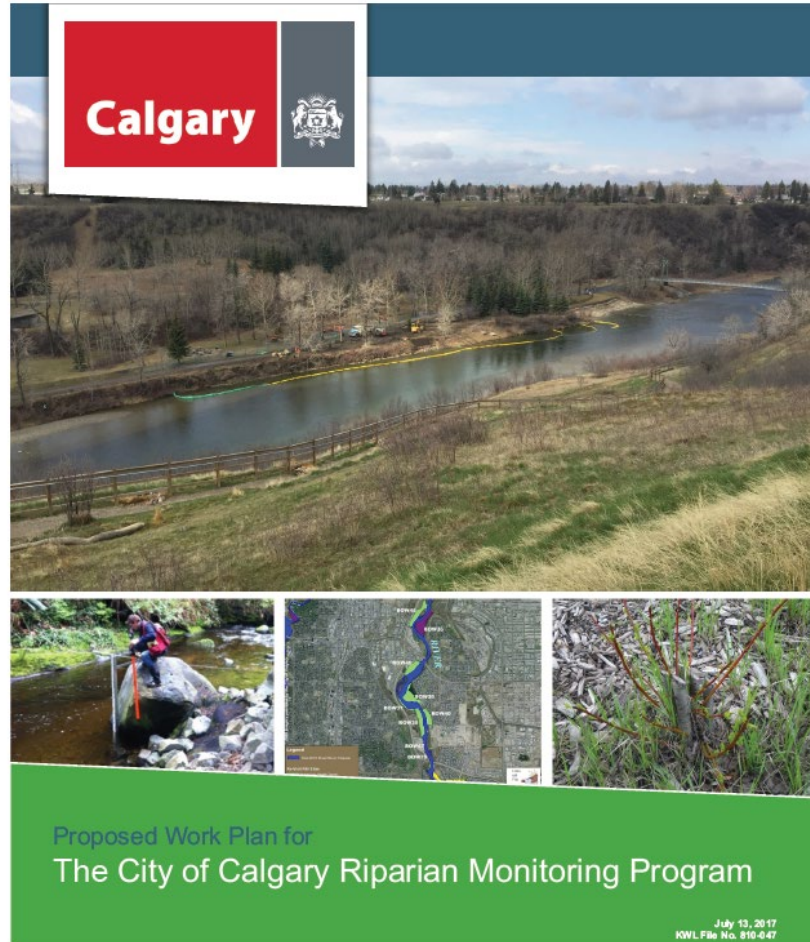
2013 – RIPARIAN STRATEGY



2017 – RIPARIAN MONITORING PROGRAM



THE CITY OF CALGARY RIPARIAN MONITORING PROGRAM



Proposed Work Plan for
The City of Calgary Riparian Monitoring Program

July 13, 2017
KWL File No. 910-247

Submitted by:

kwj KERR WOOD LEIDAL
consulting engineers

PHASE 1

- 201-2018
- Development of the Monitoring Plan

PHASE 2

- 201-2022
- Trend and effectiveness monitoring

PHASE 3

- 202-2026
- Ongoing trend monitoring and inventory work

The background image shows a riverbank with a bioengineering structure made of stacked logs and branches. A surveyor in a red vest and hat is standing on the structure, using a tripod-mounted instrument. The river is on the left, and a city building is visible in the distance under a cloudy sky.

BANK EFFECTIVENESS MONITORING OBJECTIVES

- Evaluate the effectiveness of:
 - Bioengineering and planting techniques
 - Maintenance procedures
- Identify advantages and limitations of bioengineering techniques
- Develop recommendations for:
 - Design improvements
 - Future long-term monitoring needs
- Reporting
 - Annual monitoring reports
 - Final program summary report



WHAT IS A BANK EFFECTIVENESS SITE?

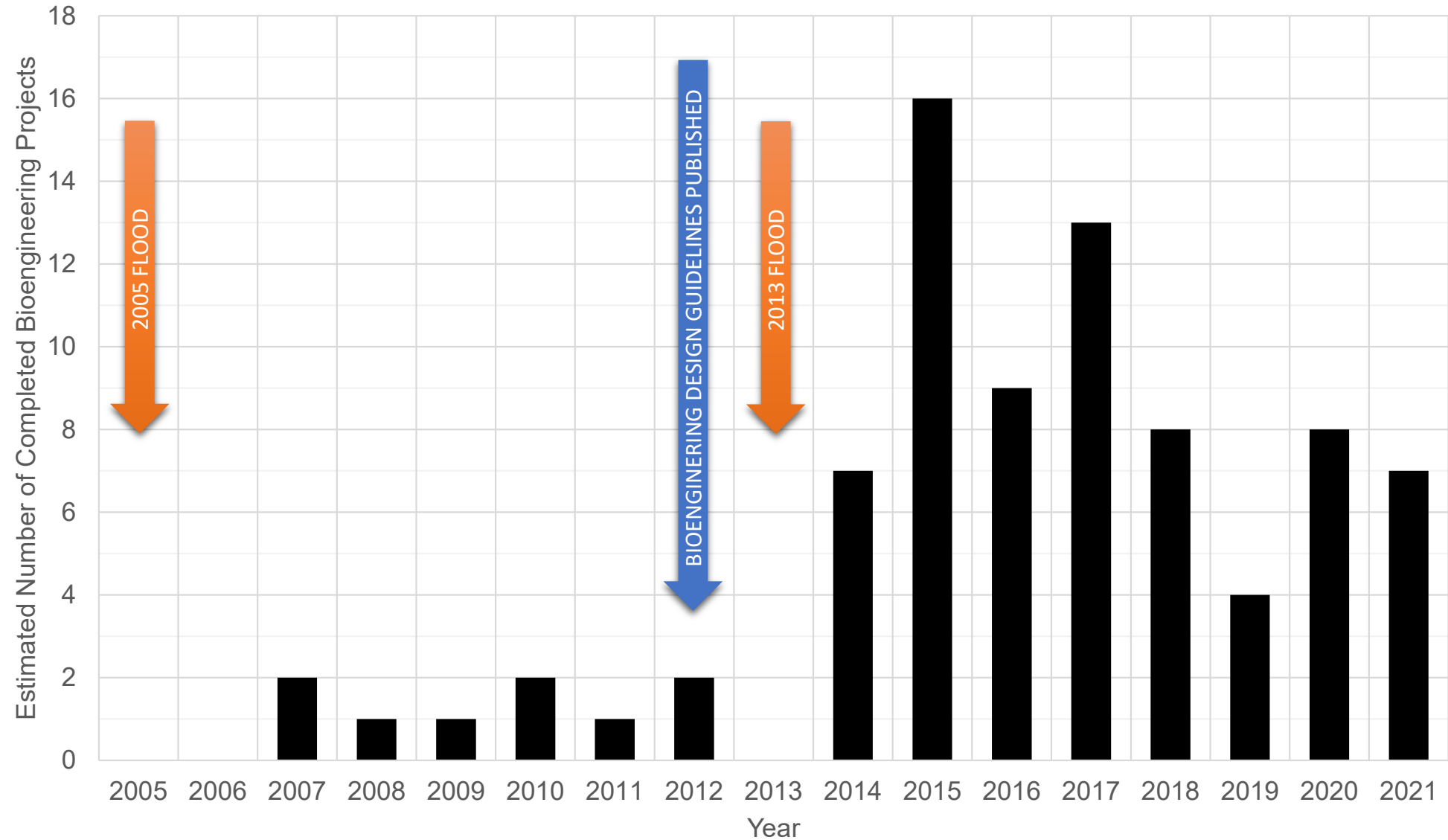
PURPOSE: BANK STABILIZATION, PROTECTION, OR EROSION MITIGATION

CONSTRUCTION: BIOENGINEERING STRUCTURAL + VEGETATION COMPONENTS

EXAMPLES: VEGETATED RIPRAP, SOIL WRAPS, BRUSH LAYERS, LIVE STAKING



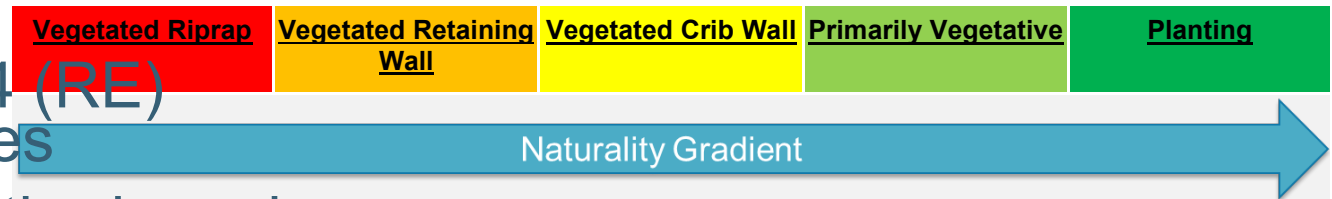
BIOENGINEERING PROJECTS IN CALGARY - 2005-2021



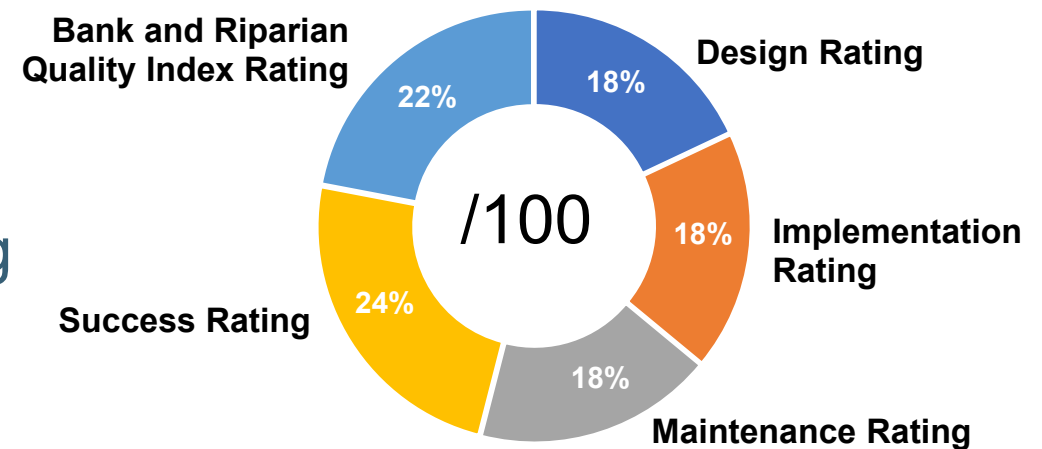


GENERAL APPROACH

- Identify suitable sites
- Classify sites into 5 (BE) / 4 (RE) typologies and 3 age classes
- Develop data collection method rating system
- Assess selected sites through desktop and field assessments
- Conduct statistical analysis
- Identify successes and learning
- Develop recommendations
- Document and report



Components of Rating System





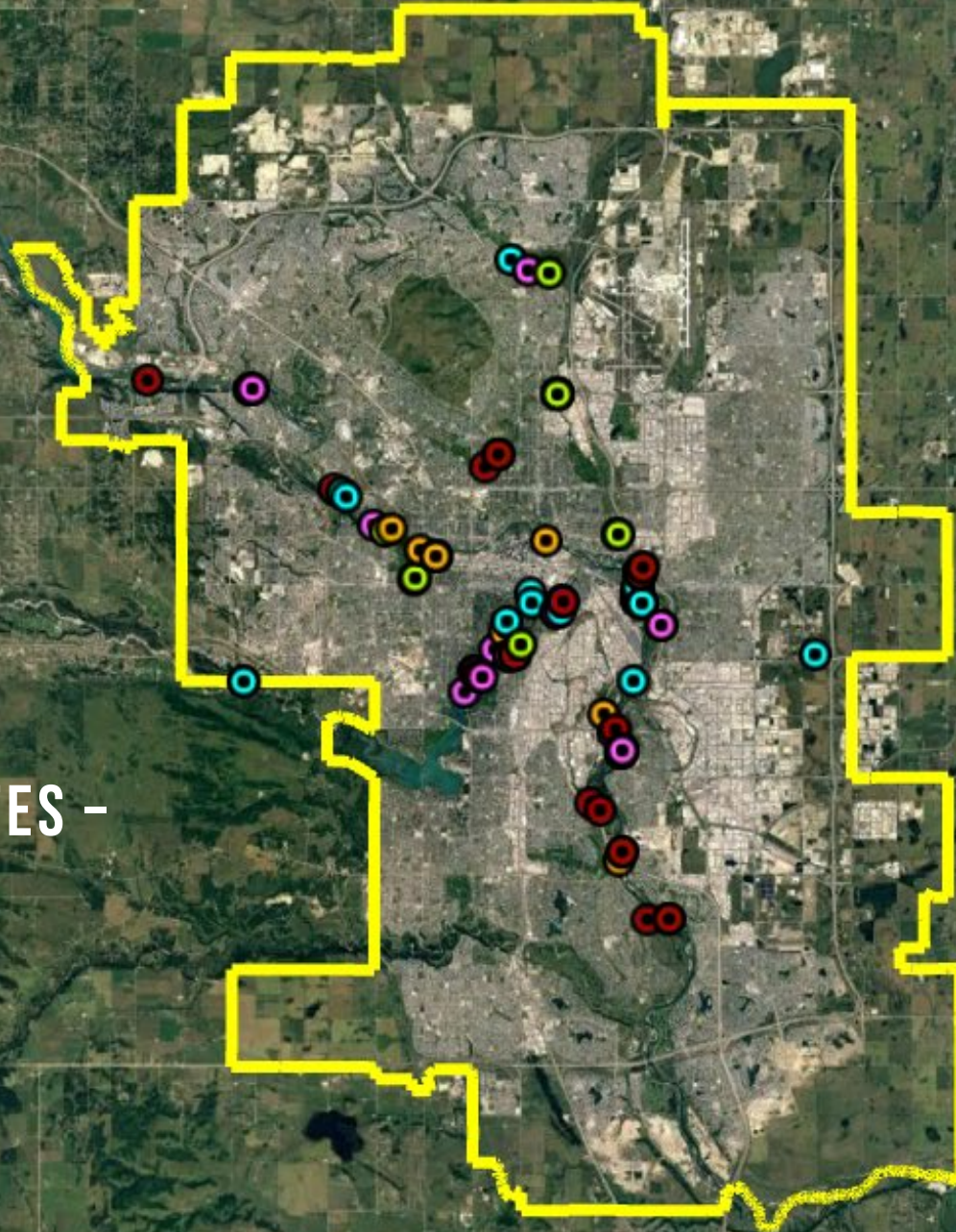
RMP DATASET HIGHLIGHTS

- Large and unique dataset
- 69 sites and 99 assessments, 7 fa
- Survival & growth data
 - 7,040 live cuttings of 14 species
 - 3,872 container plants of 31 species
 - 57 herbaceous species
- In total, ~8,000 plantings, ~8,400 from 39 species; ~300 transects; quadrats (all components)



BANK EFFECTIVENESS SITES - 2018 TO 2022

LEGEND			
Year	No. of Sites	Revisit Sites	Failure Sites
2018	19	0	5
2019	18	0	1
2020	21	9	1
2021	21	12	0
2022	20	9	0
Total	99	30	7



Watercourse	No. of Sites
Bow River	41
Elbow River	17
Nose Creek	4
West Nose Creek	3
Confederation Creek	1
Shaganappi Creek	2
Forest Lawn Creek	1
Total	69

Project Delivery	No. of Sites
City of Calgary	51
External	18



BIOENGINEERING TECHNIQUES



BRUSH LAYER
Sample size: 37



BRUSH MATTRESS
Sample size: 7



FASCINE
Sample size: 11



LIVE STAKING
Sample size: 21



PLANTING
Sample size: 55



VEGETATED CRIB WALL
Sample size: 10



VEGETATED RETAINING WALL
Sample size: 7



VEGETATED RIPRAP
Sample size: 24



WATTLE FENCE
Sample size: 1

**Sample size refers to the number of transects of each technique*

GENERAL FINDINGS / OBSERVATIONS RESULTS OVERVIEW

- Project documentation availability results
- Site stability and material condition observations
- Habitat enhancements
- Vegetation Design and installation
- Vegetation establishment
- Construction and maintenance practices
- Post construction performance monitoring recommendations
- Site specific limiting factors for project success
- Failure sites
- Ratings



STATISTICAL RESULTS OVERVIEW

- Woody vegetation Year 1 age class survivorship
- Woody vegetation growth data (Y1, Y3 and Y5+)
- Woody vegetation canopy cover and density of living shoots
- Seeding germination success
- Herbaceous vegetation cover and species diversity
- Invasive weed species monitoring
- Soil compaction impacts on vegetation growth
- Bioengineering technique success



TOP 5 RESULTS

1. Effectiveness of design, implementation and maintenance practices
2. Confirmation of best practices and documentation of innovations
3. Validation with survival and cover targets
4. Results for the top performing species and stock types
5. Filling data gap for post-construction monitoring methods, data, analysis and results



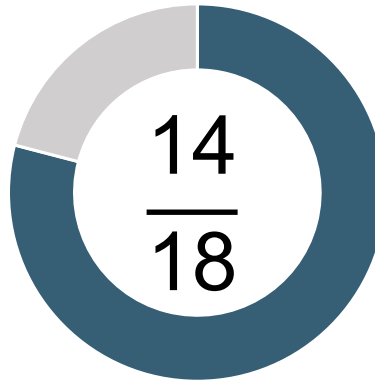
RATINGS

Overall Score

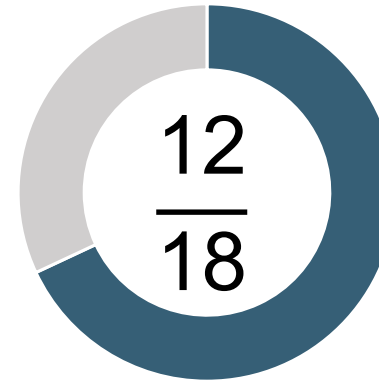
Rating	Weighted Score
Design	/18
Implementation	/18
Maintenance	/18
Success	/24
BRQI	/22
Total	/100

Rating Scores and Categories

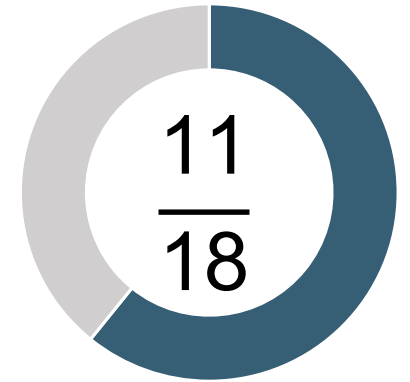
Score	Categories
75-100	Good
50-74	Fair
0-49	Poor



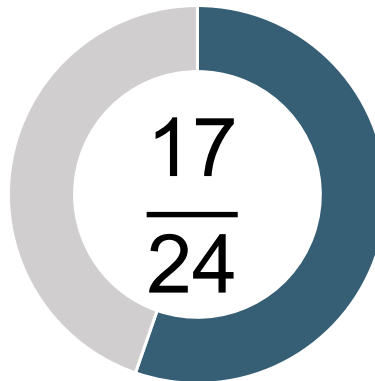
DESIGN



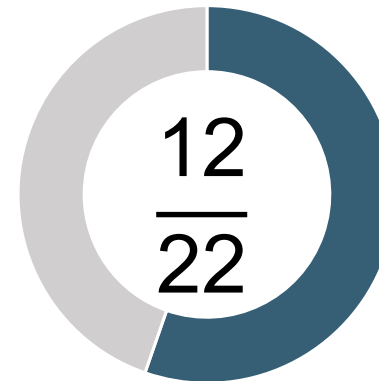
IMPLEMENTATION



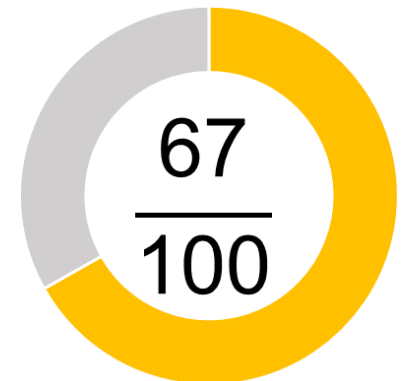
MAINTENANCE



SUCCESS



BRQI



TOTAL



HIGHEST RATED SITE

RIVERDALE AVENUE RETAINING WALL REPLACEMENT PHASE 2 - DOWNSTREAM

LIVE GRATING WITH BRUSH LAYERS AND ROCK TOE

EXCELLENT ESTABLISHMENT OF DEEPLY ROOTED CUTTINGS

OVERALL SCORE 92/100





FAILURE SITES

- 7 failure sites
 - Vegetation survival < 25% : 5 sites
 - Structural: 2 sites

Failure Factors	% of Sites
Other	100
Anaerobic soil	86
Bank or slope instability/erosion	71
Structure failure	71
Vegetation competition	71
Poor planting installation	71
Wildlife	71



TOP 5 RESULTS

1. Effectiveness of design, implementation and maintenance practices
- 2. Confirmation of best practices and documentation of innovations**
3. Validation with survival and cover targets
4. Results for the top performing species stock types
5. Filling data gap for construction monitoring methods, data, analysis





VEGETATION DESIGN AND INSTALLATION

**DEEP CUTTINGS &
GOOD ACCESS TO SOIL
MOISTURE**



**HOT AND DRY
ASPECTS**



**SHALLOW &
ANAEROBIC SOILS**



SOIL COMPACTION



VEGETATION DESIGN AND INSTALLATION - PLANTING TIMING



Vegetation Type ¹	JAN			FEB			MAR			APR				MAY			JUN			JUL			AUG			SEP			OCT			NOV				DEC					
Native Plant Seeding²										*	*	*	*																						+	+	+	+			
Container Plants³																																			+	+	+	+			
Live Cuttings - Harvest⁴																																									
Live Cuttings - Installation⁵																																									



SITE STABILITY AND MATERIALS SELECTION

TOE PROTECTION



~10% OF SITES WITH MINOR EROSION



'PERMANENT' VS 'TEMPORARY' MATERIALS



30% OF SITES WITH SYNTHETIC MATERIALS





INNOVATIONS AND RECOMMENDED PRACTICES

INNOVATION: TALL ROOTED CUTTINGS



INNOVATION: CONTRACTOR METHODS



RECOMMENDED PRACTICE: SOIL AMENDMENT



RECOMMENDED PRACTICE: FENCING





IMPORTANCE OF FENCING

BROWSED SITE



SHOOTS REGROWING



VEGETATION REGROWTH

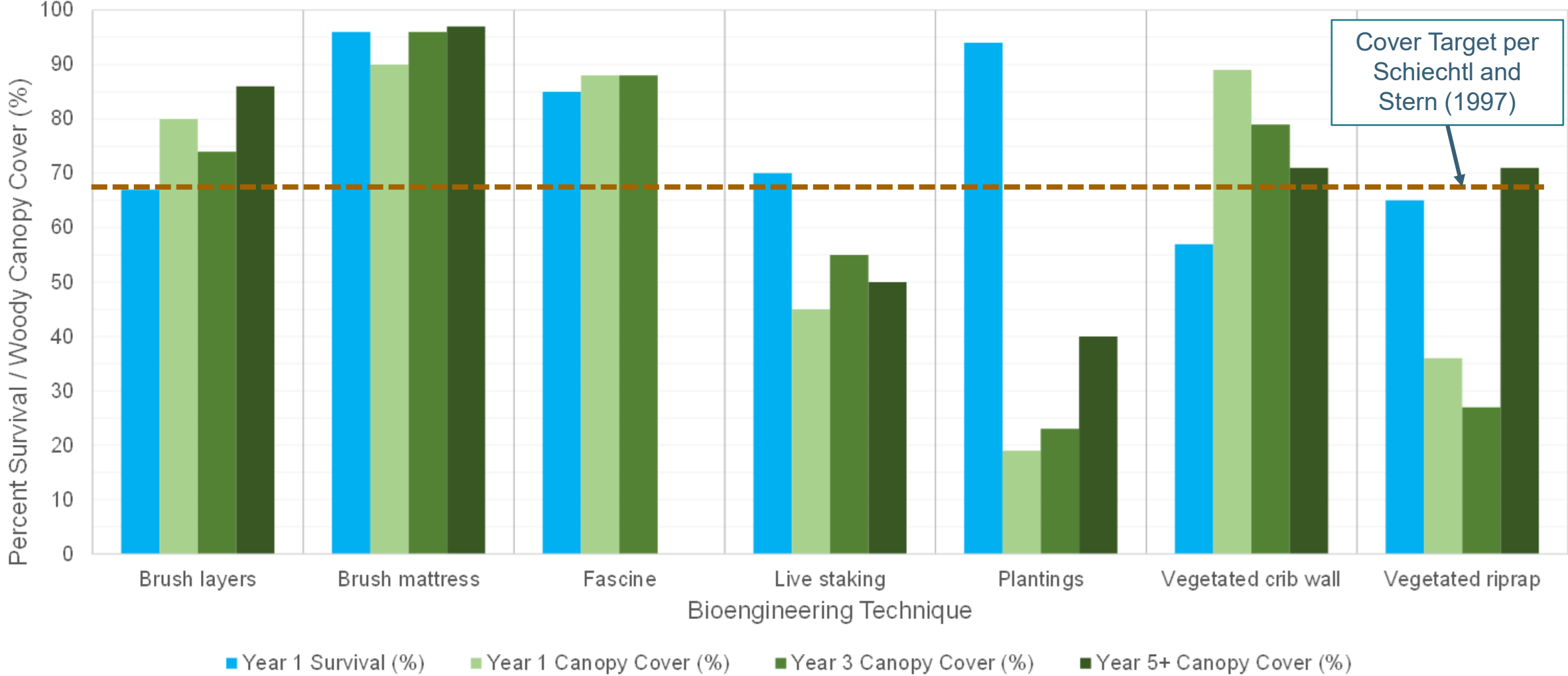


TOP 5 RESULTS

1. Effectiveness of design, implementation and maintenance practices
2. Confirmation of best practices and documentation of innovations
3. **Validation with survival and cover ta**
4. Results for the top performing speci stock types
5. Filling data gap for **construction monitoring methods, data, analysis**



SURVIVAL AND WOODY VEGETATION CANOPY COVER BY TECHNIQUE



TOP 5 RESULTS

1. Effectiveness of design, implementation and maintenance practices
2. Confirmation of best practices and documentation of innovations
3. Validation with survival and cover targets
4. **Results for the top performing species stock types**
5. Filling data gap for construction monitoring methods, data, analysis



BEST PERFORMING SPECIES

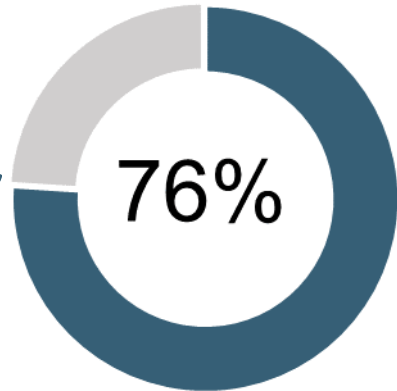
- Shrub species result
 - Sandbar willow *Salix interior*
- Herbaceous species results
 - 57 seeded species were expected
 - 5 native species identified as highest performing
 - More than half (n=28) were not observed, and 11 species seeded 5 or more times and not found
- Results support better species selection and seed mix design and to design for diversity!



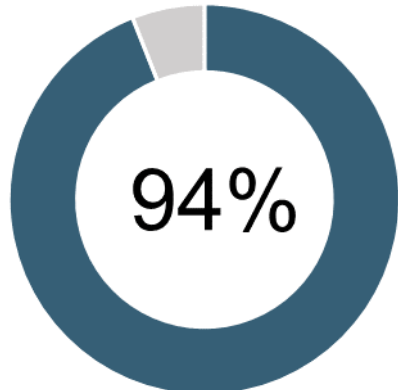


BEST PERFORMING VEGETATION STOCK TYPE

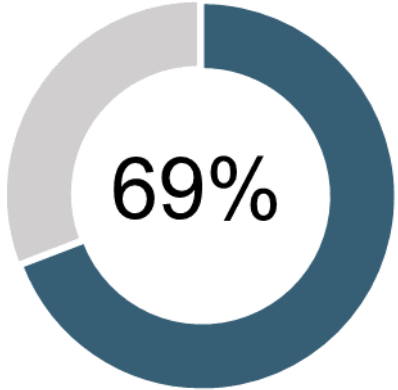
Overall Woody Vegetation Survival



Container Plants 1 Survival



Live Cuttings 1 Survival



TOP 5 RESULTS

1. Effectiveness of design, implementation and maintenance practices
2. Confirmation of best practices and documentation of innovations
3. Validation with survival and cover targets
4. Results for the top performing species and stock types
5. **Filling data gap for construction monitoring methods, data, analysis**



POST-CONSTRUCTION PERFORMANCE MONITORING

- Compare RMP data to new site data
 - Balsam poplar live cuttings: good in Year 1 but lagging in Year 3
- Identifies trajectory of planted vegetation
- Helps identify if mitigation measures may be needed at the site
- Same data available for bioengineering techniques



Species	Post-Construction Year	RMP Shoot Length Data			Measured Average Shoot Length (cm)
		25 th PCTL	Mean	75 th PCTL	
		(cm)	(cm)	(cm)	
Balsam poplar (<i>Populus balsamifera</i>)	1	26	44	56	58
Balsam poplar (<i>Populus balsamifera</i>)	3	67	99	129	68



RECOMMENDATIONS


- Structure design practices
- Vegetation design practices
- General program recommendations
- Improvements to City of Calgary project management practices
- Updates to Bioengineering Design Guidelines




SHARING RESULTS

RMP Riparian Areas in Calgary website: www.calgary.ca/Riparian

Bioengineering Demonstration and Education Project website: www.calgary.ca/BDEP



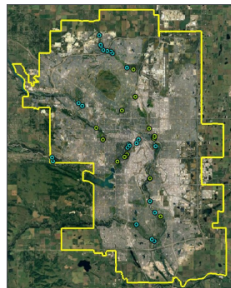
Calgary 

**The City of Calgary Riparian Monitoring Program
2018 Summary of Recommendations for Project Managers**
May 2019

The City of Calgary (The City) Riparian Monitoring Program (RMP) is a 5-year monitoring program (2018-2022) with the goal of providing a better understanding of:


1. Long-term riparian health trends, and
2. The effectiveness, limitations, and success factors of recent and ongoing river bank bioengineering, and riparian planting projects to inform continual improvements and best practices for project managers.

2018 Effectiveness Monitoring Sites
RMP monitoring sites were selected from a list provided by The City of 116 bioengineering bank and riparian planting projects constructed over the period of 2007 to 2018. In 2018 the monitoring sites consisted of 19 bioengineering bank sites (shown below in green), and 23 riparian planting sites (shown below in blue). These sites were located along the Bow River, Elbow River, Nose Creek, West Nose Creek, Fish Creek, Shaganappi Creek, and Confederation Creek. Of those sites, 4 bank and 8 riparian sites were identified as failures due to vegetation survival of less than 25% or due to unsuitability for monitoring.



Recommendations on How to Improve Riparian Projects

1. Improve project documentation and record keeping, and share it with the RMP team.
Why? Projects cannot be monitored as part of the RMP without an understanding of the design, implementation and maintenance that occurred. As-built drawings and maintenance records were particularly difficult to track down in 2018. RMP ratings for each project are based on available documentation; projects with incomplete documentation received lower ratings.
2. Apply a soil amendment on live cuttings.
Why? Applying a soil amendment was found to have a statistically significant increase on leader growth and a higher total cutting survival.
How? Use the soil amendment shown in Guideline M of the Design Guidelines for Erosion and Flood Control: Streambanks and Riparian (AMEC, 2012)



2018 RMP Effectiveness Monitoring Site





SUMMARY

- Much-needed data on structural conditions and plant establishment at bioengineering sites
- Unique insights due to its large number of sites and expansive dataset
- Findings can directly support improvement in bioengineering project design, implementation, and maintenance and overall success



CITY OF CALGARY TEAM

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Business Units Project Managers



EXTERNAL ORGANIZATIONS

Friends of Fish Creek, Trout
Unlimited, Valley Ridge Golf
Course, Alberta Agriculture and
Irrigation, Alberta Forestry, Parks
and Tourism

ACKNOWLEDGEMENTS AND QUESTIONS

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Jaymond, Marie-Anne Dusz





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