The City of Calgary
RIPARIAN MONITORING PROGRAM
PHASE 2 FINAL PROGRAM REPORT

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Executive Summary

The City of Calgary (The City) has committed to conserving and improving the ecological health of riparian areas in Calgary as outlined in the *Riparian Strategy* (City of Calgary, 2013) and the *Riparian Action Program* (City of Calgary, 2017). Riparian areas are critical habitats along Calgary's stream and river valleys, contributing to flood and drought resilience, water quality, biodiversity, and recreational amenities. The City's *Riparian Action Program* establishes actions to protect and manage riparian areas and sets a 2026 riparian health target of a city-wide average riparian health score of 72%.

To address key actions in the *Riparian Action Program*, The City initiated the Riparian Monitoring Program (RMP) in 2017. The main objectives of the program were to better understand long-term trends in riparian health in Calgary and the effectiveness of riparian restoration techniques in Calgary. Phase 1 was completed in 2018 and consisted of the development of the *Monitoring Plan* for this program. Phase 2 was undertaken from 2018 to 2022 as part of a five-year monitoring program to implement the RMP *Monitoring Plan*.

The purpose of this Final Program Report is to summarize the key results, successes, areas for improvement and recommendations that were documented during Phase 2 of the RMP. This report is not meant to be a specific guideline document for City project managers or practitioners. However, the results of the RMP will be accessible to City staff and external stakeholders including practitioners, contractors, and the public. This report provides information that can be used during the planning and design of riparian restoration projects, and the results may inform the development and/or review of City guidelines and procedures. Identified priority restoration areas may also inform future City restoration plans.

The RMP consists of five components, of which the key results from the following three components are summarized in this report: riparian health trend monitoring, bank effectiveness monitoring, and riparian effectiveness monitoring. Brief descriptions of these components are provided below.

- **Riparian health trend monitoring:** The Riparian Health Inventory (RHI) protocols were used to assess vegetation, soil, and hydrological parameters in riparian sites across major streams and rivers. The objectives were to track changes in riparian health, measure progress toward the city-wide riparian health target of 72%, and expand monitoring sites for a more representative cross-section of locations.

- **Bank effectiveness monitoring:** The success of riverbank bioengineering projects was evaluated by selecting representative monitoring sites, assessing structure and material performance, assessing vegetation establishment, and evaluating the projects' effectiveness after one, three, and five-or-more-years post-construction. The goal was to determine the effectiveness of different bioengineering techniques and provide recommendations for design improvements and long-term monitoring needs.

- **Riparian effectiveness monitoring:** The success of riparian restoration projects was evaluated by selecting representative monitoring sites, assessing vegetation establishment, and evaluating the projects' effectiveness after one, three, and five-or-more-years post-construction. The goal was to determine the effectiveness of different planting techniques and provide recommendations for design improvements and long-term monitoring needs.

Table 1 below summarizes key facts and highlights contained in this report.

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Table 1: Quick Facts and Key Highlights

Quick Facts	Trend Monitoring	Bank Effectiveness	Riparian Effectiveness
Data Collection Years	2007-2022 (16 years)	2018-2022 (5 years)	2018-2022 (5-years)
Number of Individual Sites/Projects Assessed for Riparian Health / Project Effectiveness	122 (104 permanent waterbodies[1]; 18 unnamed minor tributaries)	69 (52 City-delivered projects; 17 external projects)	42 (25 City-delivered projects; 17 external projects)
Total Number of Assessments (i.e., including revisit assessments)	780 (since 2007)	Detailed: 99	Reconnaissance: 42 Detailed: 59
Site Locations	Primarily along major rivers and streams (i.e., Bow River, Elbow River, Nose Creek and West Nose Creek)	Bow River - 41 sites Elbow River - 17 sites Nose Creek - 4 sites West Nose Creek - 3 sites Shaganappi Creek - 2 sites Confederation Creek - 1 site Forest Lawn Creek - 1 site	Bow River - 19 sites Elbow River - 8 sites Fish Creek - 6 sites Nose Creek – 1 site West Nose Creek - 8 sites
Monitoring Extent Highlights	Total of 591 ha of riparian area and 84 km of bank assessed since 2007	Total 7.6 km of bank assessed 10,912 trees and shrubs sampled	Total 16.5 km and 228 ha of bank area assessed 5,457 trees and shrubs sampled
Number of Failure Sites [2]	n/a	7 of 69 sites (5 City-delivered and 2 external projects)	12 of 42 sites (3 City-delivered and 9 external projects)
Current Average City-Wide Riparian Health Score	69% (compared to Baseline 61%)	n/a	n/a
Number of Assessed Techniques	n/a	9	2
Highest to Lowest Rated Technique [3]	n/a	Brush mattress; Vegetated crib wall; Vegetated retaining wall; Brush layers; Wattle fence; Fascine; Plantings; Vegetated Riprap; Live staking.	Planting; Live Staking

Notes:
1. Note that only 101 sites were included in the current health score due to overlap with other sites, and access constraints during relevant timing window leading to deferred assessments. See Section 2.14 in the main report for additional details.
2. Per the definition in the *Monitoring Plan* (KWL, 2018), a Year 1 site is determined to be a failure if: 1) the works are found to be missing, degraded or ineffective; and/or, 2) if the woody vegetation survival is < 25%. A Year 3 or 5+ site is a failure if the works are found to be missing, degraded or ineffective. 'Works' refers to the bioengineering approach (e.g., technique) used at a site.
3. Bioengineering technique rankings are based on a ranking of five woody vegetation growth parameters (leader growth, shoot length, diameter, Year 1 survival, and canopy cover). The preferred riparian effectiveness technique was determined based on Year 1 survivorship. Design / construction costs, construction complexity, or regulatory approval requirements/ timelines were not factored in the ranking.

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RMP Key Results

Below is a summary of key results. More detailed results can be found in the Technical Executive Summary and Sections 3.3 and 4.3 of this report.

Riparian Health Trend Monitoring Key Results

Long-Term Trend Analysis (Original 58 Sites)

The original trend analysis to support the preparation of the city-wide riparian health target in the *Riparian Action Program* report (City of Calgary, 2017) consisted of long-term data from **58** sites along major streams and rivers. These data were collected from 2007-2010, 2014-2015, and 2019-2020, with an approximate five-year revisit frequency. Based on that data, riparian health scores city-wide have increased from **61% to approximately 65%**, remaining in the *healthy, with problems* category[1] (the current City-wide riparian health score is provided on page 5). Factors contributing to this improvement include beneficial impacts from the 2013 flood along the Bow and Elbow Rivers such as the regeneration of poplar and other native trees where deposits from the flood provided ideal habitat for growth. In addition, there has been improved management and restoration efforts in some sites allowing for natural recovery of vegetation.

Riparian health trends by management zone show the largest score increase since baseline conditions for the **Restoration Management Zone**, a focal area for ongoing restoration projects city-wide. The highest average riparian health rating for riparian habitat is the **Conservation Management Zone** (i.e., natural environment parks such as Weaselhead Flats, the Inglewood Bird Sanctuary, and Bowmont Park).

By sub-basin, the Bow River's riparian health scores increased by approximately 3% from 2008-2010 to 2014/2015 but then slightly declined in 2019/2020,mainly due to post-flood landscaping and bank stabilization projects. Many of these projects included a bioengineering component that, although beneficial in the long term, can also negatively impact health in the short term while plants establish and mature. For example, these impacts can include increases in bare ground during construction or soil compaction from equipment which lessen over time as the area naturalizes and plants grow and mature. The Elbow River had different health scores for its upper and lower reaches (above and below the Glenmore Reservoir), with overall healthier scores for the upper reach and slight improvements in the lower reach. Nose Creek sites mostly rated as *unhealthy* due to historic impacts from channelization while West Nose Creek sites were generally *healthy, with problems*.

Table 2 below shows the long-term trends for key RHI parameters since 2007.

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[1] RMP trend monitoring component objective 1 and 2

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Table 2: General Long-Term Trends in Key Riparian Health Parameters Since 2007 (58 sites)

	Improving or Declining Parameters:		*Waterbody:*	*Contributing Factors:*
⬆	Improved cottonwood and balsam poplar regeneration Improved regeneration of other native trees	🌳	Bow River	– Post-2013 flood poplar and willow recruitment – Natural recovery following management improvements to fence-out riverbank habitats
	Improved regeneration of preferred shrubs		Upper Elbow River	– Post-2013 flood poplar and willow recruitment
	Improved vegetative cover Reduced human-caused bare ground		Lower Elbow River	– Riparian planting and bioengineering projects – Natural recovery following management improvements to fence-out riverbank habitats
⬇	Reduced root mass protection	🌳	Lower Elbow River, Nose Creek	– Lower Elbow: increasing riprap armouring at base of bank – Nose Creek: stormwater inputs and channelization increase bank slumping and erosion
	Increased human-caused bare ground	👣	Bow River	– Recreational trails reinstated post-flood and increasing use occurring in many river parks
	Increased invasive plants (canopy cover)	🌸	Bow River, Lower Elbow River, Nose Creek	– Increased expansion of pre-existing populations of weeds – New invasive species incursions and threats – Disturbance/bank repair related infestations
Watershed Limiting Factors:				
⬡	Control of flood peak and timing by upstream dams	🏞	Bow River	– All Bow River sites have score deductions due to stabilization of flows by operation of upstream dams (i.e., the Kananaskis Falls, Horseshoe Falls, Ghost and Bearspaw dams and an additional five hydroelectric facilities/dams located along tributaries of the Bow River).
	Channelization	🚜	Nose Creek	– The majority of Nose Creek south of Airport Trail NE was historically straightened, resulting in loss of natural meanders and historic floodplain riparian habitat.

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Expanded City-Wide Riparian Health Results (major streams and rivers only) and Current City-Wide Score

From 2014 onward and during Phase 2 of the RMP, the trend monitoring program expanded from 58 sites to 101 sites city-wide[2], resulting in a **current city-wide riparian health score of approximately 69%** (*healthy, with problems*)[3]. Figure 1 below shows the results for the expanded project area in comparison to baseline. The highest rated riparian sites were located along the southeast fringe for the Bow River and in Weaselhead Flats and Clearwater Legacy Parks for the Elbow River.

Figure 1: City-Wide Current Score Summary by Waterbody (n=101 sites, 84 km of bank length; 590.5 ha of habitat)

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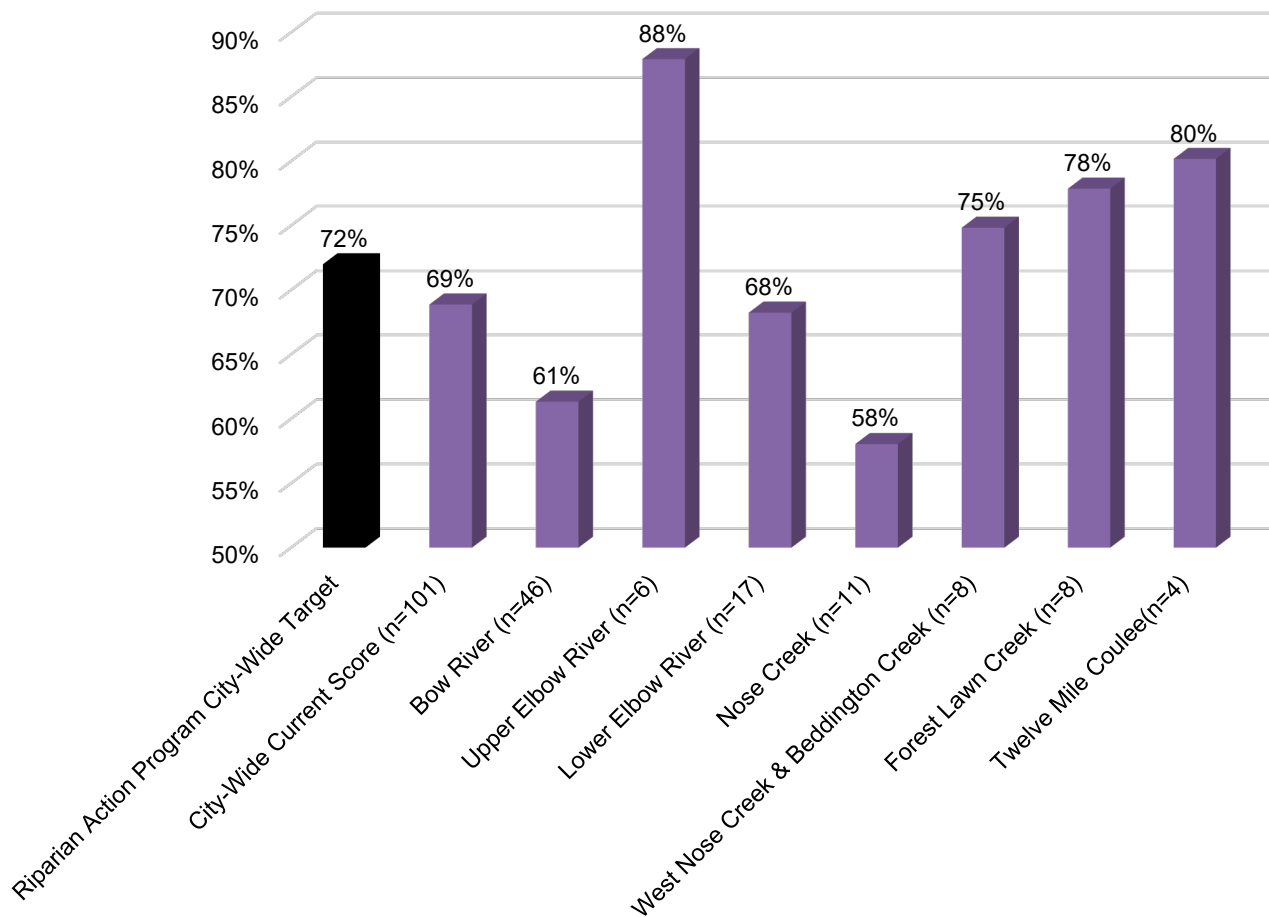
[2] RMP trend monitoring component objective 3

[3] RMP trend monitoring component objectives 1 and 2

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Bank Effectiveness Monitoring Key Results

For the bank effectiveness component of the RMP, each site was classified by typology and age class[4]. Data collection included observations of physical stability and material condition, and measurements of vegetation survival and growth. A rating system was used to evaluate project effectiveness, combining five individual ratings to create an overall score out of 100. Statistical analysis was conducted to determine statistically significant results regarding age class, typology, bioengineering technique, vegetation survival and growth, beneficial practices, and limiting factors. Key results are provided below and split into general findings and statistical results.

General Findings

Monitoring Data Filling Key Knowledge Gap

The data that was collected for the bank effectiveness component is helping to fill a key technical, practical, and scientific knowledge gap for bioengineering projects. Until now there have been few monitoring studies conducted for bioengineering projects in Calgary or elsewhere in the province, across North America, or worldwide and none as thorough as the RMP.

Project Documentation[5]

Key project documentation such as design drawings, maintenance records, and as-built reports was not always available to the RMP team for review for the monitoring sites. As-built/record drawings and maintenance records were available for less than 50% of assessed sites.

Physical Stability and Material Condition[6]

Results showed that most sites were stable with little erosion, but there were some erosion issues due to unsuitable materials or design – particularly in the backfill material in vegetated crib walls. Permanent bioengineering construction materials such as rock, timber, concrete, and steel were generally in good condition, but the condition of temporary materials varied with some issues with installation and material selection. Synthetic erosion and sediment control materials were observed at 21 of the 69 bank effectiveness monitoring sites (30%) and will persist in the environment, and where exposed may cause risks for wildlife, fish, and the public over the lifespan of the product.

Habitat Enhancements [6]

Habitat enhancements such as instream boulders, woody debris, and overhanging vegetation that were incorporated into bioengineering structures are performing well. For example, overhanging cover was observed to be 2 m to 3 m at some locations and providing good overhead shade, cover, and organic debris input for fish habitat.

Vegetation Design, Installation, and Establishment [6]

Most often, vegetation species and stock were selected appropriately. A relatively new stock referred to as tall rooted stakes were found to provide a good option for summer construction when the use of dormant live cuttings is no longer recommended. Poor vegetation growth and high mortality was observed at sites where best

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[4] RMP effectiveness monitoring component objective 2

[5] RMP effectiveness monitoring component objective 8

[6] RMP effectiveness monitoring component objective 3, 4, 5, and 7

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practices for scheduling the installation of live cuttings was not followed. It was visually estimated that overall an average of 85% of the streambank for all monitoring sites had deep, binding root mass with 23 sites with 100%. It was observed for several sites that full canopy closure from higher density planting was limiting invasive weed growth, root growth from planted vegetation was binding soil, and that natural stabilization and ecological development is occurring over time.

Site-Specific Limiting Factors[7]

The dry climate governs bioengineering design in Calgary overall due to low soil moisture conditions. Because of this, irrigation is needed to support vegetation establishment until an adequate root system is established. For failure sites, the next most often documented site-specific limiting factors for site stability and vegetation establishment were "erosion", "existing vegetation competition", and "maintenance issues" (six of seven sites). Over all sites, the most often noted limiting factors for site stability and vegetation establishment were "maintenance issues" (93 of 99 assessments), "existing vegetation competition" (92 of 99 assessments), and "compacted soils" (76 of 99 assessments). Additionally, soil compaction was found to have a negative impact on vegetation growth.

Maintenance Practices[8]

Maintenance documentation needs to be improved, and practices such as weed whacking should be discontinued in favor of hand practices due to the damage to planted vegetation that was observed. While limited irrigation data was available, better irrigation appears to be needed for container plants that are installed above the bank on the terrace. Temporary browsing protection fencing needs to be repaired immediately, otherwise severe browsing has been observed to occur.

Failure Sites[9]

Seven failure sites were identified, mainly due to Year 1 age class vegetation survival of less than 25% or structural issues.

Performance Targets[10]

Results for woody vegetation survival, cover, and density of living shoots for several bioengineering techniques were compared to the literature values to validate site performance and confirm if literature targets are applicable to projects in Calgary. Several published targets were met or exceeded, confirmed that the literature values can be used for Calgary bioengineering projects.

Highest Rated Bank Effectiveness Site [9]

Many sites were observed with outstanding vegetation establishment and growth across the city that will serve as benchmarks for future bioengineering and riparian planting projects. **The highest-rated site was the Riverdale Avenue Retaining Wall Replacement Phase 2 – Downstream on the Elbow River** (see Photo 3 Photo 2 below).

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[7] RMP effectiveness monitoring component objectives 3, 4 and 5

[8] RMP effectiveness monitoring component objective 8

[9] RMP effectiveness monitoring component objective 1

[10] RMP effectiveness monitoring component objective 6

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Photo 1: Bank Effectiveness Highest Rated Site: Riverdale Avenue Retaining Wall Replacement Phase 2 – Downstream (July 21, 2020)

Photo 2: Bank Effectiveness Highest Rated Site: Riverdale Avenue Retaining Wall Replacement Phase 2 – Downstream (July 25, 2022)

Statistical Results

Details on the statistical approach are included in the Technical Summary and the main report Section 3.2.

Woody Vegetation Survival and Growth[11]

Survival rates for Year 1 live cuttings and container plants combined were **76%**, which was significantly weighted towards the much higher Year 1 survival for container plants over live cuttings. Based on data from a total of 3,872 container plants and 5,298 live cuttings**, sandbar willow (*Salix interior*) was the highest performing species** as both a container plant and live cutting. Unique growth data for species used in Calgary were collected and are presented in the report. Tall rooted stakes were found to be a suitable plant material that can be used outside of the dormancy period for traditional live cuttings[12].

Seeding Germination Success [11]

Seeding germination success analysis showed that many species are not present; however, five native species were identified to have the best success rates, including slender wheat grass (*Elymus trachycaulus* ssp. *trachycaulus*), fowl bluegrass (*Poa palustris*) Canada wild rye (*Elymus canadensis*), wild blue flax (*Linum lewisii*), and northern wheat grass (*Elymus lanceolatus*).

Matching Vegetation Elevation, Soil Amendment, and Fencing [11]

Beneficial practices that were identified as statistically significant included matching the lowest elevation of planted woody vegetation with native woody vegetation, using soil amendment, and installing fencing around sites until vegetation establishes.

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[11] RMP effectiveness monitoring component objective 3, 4, 5, and 6

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Bioengineering Technique Success[13]

Based on data from five woody vegetation growth parameters (leader growth, shoot length, diameter, Year 1 survival, and woody vegetation canopy cover), each bioengineering technique was ranked from highest to lowest performance. **The highest rated technique was brush mattress, followed by the vegetated crib wall, vegetated retaining wall, and brush layers**. The lowest performing technique based on the above listed parameters was **live staking.**

Invasive Plant Species [14]

Noxious weeds were identified at most sites and two *Prohibited noxious* weeds (nodding thistle [*Carduus nutans*] and common buckthorn [*Rhamnus cathartica*]) were identified on the Elbow River at Sandy Beach and at the Riverdale pedestrian bridge.

Riparian Effectiveness Monitoring Key Results

For the riparian effectiveness component of the RMP, each site was classified by typology and age class[15]. Data collection involved desktop reviews and field assessments of functional performance, vegetation growth, and health parameters. Ratings were calculated similarly to the bank effectiveness component, using five categories to determine the overall score.

General Findings

Record Keeping [14]

Improved record keeping of project-specific documents was noted as a potential improvement area for future riparian effectiveness projects.

Site-Specific Limiting Factors [16]

In the same way as the bank effectiveness component, the dry climate is the overall governing limiting factor for riparian restoration design, but other, site-specific limiting factors were assessed as well. Herbaceous species competition, wildlife, and human disturbance were found to be the main limiting factors to restoration success, affecting 83%, 31%, and 26% of sites, respectively.

Failure Sites [17]

Twelve total failures and 3 partial failures were observed, with the Native Tree and Shrub Cuttings typology having the most failures due to Year 1 age class vegetation survival of less than 25%.

Highest Riparian Effectiveness Rated Site [17]

The overall scores for the sites ranged from Poor to Good, with maintenance, implementation, and BRQI ratings often scoring lower. **Griffiths Woods – RBC and Other Plantings** site (see Photo 3 and Photo 4 below)

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[13] RMP effectiveness monitoring component objective 6

[14] RMP effectiveness monitoring component objective 8

[15] RMP effectiveness monitoring component objective 2

[16] RMP effectiveness monitoring component objectives 3, 4 and 5

[17] RMP effectiveness monitoring component objective 1

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received the highest overall rating among all riparian monitoring sites, with success factors including good planting design and appropriate native species selection.

Photo 3: Riparian Effectiveness Highest Rated Site: Griffiths Woods – RBC and Other Plantings site (2018)

Photo 4: Riparian Effectiveness Highest Rated Site: Griffiths Woods – RBC and Other Plantings site (2018)

Statistical Results

Details on the statistical approach are included in the Technical Summary and the main report Section 4.2.

Vegetation Survival and Growth [18]

A large amount of data was collected on the growth performance of individual live cutting and container shrub species, data which will be useful to practitioners when selecting woody species for future restoration projects. In general, container plants had higher survival rates one year after installation than live cuttings. Species like **balsam poplar** (*Populus balsamifera*), **red-osier dogwood** (*Cornus sericea*), and **sandbar willow** had significantly higher survivorship rates as container plants compared to live cuttings. Survivorship and growth of Year 1 cuttings was higher on southerly aspects, but the results for plantings were not significant. When live cuttings did establish, their growth rate outperformed container plants. Stem diameters and shoot lengths of woody species as a whole were generally higher for older age class sites, indicating successful establishment over time. Leader growth tended to be higher for Year 1 and 3 age class sites compared to Year 5+ sites, a trend which is reflects natural slowing of growth as vegetation ages.

Herbaceous Seed Mixes [18]

Grass species that established best when used in herbaceous seed mixes included: slender wheat grass (*Elymus trachycaulus* ssp. *trachycaulus*), northern wheat grass (*E. lanceolatus*), Canda wild rye (*E. canadensis*), fowl bluegrass (*Poa palustris*), and western wheat grass (*Pascopyrum smithii*). Forb species that established best included: tall goldenrod (*Solidago altissimus*), Canada milk vetch (*Astragalus canadensis*), purple prairie clover (*Dalea purpurea*), wild blue flax (*Linum lewisii*), and wild vetch (*Vicia americana*).

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[18] RMP effectiveness monitoring component objectives 3, 4, and 5

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Invasive Plant Species [19]

Invasive plant species were common at riparian restoration sites, with an average of five species present. *Prohibited Noxious* weeds observed included nodding thistle and common buckthorn, both of which were found at two sites each, the former along the Bow River and the latter along the Elbow River.

Soil Compaction [19]

Compacted soil was generally not a concern at most riparian effectiveness sites except where large construction equipment was used at three Large-Scale Riparian Retrofit typology projects.

General Conclusions and Potential Program Opportunities

The RMP is an important component of the implementation of the *Riparian Action Program*. City-wide data is being collected regarding riparian health, and trends are being analyzed that provide key information to understand the condition and trajectory of the health of riparian areas in the city. Annual reporting on the riparian health indicator is being submitted to Council to inform on the progress toward meeting the riparian health target of 72% average city-wide riparian health score by 2026.

The results of Phase 2 of the RMP indicate that great strides have been made and riparian health is improving. However, the expanded city-wide results show that **accelerated efforts such as riparian restoration and the conservation of existing undeveloped riparian areas are needed to improve the 2022 riparian health scores from 69% to 72% by 2026**. Proactive conservation of existing undeveloped riparian areas is essential to achieving The City's *Riparian Action Program* goals including the Land Use Planning target of "No Net Loss" of riparian open spaces along major perennial creeks and rivers at a city-wide scale. Monitoring riparian health trends is integral to assessing success/failure and for informing and directing ongoing riparian restoration, stewardship and management efforts in Calgary.

The results of the effectiveness monitoring components show that the **overall average rating for all sites was in the 'Fair' category** with a relatively small number of failure sites. Most of the effectiveness projects were found to be successful, but there is room for improvement in the way that bioengineering and riparian restoration projects in Calgary are delivered. The data and analysis for the effectiveness components are helping to fill a key technical and scientific knowledge gap for bioengineering and riparian restoration projects and place the city in a unique position worldwide regarding these practices. Until now there have been few if any monitoring studies done for bioengineering and planting projects in Calgary or elsewhere in the province, across North America, or worldwide.

Detailed RMP conclusions are included in the Technical Summary and Section 6.0 of this report. Trend monitoring and effectiveness recommendations can also be found in the Technical Summary and Section 7.0 of this report including recommendations for improved design, construction, and maintenance practices.

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[19] RMP effectiveness monitoring component objective 8

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