Report

January 29, 2024

Updated 2024 Exploratory Analysis of Potential Water Savings, Costs and Benefits of Turf Replacement in Colorado

Prepared for
Colorado Water Conservation Board

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PREFACE FROM CWCB

On January 4, 2023, ahead of the launch of the state's pilot Turf Replacement Program, the Colorado Water Conservation Board (CWCB) released an exploratory economic analysis of potential costs and benefits of turf replacement in Colorado (2023 Exploratory Analysis). The topic of turf replacement - an effort primarily intended to save water but also driven by myriad other factors - has appealed to the collective interest of water policy leaders across the West.

The State of Colorado advanced landscape transformation through the passage of House Bill 22-1151 (the "Turf Bill") and made progress on advancing work at its own facilities through Executive Order D 2023 018, which directs the development of water-efficient landscapes at state facilities. Across 2023-2024, the State of Colorado has committed nearly $6 million that the CWCB has administered through a combination of funding from the initial Turf Replacement Program, a request to fund an additional program in 2024[1], significant Water Plan Grant investments, supporting the Urban Landscape Conservation Task Force, and commissioning the updated 2024 exploratory economic analysis that follows this preface.

This revised analysis aims to refine the understanding of the amount of turf grass in Colorado, the water savings associated with removing this turf, and the potential turf replacement costs. This analysis aims to revisit our original questions with new data and research. Ultimately, the intent of this analysis, like much of the work CWCB supports, is to steward state resources to responsibly advance the most promising work, promote the uptake of proven and cost-effective conservation measures, mitigate adverse outcomes, and support scientific research.

While transformative landscape efforts have benefits beyond water savings, such as building climate resilience for local water providers and communities, CWCB's mission is to conserve, develop, protect, and manage Colorado's water for present and future generations. As such, turf removal's potential to reduce the Colorado Water Plan's projected municipal & industrial gap (up to 740,000 acre-feet per year) is a primary focus. The 2023 Exploratory Analysis identified that Colorado could potentially conserve up to 20,000 acre-feet of water if one-third of all non-functional turf were removed. Still, the exact amount of nonfunctional turf or how much might truly be removed is not fully understood. This 2024 exploratory analysis works to better refine the core understanding of the amount of turf (167,800 Acres, Section 2.2), the potential range of costs to remove it (150 Million - 2.5 Billion, Section 4.4), and the potential gallons-per-square foot (gpsf) water savings (~12 gpsf, Section 3). However, the 2024 analysis does not revise the nonfunctional turf estimate as it was beyond the scope of this effort and will require additional analysis to move beyond rough estimates toward a more informed quantification.[2]

Understanding the potential return on investment and statewide impact of varying conservation tools is an important goal that this research supports. This exploratory analysis can help policy experts at the local and state levels across Colorado make informed decisions on how to allocate funding and resources among the many conservation tools at their disposal (e.g., restricting nonfunctional turf installations, conservation-oriented tiered rate structures, etc.). A suite of tools, including turf replacement, will likely be needed to close the projected municipal & industrial gap. This report builds on the body of knowledge on transformative landscape change and represents an important step in the iterative learning process that will serve to strengthen policy decisions moving forward.

[1]On November 15, 2023, the CWCB Board voted to approve the inclusion of a request for $2 million in funding for the Turf Replacement Program, which will be considered by the Colorado General Assembly during its 2024 Session.

[2]The 2023 Exploratory Analysis used the *2022 Memorandum of Understanding (MOU) by and among Colorado River Basin Municipal and Public Water Providers* as reference for assuming ⅓ of turf may be nonfunctional; however, the MOU might also suggest that only ⅓ of any determined nonfunctional turf acreage could be removed.

1. Introduction and Summary of Key Refinements from 2023 Exploratory Analysis

Nonfunctional turf replacement efforts to reduce the amount of non-native cool-season grasses in Colorado, such as Kentucky bluegrass, continue to be an important municipal water conservation topic. Turf reduction efforts are proceeding along two fronts. The first, involving incentivized and voluntary water-user-driven replacement of existing Kentucky bluegrass areas with lower water-use native plants or grasses, is the focus of this report. The second, which may be equally important, is the simultaneous effort to reduce or altogether eliminate the installation of bluegrass and other cool-season grasses in new developments.

On June 8, 2022, Governor Jared Polis signed House Bill 22-1151 (HB 22-1151) into law, establishing a state Turf Replacement Program and fund intended to accelerate turf replacement. The funding enabled by the legislation is increasing and expanding existing turf replacement programs offered by Colorado municipal water providers (M&I providers) and municipalities and helping to establish and support new turf replacement programs throughout the state. The Colorado Water Conservation Board (CWCB) implements and manages the State's Turf Replacement Program and oversees matching grants to enhance turf replacement.

In 2022-23, CWCB also sponsored initial research by BBC Research & Consulting to develop an exploratory analysis of the potential water savings, costs, and benefits from turf replacement in Colorado (2023 Exploratory Analysis). One of the key findings from that research was that there were important information gaps that needed further research in areas including:

- The total amount of turf acreage in Colorado and the amount of non-essential turf,
- The amount of water saved by replacing turf with native plants or grasses, and
- The economic and financial benefits and costs of turf replacement.

Consequently, the 2023 Exploratory Analysis provided estimates of some of these metrics in terms of ranges of estimated values.

Since the 2023 BBC Analysis, the State's Turf Replacement Program along with local experience and advancements in turf replacement has generated new data and information. This updated 2024 analysis incorporates the growing body of experience with planting native grasses (such as buffalo grass and/or blue grama) in addition to the more established strategy of planting individual ornamental plants as alternatives to turf.

NEW INFORMATION IN THIS REPORT

TRP Grant Applications

Native Grass Experience

Additional Interviews with Turf Replacement Leaders, Landscapers, and Others

In general, this 2024 update is more nuanced than the 2023 Exploratory Analysis and attempts to recognize the diversity of Colorado's turf replacement efforts and strategies. Information from the 2023 Exploratory Analysis is referred to in cases where that information remains the best available data or estimates. The bottom line of this report is that more and better information continues to become available as turf replacement accelerates and diversifies in Colorado.

Figure 1 summarizes significant changes between estimates provided in this report and information provided in the initial 2023 Exploratory Analysis.

Figure 1. Significant Changes Between 2024 Analysis and Exploratory Analysis in 2023

Estimated Information	2024 Report	2023 Report	Reasons for Change
Municipally Irrigated Acreage (Statewide)	167,800 Acres	52,362 to 156,303 Acres	New DRCOG Planimetric Analysis
Non-essential Turf Acreage (Statewide)	No Estimate	26,000 Acres	No consistent definition, lack of available estimates
Avg. Annual Water Savings per Square-Foot Converted	12 Gallons	9.5 to 19 Gallons	New Information from TRP Applications and Resource Central
DIY Costs per Square Foot to Replace Turf	$0.28 to $4.63	$5.00	New data including costs for Native Grass installation
Typical Annual Benefits from 500 Square Foot Conversion			
Property Owner Benefit from Reduced Water Bills	$50.58	$30.97 to $61.84	Revised water savings & additional rate research
Property Owner Benefit from Reduced Maintenance	$75 to $107	No estimate	New conceptual analysis
Water Provider Benefits from Reduced Operating Costs	$10.50	$9.50 to $19.00	Addiitonal research with more water providers
Avoided One-time Costs from 500 Square Foot Conversion			
Water Provider Benefits from Avoided Cost of New Supplies	$460 to $920	$364 to $728	Revised estimate of costs of new supply[1]
Water Provider Benefits from Avoided Cost of Adding Treatment Capacity	$207 to $245	$26	Now based on recent Denver Water and Thornton facilities[2]

Notes: [1]In this 2024 update, BBC has used a range of costs for developing new water supplies of $25,000 to $50,000 per acre-foot, as discussed in section 5.3.

[2]In the 2023 Exploratory analysis, avoided costs for added treatment plant capacity were based on generic EPA models for various water treatment technologies.

2. Municipal Outdoor Water Use, Irrigated Acreage and Water Use Intensity

In considering some of the potential benefits of turf replacement, important considerations include the extent of municipally supplied outdoor water use, the number of acres irrigated with municipal supplies and corresponding outdoor water use intensity. The latter also includes considerations such as the typical efficiency of outdoor water use and the extent of deficit irrigation by residents and other property managers.

MEASUREMENTS/CONVERSIONS

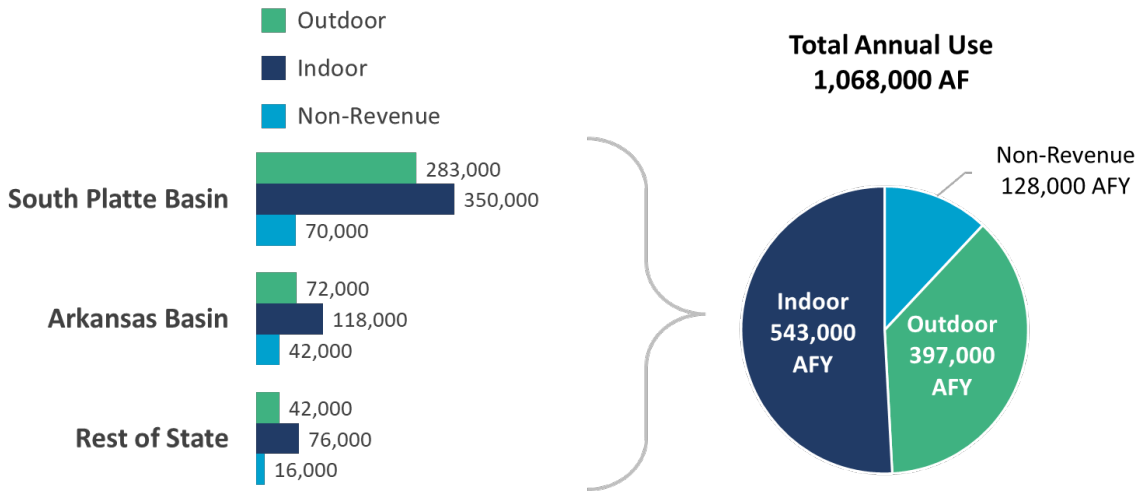
1 acre = 43,560 square-feet

1 acre-foot = 325,851 gallons

1 acre-foot/acre = 7.48 gallons per square-foot

2.1 Municipally Irrigated Outdoor Use. As reported in the 2023 Exploratory Analysis, data from the latest Technical Update for the Colorado Water Plan[3] indicates that, as of 2020, almost 400,000 acre-feet of water per year (AFY) was used for outdoor purposes by municipal and industrial customers in Colorado. If the portion of 'non-revenue' water related to the volume of water used for outdoor purposes is included — such as water lost to treatment processes and distribution leaks — outdoor water use may require 450,000 AFY of water or more from M&I providers. This amount is at least 42 percent of total M&I water use. About 70 percent of outdoor water use by M&I customers occurs in the South Platte Basin (including the Metro Sub-basin and the Republican River Basin), 18 percent in the Arkansas Basin, and the remaining 11 percent across the rest of Colorado, as shown in Figure 2.

Figure 2. Estimated Current Annual M&I Water Use in Colorado



Source: Interpolated between 2015 estimates and 2050 projections from *Current and Projected Planning Scenario Municipal and Industrial Water Demands.* Analysis and Technical Update to the Colorado Water Plan. Element Water. July 15, 2019.

[3] *Current and Projected Planning Scenario Municipal and Industrial Water Demands*, Element Water. Prepared for the Colorado Water Conservation Board. July 15, 2019.

2.2 Municipally Irrigated Acreage. Based on the Water Plan estimates of statewide outdoor municipal water use described above and a range of assumptions regarding the annual volume of a full irrigation supply at the plant, irrigation efficiency, and the extent of deficit irrigation, BBC estimated the statewide number of acres irrigated with municipal water supplies at between approximately 52,000 acres and 156,000 acres in the 2023 Exploratory Analysis.[4]

Newly available research suggests that even the top end of the estimated range of potential acreage irrigated with municipal water supplies in the 2023 Exploratory Analysis was likely an underestimate. During the past year, Dr. Austin Troy led a planimetric analysis to quantify the irrigated acreage within the boundaries of the Denver Regional Council of Governments (DRCOG) metropolitan planning organization. The area encompassed by DRCOG represents about 57 percent of Colorado's total population. The planimetric analysis concluded that there were approximately 113,900 irrigated acres within the DRCOG area alone.[5]

The DRCOG area includes approximately 91 golf courses, which are generally not irrigated with supplies from municipal providers (and whose water use was typically reflected in the Water Plan as agricultural water use).[6] Assuming each of these golf courses averages around 100 irrigated acres, there would still be about 104,800 acres irrigated with municipal water supplies within the DRCOG region. Based on an estimated population in the DRCOG region of about 3.37 million people in 2022, there is an average of about 31 irrigated acres per 1,000 residents in the region.

The DRCOG region does not include the large Front Range populations located north of the Denver Metropolitan Area (e.g., in Larimer and Weld counties) or south of the metro area (e.g., in El Paso and Pueblo counties). Assuming the same average number of irrigated acres per resident as in the DRCOG region, there would be about 47,750 additional irrigated acres in these areas, bringing the Front Range total to about 152,500 irrigated acres supplied by municipal water providers.

Nearly one million Colorado residents live outside the Front Range in areas including the Western Slope, the San Luis Valley, the mountain communities, and the Eastern Plains communities located east of the Front Range corridor. In some areas – such as the Western Slope communities of Grand Junction, Delta, and Montrose – the amount of municipally irrigated acreage per resident may be comparable to the DRCOG region. In others, and particularly in the urbanized portions of Colorado's high country which have a very different climate, municipal irrigation is likely lower. For the purposes of this study, we have assumed the non-Front Range irrigated acreage averages about ½ of the irrigated acres per resident in the Front Range (or around 15.5 acres per 1,000 residents). On that basis, these areas would have about 15,300 irrigated acres, bringing the statewide total to approximately 167,800 acres, as shown in Figure 3.

[4] BBC 2022, page 8.

[5] Dr. Troy is a Professor at the University of Colorado Denver and Director of Presidential Initiative on Urban & Placed-Based Research, interviewed for this study on July 31, 2023.

[6] Personal communication with Kara Sobieski, Wilson Water Group, November 16, 2023.

Figure 3.
Estimated Acres Irrigated with Municipal Water Supplies in 2022

DRCOG Region[1]	
Estimated 2022 Population[2]	3,371,100
Municipally Irrigated Acres[3]	104,800
Acres per 1,000 Residents	31.1
Other Front Range Areas	
Estimated 2022 Population[2]	1,533,200
Assumed Acres per 1,000 Residents	31.1
Estimated Municipally Irrigated Acres	47,700
Non-Front Range Areas	
Estimated 2022 Population[2]	987,900
Assumed Acres per 1,000 Residents	15.5
Estimated Irrigated Acres	15,300
Estimated Statewide Irrigated Acres	**167,800**

Note:

[1] The DRCOG region includes the following counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Clear Creek, Douglas, Gilpin, and Jefferson.

[2] 2022 population estimates based on Colorado State Demography Office 2020 population estimates and projected growth rates through 2021. 2022 growth rate assumed the same as in 2021.

[3] Municipally irrigated acres in the DRCOG region based on planimetric analysis by Dr. Austin Troy (UCD), adjusted by BBC to exclude estimated irrigated acres in golf courses.

It should be noted that these irrigated acreage estimates include gardens, trees, and shrubs, as well as turf. Though turf is the predominant irrigated vegetation, the actual proportion of landscapes irrigated with municipal water supplies that are planted in turf is currently unknown.

2.3 Municipal Irrigation Water Use Intensity. From the Water Plan-based estimates of outdoor municipal water use and the estimates of the amount of acreage irrigated with municipal supplies shown in Figure 3, we can draw some inferences regarding the intensity of municipally supplied outdoor water use. This information is useful in considering potential water savings from turf conversion. However, there are two other important considerations in that analysis – the efficiency of municipally supplied outdoor water use (the proportion of water supplied to customers' meters which is used by outdoor turf and other plants) and the extent to which municipal water customers may be using less water than the full irrigation supply required by their landscape (deficit irrigation).

Figure 4 outlines two different water use intensity scenarios. Both scenarios incorporate the Water Plan-based estimate of total annual outdoor municipal use (397,000 AF per year) and the estimate of the total area irrigated with municipal water supplies shown in Figure 3 (167,800 acres). The scenarios differ, however, in their assumptions regarding average irrigation efficiency and the prevalence of deficit irrigation.

A full irrigation supply for cool-season turf in Colorado averages about 19 gallons per square-foot (delivered to the turf).[7] As illustrated in Figure 4, this water requirement can be reconciled with the estimated number of municipally irrigated acres and the estimate of annual municipally supplied outdoor water use in different ways. High average irrigation efficiency (such as the 85 percent scenario shown in Figure 4) is consistent with a relatively low prevalence of deficit irrigation (21% in Figure 4). If

[7] Based on Denver Water and Integrated Lawn and Tree Care Colorado Springs websites as well as *Estimates of energy partitioning, evapotranspiration, and net ecosystem exchange of CO2 for an urban lawn and a tallgrass prairie in the Denver metropolitan area under contrasting conditions.* Thomas S. Theinelt and Dean E. Anderson. Urban Ecosystems (2021) 24:1201-1220.

irrigation efficiency is lower (such as the 75 percent scenario shown in Figure 4), reconciling the water use and irrigated acreage estimates requires a greater prevalence of deficit irrigation (30% in Figure 4). If average irrigation efficiency is even lower than the 75% assumed in the Low Irrigation Efficiency scenario shown in Figure 4, then the extent of deficit irrigation would have to be even higher than the 30% shown under the Low Irrigation Efficiency scenario in Figure 4.[8]

Figure 4.
Potential Range of Irrigation Efficiency and Deficit Irrigation Consistent with Outdoor Municipal Water Use and Irrigated Acreage Estimates

	Irrigation Efficiency and Deficit Irrigation Scenarios	
	High Irrigation Efficiency	**Low Irrigation Efficiency**
Full Annual Irrigation Supply at Plants	19 gallons/SF 2.54 AF/Acre	19 gallons/SF 2.54 AF/Acre
Irrigation Efficiency	**85%**	**75%**
Water Use at Customer Meters	22.4 gallons/SF 2.99 AF/Acre	25.3 gallons/SF 3.39 AF/Acre
Extent of Deficit Irrigation	**21%**	**30%**
Adjusted Average Water Use at Customer Meters	17.7 gallons/SF 2.37 AF/Acre	17.7 gallons/SF 2.37 AF/Acre
Estimated Irrigated Acres	167,800	167,800
Annual Municipal Outdoor Use	397,000	397,000

Why does this matter? As turf replacement programs continue to expand, there are important choices to be made regarding which customers and properties to target with incentives funded by utilities and by the state government. A single-minded focus on maximizing water savings would suggest that utilities primarily focus on the highest water users – though this may also mean that most of the turf replacement incentives would be paid to relatively affluent customers. Some water providers, such as Colorado Springs Utilities, have a different perspective. They are seeking to provide turf replacement funding to customers spanning the range of socioeconomic conditions within their service area. While turf replacement funds paid to high water users may generate the largest water savings, using these funds for lower-income customers can help them establish a more attractive and economically viable landscape that benefits the customers and their neighborhoods.[9]

[8] Colorado Springs Utilities has analyzed their billing records from 2016 through 2021 and found that around 60 percent of their customers are deficit irrigating, including nearly 40 percent that have been using an average of less than 5 gallons per square-foot of irrigated area. Denver Water has also previously reported that deficit irrigation or landscape abandonment is a substantial phenomenon in portions of their service area and appears to be highly correlated with low-income areas.

[9] Personal communication with Catherine Moravec, Lisa Pace and Lance Ackerman, Colorado Springs Utilities, November 7, 2023.

3. New Information from Turf Replacement Program Grant Applications

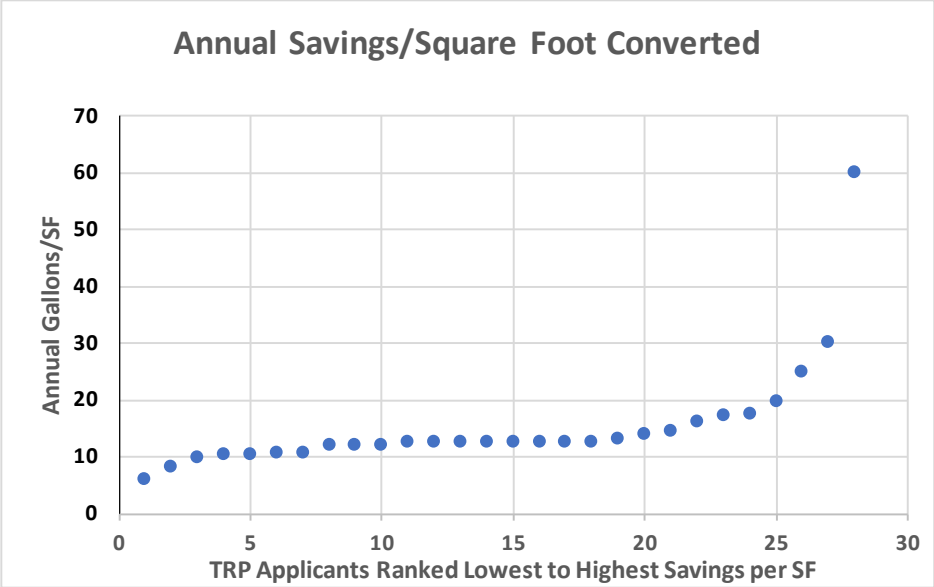
To implement the turf replacement bill passed in 2022, CWCB established the Turf Replacement Program (TRP) to provide matching funding for turf replacement incentive programs or site-specific replacement projects managed by municipal water providers (and, in a few cases, regional water management agencies or municipal governments). The information provided in the first round of grant applications and contracting provides additional insight into existing turf replacement programs across the state.

During the period of research included in this report, 50 entities have applied for TRP matching funds for their turf replacement efforts. While some applicants have yet to provide complete data in their contracting documents, including the projected square-footage they expect to convert from turf to lower water using vegetation and the amount of water they expect to save from their program, 26 applicants have provided both metrics. These 26 entities expect to convert about 1.56 million square-feet of turf (roughly 36 acres) and save an annual total of approximately 19.2 million gallons of water (roughly 59 acre-feet) at a total cost of about $1.75 million in rebates (including state matching funds). It is important to note the data extracted from the TRP contracting documents are best estimates and are subject to change as projects and programs expend the awarded funding.

In the 2023 Exploratory Analysis, annual turf replacement activity (prior to the TRP) was estimated at about one million square-feet (roughly 23 acres) based on water provider Water Efficiency Reports (HB-10-1051 reports). However, the report noted that this was undoubtedly an underestimate due to incomplete reporting. Many of the water providers that quantified their turf replacement programs in their 2020 or 2021 Water Efficiency Reports are also participating in the TRP. Still, some are not – or are among the 26 TRP participants that have not provided complete data on square-footage or water savings. Assuming these providers have continued their turf replacement programs at the same level shown in their earlier 1051 reports, we estimate that total turf replacement in Colorado this year may exceed three million square-feet (roughly 69 acres) – so the pace of turf replacement appears to be accelerating, as intended by the legislation.

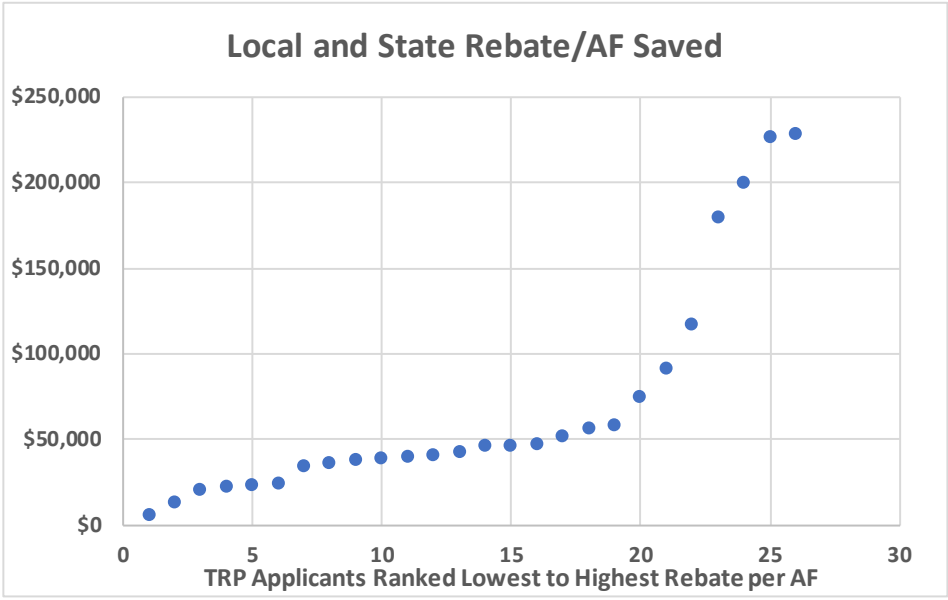
The TRP applications provide further insight into water provider estimates of water savings per square-foot converted from turf. Figure 5 shows a few instances where anticipated water savings are below 10 gallons per square-foot or above 20 gallons per square-foot, but most savings estimates are relatively consistent. The median water savings estimate among the 26 providers included in the analysis is 12.5 gallons per square-foot.

Figure 5.
Projected Annual Water Savings per Square-foot of Turf Replacement from TRP Applications



The TRP data also provide information regarding the expected rebate per square-foot of turf converted. Figure 6 shows a wider range of expected rebate costs per square-foot than the comparatively consistent water savings estimates. The median projected rebate cost per square-foot is $1.69.

Figure 6.
Projected Combined Local and State Rebate per Square-foot of Turf Replacement from TRP Applications



Combining the median rebate per square-foot ($1.69) with the median projected water savings per square-foot (12.5 gallons) from the TRP applications, the projected rebate costs total about $44,000 per acre-foot of annual water savings. However, based on the total rebate costs of $1.56 million and the total projected annual water savings of 19.2 million gallons across the 26 entities that have supplied relatively complete information, the average rebate costs are lower – at about $30,000 per acre-foot.

4. Costs of Turf Replacement

As turf replacement accelerates in Colorado, one of the important questions is the cost of converting landscapes to use less water.

4.1 Changes from Cost Estimates in 2023 Exploratory Analysis. The 2023 Exploratory Analysis outlined the potential costs of turf replacement, based on a 500 square-foot conversion using a do-it-yourself (DIY) approach (working with the assistance of experts such as Resource Central). The 2023 cost analysis also focused exclusively on converting turf to individual low-water use plants such as those provided in the ubiquitous Garden-in-a-Box kits. Total costs were estimated at about $5 per square-foot of conversion, including $1 per square-foot for turf removal and disposal, $3.50 per square-foot for new plants and planting costs, and $0.50 per square-foot for relatively minor modifications to irrigation systems.[10]

During our interviews with turf replacement practitioners for this 2024 update, it became clear that there is no single answer regarding the costs of converting turf to lower water-use vegetation. Instead, homeowners (or other property owners/managers) face a number of decisions that can result in a wide range of potential costs for their project. While cost is likely one consideration in making those choices, it may be secondary to other objectives and aspects such as their desired end result for their landscape, their willingness and ability to contribute their own labor to the project, the condition of their existing soil and irrigation system, their willingness to use chemicals (herbicides) to eliminate their existing turf, and others.

Considering these aspects, we have adopted a different framework for this updated cost analysis based on a typical homeowner "decision-tree." We feel that this framework better reflects some of the nuances of turf replacement and produces more realistic estimates of the range of potential costs of converting to low-water-use landscapes.

4.2 Turf Replacement Costs Using a Decision-Tree Approach. The turf replacement cost estimates for this 2024 update continue to focus on an assisted DIY approach for a couple of reasons. This still appears to be the most common model for residential turf replacement in Colorado, and the costs of professionally installed turf replacement using landscapers are generally much higher – particularly for smaller projects that may fall beneath a minimum charge for the work. While we expect landscaper-installed turf replacement to increase along with the overall growth in turf replacement efforts (and as more contractors become experienced with turf replacement) and recognize the potential benefits of using professionals to do the work, homeowners that choose this option are likely less focused on minimizing costs than those who choose to do much of the work themselves.

Choice of new landscape vegetation? The first key decision facing a homeowner who decides to replace their turf is what they want their landscape to look like when their project is complete. While there are many details to consider – and homeowners may seek a mix of different kinds of vegetation for their

[10] Irrigation system modification costs were based on relatively low-cost kits available from companies like Rain Bird to convert spray emitters to drip irrigation.

KEY ASSUMPTIONS

Assumes 500 Square-foot Project

Mostly DIY, except:

With assistance from Resource Central for LWU Plant Approach

Assumes 2-man crew to cut/haul away existing turf

LWUP: 5 to 8 G-in-a-Box kits, 60 to 100 sq.ft. each. $115 per kit

Native Grass: 1.5 to 2 pounds of blue gramma or buffalo grass seed ($40/lb for blue gramma, $80/lb for buffalo grass)

Cut/Haul Away Sod: $700 to $1,000 for 2-person crew with cutter

Herbicide (Glyphosate) cost of $20 if done by homeowner, $75 by professional

Cost to smother based on materials only (high end is heavy duty polyurethane sheeting)

Add 1" of topsoil if sod is cut and hauled away (40 cubic feet at $4 to $7 per cu.ft.)

Seeder rental is $60 from Home Depot

Sprinkler conversion for LWUP involves 6 six Rainbird kits for drip irrigation at $26 per kit

Sprinkler conversion for native grass involves 6 taller heads at $16 per head

new landscape, we have simplified the choice for this analysis to either individual low-water use plants or low-water use native grasses.

A 500 square-foot turf replacement project – typical for a residential project – would require between five and eight Garden-in-a-Box kits at about $110 per kit, for a total cost of between $550 and $880 for the plants alone.

Native grass seed is a less expensive alternative. 500 square-feet can be covered by about two pounds of grass seed, which currently sell at retail for about $40 per pound for blue grama seed, or about $80 per pound for buffalograss, implying a cost range of $80 to $160 for a 500 square-foot conversion to native grasses.

Following the fundamental choice of what type of new landscape is desired, other choices that can impact the costs include:

How do they want to dispose of their existing turf? For homeowners changing their landscape to a garden of individual low-water use plants, the typical strategy is to cut out their turf and either haul it away or compost it on site – this is a primary focus of Resource Central's Lawn Replacement program. While it is possible for homeowners to rent a sod cutter and cut out and haul away the turf themselves, most are likely to prefer to take advantage of a program like Resource Central's Lawn Replacement program or to hire a crew with a cutter to do the work. Typical costs for the latter approach for a 500 square-foot garden would be between $700 and $1,000.[11]

Homeowners who are converting their cool-season turf to native grasses can also choose to cut and remove their turf, but they also have other, lower-cost and potentially easier options. The simplest alternative is to use an herbicide to kill their bluegrass, wait at least ten days, and then seed the native grass directly into the existing turf and topsoil. This is a $20 proposition for a 500 square-foot area if done by the homeowner or about $75 if done by a licensed landscaping professional.[12]

[11] Interview with Steve Loy, President and Owner of Sun Maintenance Service, Colorado Springs, Colorado. August 16, 2023.

[12] Ibid.

Not all homeowners are comfortable with using herbicides to kill their turf. A slightly more expensive and more labor-intensive approach to kill the existing turf and leave it in place is to smother the turf for an extended period with a moisture-proof barrier. Costs depend on the material used to cover the turf, but using high-quality polyurethane sheeting for a 500 square-foot area would cost about $200. The downside to the cover and smother approach is that it requires about nine months to kill the existing bluegrass completely.[13]

Do they need or want to amend their soil before planting? Depending on how the homeowner disposes of their existing turf, they may need to add topsoil or other soil amendments to help their new, lower water-use landscape thrive. In particular, if they opt to cut out and remove their existing turf, they may also be removing the best of their soil. Adding one inch of topsoil for a 500 square-foot project would require 40 cubic feet of new material, typically available at retail for $4 to $7 per cubic foot, or a total cost of $160 to $280.

How do they want to plant the new vegetation? If the homeowner is replacing their turf with individual plants, such as the Garden-in-a-Box kits, they will need to plant the area manually. Planting native grasses can be easier. If the homeowner has killed their bluegrass with herbicides or by smothering and leaving it in place, they can rent a slit seeder for about $60 for one day and seed directly into the thatch and topsoil.

The final decision for the homeowner is what modifications they want/need to make to their irrigation system to appropriately and efficiently water their new landscape. To achieve the potential water savings from turf replacement, the homeowner will need to adjust their irrigation scheduling to match the lower water needs of their new landscape and may need to modify their irrigation system. If the homeowner is planting low-water use plants, they can purchase relatively inexpensive kits to convert one or more irrigation zones from spray nozzles to drip emitters. For example, a 500 square-foot project could require about six Rainbird kits currently available for about $26 per kit – for a total cost of $156.

If the homeowner is planting native grasses, they may need to purchase taller heads for their irrigation system – since a thriving native grass area that requires little additional irrigation will need to be left taller after less frequent mowing than their previous bluegrass turf. Taller heads can be purchased for about $16 each, so converting six heads for a 500 square-foot area would cost about $96.

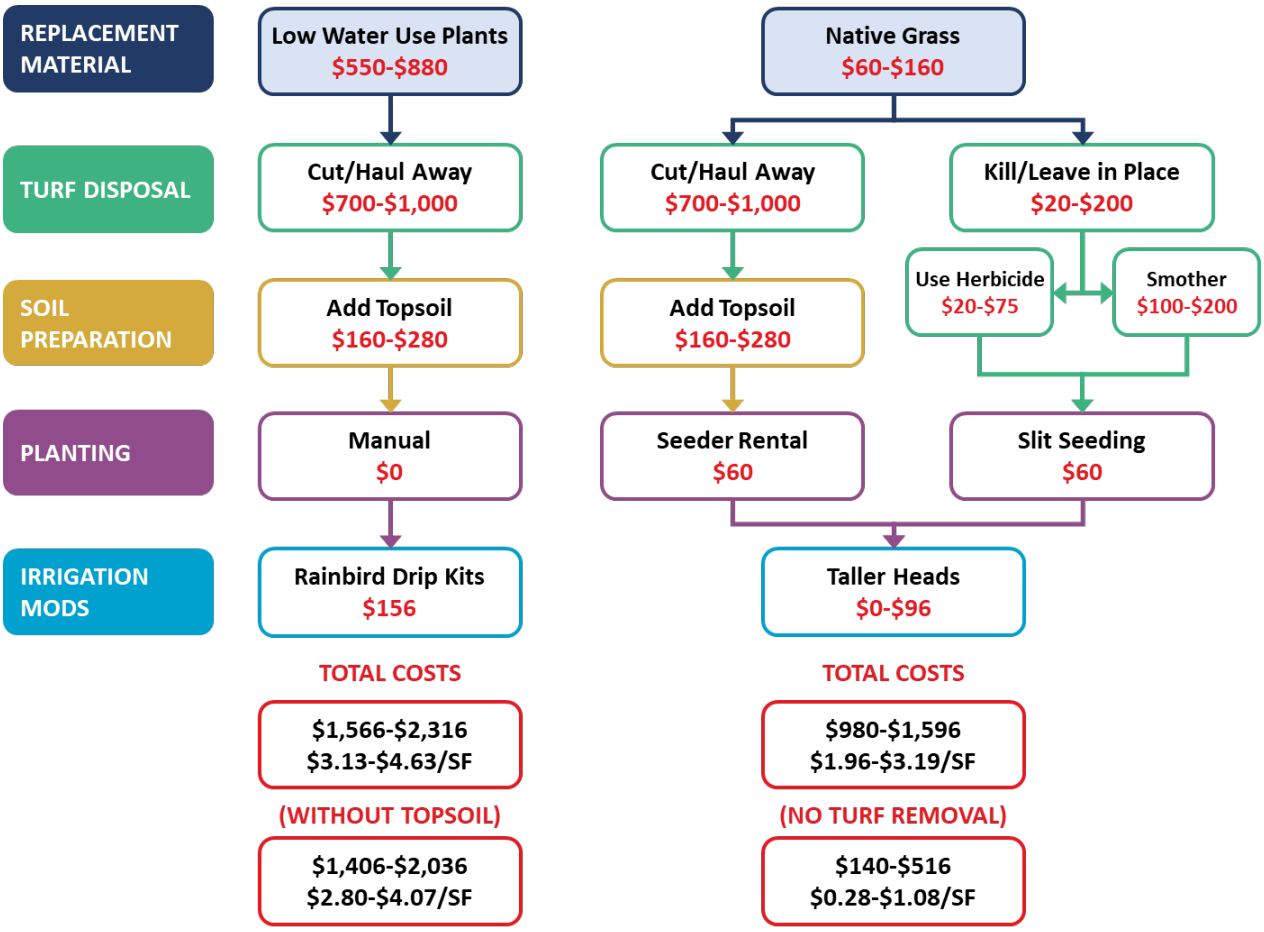
These relatively low-cost estimates for irrigation conversion assume a well-functioning irrigation system prior to the turf replacement project. Depending on the specifics of a particular project and property, more extensive repairs or improvements may be required to produce a thriving conversion.

Overall potential installation costs. Figure 7 summarizes the potential costs for the installation of a 500 square-foot turf replacement project based on the choices described above. Relying in large part on their own DIY labor, the installation cost for a 500 square-foot area using individual, low-water use plants are likely to be between about $1,406 to $2,036 ($2.80 to $4.07 per square-foot) if they do not add topsoil before planting, or about $1,566 to $2,316 if they do add topsoil ($3.13 to $4.63 per square-foot).

[13] Ibid.

Native grass conversions can be less expensive. Assuming a mostly DIY approach, converting 500 square-feet can be accomplished for between $140 and $516 ($0.28 to $1.08 per square-foot) if the homeowner kills their sod and plants into their existing thatch and soil without turf removal. If the homeowner instead chooses to cut out their existing sod, the total costs for a 500 square-foot native grass conversion would be between about $980 and $1,596 ($1.96 to $3.19 per square-foot).

Figure 7. DIY Installation Cost Estimates -- 500 Square-Foot Residential Turf Replacement Project



4.3 Additional Turf Replacement Cost Considerations. While the preceding analysis indicates that converting turf to native grass can be less expensive than converting to a garden of individual low-water use plants, the preferred option for a homeowner considering turf replacement may depend more on their motivations for the landscape conversion.

In addition, the cost of turf conversion can vary depending on the scale of the project and whether the property owner chooses to do much of the work themselves or to rely on professional landscaping contractors.

Motivations for replacing turf. It is important to remember that the cost of turf replacement is just one of the considerations in choosing what to plant and how to plant it. The best choice for a homeowner may primarily depend on what they ultimately want their landscape to accomplish.

Resource Central, the leading service provider in assisting Colorado water providers and homeowners in converting to low-water use landscapes[14], reported that the primary motivations for homeowners to replace their turf were to help conserve water, provide habitat to pollinators and other insects, and improve the attractiveness of their landscape. Reducing lawn maintenance was also an important consideration.[15] Colorado Springs Utilities reports that the primary motivations for homeowners that are replacing their turf are reduced maintenance, dissatisfaction with their existing landscape, and cost savings from reduced water use and maintenance – but commercial customers are primarily motivated by cost savings.[16]

Larger scale turf conversions and turf replacement using professional contractors. Larger scale conversions of non-residential turf areas can benefit from economies of scale, including the potential to use larger equipment to remove existing turf, add soil amendments if needed, and plant native grass. However, these types of conversions are not typically DIY efforts and most often involve professional contractors or paid employees of water providers, parks departments, or other agencies.

Since 2019, Northern Water has partnered on 37 turf conversion projects averaging about 20,700 square-feet for each project. The average cost of these conversions was about $1 per square-foot for conversions to native grass and about $9 per square-foot for conversions to low-water use plants. While some of the reasons for the difference in cost reflect similar factors to the residential cost comparison shown in Figure 7, there has also been a substantial difference in scale between the two alternative approaches. The nine conversions to native grass that Northern has partially funded have averaged over 60,000 square-feet in size, while the 23 conversions to low-water use plants have averaged about 7,700 square-feet in size.[17]

Colorado Springs Utilities has also been involved in a large number of commercial-scale turf conversion projects. They estimate the typical cost range for a commercial conversion from turf to native grass to be about $0.25 to $1 per square-foot. Commercial conversions to low-water use plants typically cost $5 or more per square-foot.[18]

On the residential scale, not all homeowners will have the ability or the desire to do much of the work themselves – as we have assumed in the analysis summarized earlier in Figure 7. If the homeowner chooses to replace their turf using professional landscapers, the typical minimum charge is around $3,000 – or around $6 per square-foot for a 500 square-foot conversion project. Even for a larger residential project, the costs of professionally installed turf replacement are likely to be at least $5 per square-foot.[19]

[14] Resource Central partnered with 15 Front Range water providers to replace more than 260,000 square-feet of turf and provided over 8,600 Garden in a Box kits to more than almost 6,000 water users in 2022. *2022 All Cities Annual Report*. Resource Central.

[15] Ibid.

[16] Interview with Catherine Moravec, Lisa Pace and Lance Ackerman, Colorado Springs Utilities, November 7, 2023.

[17] Data provided by Darren Nowles, Northern Water, November 20, 2023.

[18] Data provided by Colorado Springs Utilities, November 5, 2023.

[19] Ibid.

4.4 Costs per acre-foot of water savings. Figure 8 puts the estimated range of installation costs for replacing turf with low-water use plants or native grasses in further context by using the estimated costs per square-foot to calculate the potential costs per acre-foot of reduced water use – using the 12 gallons per square-foot annual water savings estimate described later in section 5.1. At an annual water savings rate of 12 gallons per square-foot, 27,154 square feet of turf need to be replaced to save one acre-foot of water.

As shown in Figure 8, the low-end estimate of turf replacement cost ($0.28 per square-foot for a DIY replacement with native grasses that doesn't require turf removal) suggests that the installation costs to save an annual acre-foot of water use can be as low as $7,600 – though these costs do not include the value of the labor contributed by the property owner. With these low-cost installations, the aggregate cost to save 20,000 acre-feet per year of water use – about 5 percent of total annual outdoor water use with municipal water supplies – would be about $152 million.

At the other end of the spectrum, the high-end estimate of replacing turf with low-water use plants ($4.63 per square-foot) would mean that the cost of saving an acre-foot of annual water use would be about $125,700 – and the cost to save 20,000 acre-feet per year could be over $2.5 billion. A middle case – where the installation costs are about $2.46 per square-foot – would have an installation cost of about $67,000 per acre-foot, and the cost of saving 20,000 acre-feet per year would be about $1.3 billion. The actual cost of turf removal may be somewhere between or outside these estimates depending on the methods applied, replacement materials, and irrigation updates and maintenance.

Figure 8. Potential Installation Costs Required to Save An Acre-foot of Annual Water Use and 20,000 Acre-feet of Water Use per Year

	One Acre-foot of Annual Savings	20,000 Acre-feet of Annual Savings
Low ($0.28/SF)	$7,603	$152,060,000
Middle ($2.46/SF)	$66,799	$1,335,976,800
High ($4.63/SF)	$125,723	$2,514,460,000

It is important to note, however, that these cost estimates do not account for the potential "neighbor effect" – or the hope and expectation that increasing prevalence of low water use landscapes will encourage other property owners to replace their turf without requiring incentives to do so.

5. Benefits of Turf Replacement

The most obvious benefit from replacing cool-season grass like bluegrass with either low-water use plants or low-water using native grasses – and the primary motivation for the passage of HB 22-1151 in 2022 and the creation of the Turf Replacement Program administered by CWCB – is the potential reduction in outdoor water use. Reduced water use, in turn, offers financial benefits for property owners and water providers. In addition, there are other potential benefits from turf replacement that are harder to measure in monetary terms, such as increased biodiversity, improved aesthetics, and more drought-resistant landscapes.

5.1 Reduced Water Use from Turf Replacement. Converting from cool-season grass to either native grass or low-water-use plants should result in reduced water use — presuming a properly functioning irrigation system and vegetation-appropriate irrigation scheduling. In addition to the lower water use requirements of native grasses or low-water use plants, turf conversion projects assisted by experts such as Resource Central, water utility staff, or professional landscapers also typically involve an examination of the water user's existing irrigation system and clock/controller which can identify existing problems and also reduce water use.

As turf conversion continues to gather momentum in Colorado, there are growing efforts to quantify the water savings, typically by analyzing "before and after" water use from utility billing records. These analyses are complicated by the year-to-year variability in Colorado's weather during the irrigation season, which can also greatly impact outdoor water use. Analysts can account for the influence of weather by either adjusting the metered water use data based on variables such as net crop evapotranspiration (ET) or precipitation and temperature records or by simply using longer periods of before and after data to create a more reliable estimate of the savings. As experience with turf replacement in Colorado continues to grow, we should see more definitive analyses of average water savings from conversion.

As discussed earlier in Section 3 and shown in Figure 5, the median estimated annual water savings from this year's Turf Replacement Program applications is 12.5 gallons per square-foot, and most of the applications project savings close to that estimate. The 12.5 gallons per square-foot number is also close to Resource Central's estimate of their 2022 lawn replacement program's water savings of 3.1 million gallons for 261,384 square-feet of turf replacement (about 11.9 gallons per square-foot).[20]

Figure 4 (shown on page 5) compares annual outdoor municipal water use from the Water Plan to our updated estimates of the statewide number of acres irrigated with municipal supplies. As shown in that figure, average annual water use at customer's meters (prior to considering deficit irrigation by many water users) was estimated to be between 22.4 gallons per square-foot and 25.3 gallons per square-foot. Using the common assumption that converting turf to lower water use landscaping reduces water use by about 50 percent, those numbers are consistent with annual savings of between 11.2 and 12.6 gallons per square-foot – which is in the same range as the median from the TRP applications and Resource Central's water savings estimate.

[20] *2022 All Cities Annual Report*. Resource Central.

While annual water savings of around 12 gallons per square-foot (measured at customers' meters) seems to be a reasonable assumption based on these estimates, not all water providers expect to achieve that amount of savings from turf replacement. During interviews conducted for this update, both Denver Water and Colorado Springs Utilities stated that they see turf replacement as a strategy for achieving additional benefits for their communities beyond just water savings and that equity in access to turf replacement is also important.[21] More specifically, Colorado Springs Utilities is using analyses of their billing data to target their turf replacement effort at customers that are either deficit irrigating or may have altogether abandoned their landscape for financial or other reasons as well as customers that are currently fully irrigating or over irrigating. Not surprisingly, given these broader objectives, Colorado Springs Utilities anticipates somewhat lower water savings through the TRP than other water providers.

Some other large water providers expect to achieve savings greater than 12 gallons per square-foot. In their TRP application, Aurora Water projected savings of about 17.5 gallons per square-foot. These higher water savings projections may be due to localized factors such as differences in temperature, precipitation and/or local landscaping practices. They may also be the result of efforts to specifically target high water users for turf replacement.

How much water will turf replacement save?

Most projections ≈ 12 gallons per square-foot

Example projections or estimates include:

Aurora Water (17.5 gpsf)

Boulder (12.1 gpsf)

Broomfield (10.25 gpsf)

For purposes of simplifying the following analyses of the potential financial and economic benefits from turf replacement, we will use the common estimate that annual water savings will be approximately 12 gallons per square-foot, while recognizing that these monetary benefits may be larger or smaller depending on actual water savings.

5.2 Homeowner Benefits from Turf Replacement. The most obvious potential financial benefit for homeowners from replacing cool-season turf like bluegrass with native grass or low-water use plants is the reduction in their water bills during the irrigation season. Returning to our example 500 square-foot turf replacement project, assuming the new landscape (native grass or low-water use plants) requires 12 gallons less water per square-foot, the annual water savings would be 6,000 gallons.

Financial benefit from reduced water use. The financial value of that water savings can be estimated based on the marginal water rates applicable during the irrigation season. To establish a representative water rate for this analysis, BBC has reviewed the current water rate schedules for eight larger municipal water providers involved in turf replacement: Aurora, Arvada, Castle Rock, Colorado Springs, Denver, Fort Collins, Thornton, and Westminster. To simplify the analysis, we excluded several other providers now using water budget-based rates (e.g., Boulder, Centennial, and Greeley).

We have used the average of the rate for the highest tier of consumption (which is often a penalty rate designed to incentivize reductions in water use) and the rate for the second highest tier of consumption

[21] Interview Greg Fisher from Denver Water on November 16, 2023 and interview with Catherine Moravec, Lisa Pace and Lance Ackerman from Colorado Springs Utilities, November 7, 2023.

because we believe the blend may be more representative of the typical marginal cost of water for homeowners involved in turf replacement. Where applicable, we have also used "inside city" rates rather than "outside city" rates because the inside city rates may apply to a larger share of the households in the providers' service areas.

As shown in Figure 9, based on this methodology, we have estimated a representative marginal water rate of about $8.43 per thousand gallons of water used during the irrigation season. While we use this rate to estimate typical annual homeowner water bill savings from turf replacement, there is substantial variation in the rates for our sample of water utilities, with the highest marginal rate estimated at $12.74 per thousand gallons in Thornton and the lowest estimated at $3.65 per thousand gallons in Fort Collins.

Figure 9.
Representative Marginal Water Rates Applicable to Reduced Water Use from Turf Replacement

Provider	Top Tier	Second Tier	Average
Aurora Water	$13.90	$8.50	$11.20
Arvada	$10.07	$7.56	$8.82
Castle Rock	$8.95	$6.00	$7.48
Colorado Springs	$12.50	$8.33	$10.42
Denver	$6.31	$4.73	$5.52
Fort Collins	$3.90	$3.39	$3.65
Thornton	$16.98	$8.49	$12.74
Westminster	$8.48	$6.78	$7.63
Average	$10.14	$6.72	**$8.43**

Source: 2021-2023 annual financial reports.

Applying the representative rate of $8.43 per thousand gallons shown in Figure 9 to our estimated 6,000 gallons in water savings from a 500 square-foot turf replacement results in annual water bill savings of $50.58 (about $0.10 per square-foot of conversion). If the homeowner stays in their home for ten years following turf replacement[22], they could save about $506 in water bills ($1.01 per square-foot converted) over that period – excluding potential increases in future water rates that would increase their financial savings from reduced water use.

Potential financial/economic benefit from reduced maintenance. As discussed earlier, reduced maintenance can also be an important motivation for turf replacement, along with reduced water use. There is no known empirical data available at this time regarding reductions in maintenance associated with turf replacement in Colorado. Still, a conceptual exercise suggests the value of the maintenance savings to homeowners could be as large as, or larger than, the value of the water savings.

[22] National average annual duration of home ownership has been estimated at between 8 years (Redfin 2023) and 13 years (National Association of Realtors 2018). In general, the average homeownership duration in the West is shorter than in the East.

Interviews with turf replacement experts consistently indicate that maintenance during the first year or two following conversion to either native grass or low-water use plants is a challenge, particularly in terms of controlling weeds. The time and effort required for maintenance during the establishment period are likely to be greater than it was when the area was planted in turf. However, once the new landscape is established, it should require less maintenance time and fewer chemicals and other inputs than a traditional bluegrass lawn.

Figure 10 conceptualizes the potential annual reduction in time required for maintenance of a 500 square-foot area converted from growing bluegrass to either native grass or low-water use plants – after the new landscape has become fully established (likely one to two years following conversion). Assuming the homeowner does their own maintenance and manually removes weeds from their turf or garden areas, we estimate that converting a 500 square-foot area from bluegrass to native grass could ultimately save over six hours per season of homeowner work. Using a value of $14 per hour based on updated estimates from a widely cited study of individual willingness to pay for additional leisure time,[23] the annual value of these time savings is around $91 per year. Adding in reduced costs for fuel and fertilizer, the total annual savings could be around $107 per year, or approximately $0.21 per square-foot of turf conversion. The value of maintenance savings from converting turf to low-water use plants is likely to be similar in magnitude.

[23] *Time is Money: Investigating the Value of Leisure Time and Unpaid Work.* Verbooy, Kaya et.al. Value in Health 21 (2018).

Figure 10. Potential Annual Maintenance Cost Savings for 500 sq. ft. Area – Including Value of Homeowner Time Savings

	Bluegrass Lawn		Native Grass		Low Water Use Plants	
MOWING/ TRIMMING	20 times per year	20	2 times per year	2	2 times per year	2
	15 minutes per time	x 0.25 hrs	45 minutes per time	x 0.75 hrs		x 1.00
		5.00 hrs		1.50 hrs		2.00
	Value per hour	x $14.00	Value per hour	x $14.00		x $14.00
		$70.00		$21.00		$28.00
	3 gallons of gas	+ $12.00	1/2 gallon of gas	+ $2.00		
	Subtotal mowing	**$82.00**	**Subtotal mowing**	**$23.00**	**Subtotal trimming**	**$28.00**
FERTILIZING	3 times per year	3	1 time per year	1	1 time per year	1
	30 minutes per time	x 0.50 hrs	30 minutes per time	x 0.50 hrs	30 minutes per time	x 0.50 hrs
		1.50 hrs		0.50 hrs		0.50 hrs
	Value per hour	x $14.00	Value per hour	x $14.00	Value per hour	x $14.00
		$21.00		$7.00		$7.00
	Granular fertilizer	+ $10.50	Granular fertilizer	+ $3.50	Granular fertilizer	+ $3.50
	Subtotal fertilizing	**$31.50**	**Subtotal fertilizing**	**$10.50**	**Subtotal fertilizing**	**$10.50**
WEEDING (MANUAL)	20 min/week May-June	2.67 hrs	Assume 1/2 of bluegrass		Assume same as bluegrass	
	20 min/mo. July-Sept	+ 1.00 hrs	(Once established)		(Once established)	
		3.67 hrs		1.83 hrs		3.67 hrs
	Value per hour	x $14.00	Value per hour	x $14.00	Value per hour	x $14.00
	Subtotal weeding	**$51.38**	**Subtotal weeding**	**$25.67**	**Subtotal weeding**	**$51.38**
ESTIMATED ANNUAL TOTALS	Homeowner Time	10.17 hrs	Homeowner Time	3.83 hrs	Homeowner Time	6.17 hrs
	Value of Time	$142.38	Value of Time	$53.62	Value of Time	$86.38
	Fuel and Fertilizer	$22.50	Fuel and Fertilizer	$4.50	Fuel and Fertilizer	$3.50
	Total Value	**$164.88**	**Total Value**	**$58.12**	**Total Value**	**$89.88**
POTENTIAL ANNUAL COST SAVINGS				**$106.76**		**$75.00**
				$0.21/SF		**$0.15/SF**

Note: * Assumes $14 per hour value of time (willingness to pay for additional leisure time) based on Time is Money: Investigating the Value of Leisure Time and Unpaid Work. Verybooy, Kaya et.al. Value in Health 21 (2018). Updated to 2023 values using the Bureau of Labor Statistics CPI Inflation Calculator.

5.3 Water Provider Benefits from Turf Replacement. Reductions in water use during the irrigation season can also provide financial benefits for water utilities by reducing their operating costs. Assuming the water savings from turf replacement prove to be sustainable over time (which appears likely to be the case based on the long-running turf replacement program in Southern Nevada),[24] reduced water use due to turf replacement can also help water providers with growing customer bases to avoid at least a portion of the costs of obtaining and developing new water supplies and adding water treatment capacity.

Reductions in annual operating costs. To develop an estimate of the magnitude of potential reductions in operating costs, BBC reviewed the most recent annual financial reports for the same set of water utilities that we used to derive a typical, marginal water rate for summertime consumption to help quantify some of the benefits of turf replacement for homeowners (shown earlier in Figure 10). In a number of cases, however, the level of expenditure detail in the financial reports was not sufficient to isolate the variable costs that could be reduced by reductions in customer water use – typically including water production, treatment, and distribution costs (but not costs associated with customer service, administration and other expenses unrelated to the volume of water sold and delivered to customers).

Ultimately, the most useful financial data for our purposes was available from the annual financial reports for Colorado Springs Utilities, Denver Water, Fort Collins, and Thornton. Across those four water providers, the annual variable costs that could be partly reduced through reductions in water deliveries averaged $1.75 per thousand gallons and ranged from a low of $1.32 per thousand gallons for Fort Collins to a high of $2.47 per thousand gallons in Thornton. Across the four utilities, the variable costs averaged about 35 percent of the utility's total annual operating costs.

Applying the $1.75 per thousand gallons estimated average savings in annual utility operating costs to our estimated typical annual water savings of about 6,000 gallons from a 500 square-foot conversion, replacing turf would reduce the variable costs of providing water service by about $10.50 per year – which can also be expressed as an annual savings of about $0.02 per square-foot converted.

Avoided costs for new water supplies and treatment capacity. Larger financial savings for water providers could result from enabling the provider to delay or avoid developing new water supplies and additional water treatment capacity due to water savings from turf replacement.

Developing new water supplies has become increasingly challenging and expensive. While it's difficult to pick a single number that best represents the cost of adding new municipal water supply, recent experience suggests a range of $25,000 to $50,000 per acre-foot (AF) may be reasonable at this time. In the South Platte Regional Water Development Concept Feasibility Study (SPROWG study) published in 2020, typical costs of major new Front Range water supply projects were estimated at $20,000 to

[24] Two econometric studies of billing data from the SNWA turf replacement program have also examined the durability of the water savings over time The study *How Smart are Water Smart Landscapes?* Brelsford, Christa and Abbott, Joshua K. Journal of Environmental Economics and Management 106 (2021) found no erosion in water savings over time. The similar study, Baker, Jonathan E. *Subsidies for Succulents: Evaluating the Las Vegas Cash for Grass Rebate Program.* Journal of the Association of Environmental and Resource Economists. March 17, 2021 reported and estimated water savings erosion at the rate of 0.1% per month. At that rate of erosion, it would take more than 80 years for the water savings from turf replacement to disappear.

$30,000 per AF[25], and in BBC's exploratory analysis of the economic benefits and costs of turf replacement produced in 2022, we used an estimated cost of $25,000 per AF in our analysis. However, the costs continue to escalate rapidly – as exemplified by the change between the estimated average cost of new municipal supply developed in 2010 for the first edition of the Water Plan of $5,900 per AF and the SPROWG estimates cited above. Costs for the Northern Integrated Water Supply Project (NISP) are reportedly approaching $50,000 per AF, and recent sales between Northern Front Range water providers of Windy Gap units have also transacted at about $50,000 per AF.[26] Apart from the high costs, the options to add new water supplies may be extremely limited for many water providers.

Based on the previous estimate that a typical 500 square-foot turf replacement project may save about 6,000 gallons per year (0.0184 AF), it could help avoid the need to spend between $460 to $920 to obtain or develop new water supplies, producing a one-time benefit for water providers of between $0.92 and $1.84 per square-foot of turf replaced.

New water treatment capacity is also very expensive. Denver Water's new North Treatment Plant will add 75 million gallons per day of treatment capacity for a cost of $400 million (about $5.33 per gallon per day of capacity). Thornton's new 20 million gallon per day treatment plant reportedly cost $90 million (about $4.50 per gallon per day of capacity.)

Our 500 square-foot turf replacement example was projected earlier to save about 6,000 gallons over the course of an annual irrigation season. Assuming irrigation begins in mid-April and ends in mid-October, the average daily water savings during the season would be approximately 33 gallons. Assuming the peak day water use during the irrigation season is around 1.4 times the average daily use during the season, the 500 square-foot turf replacement project could reduce peak daily demand by about 46 gallons. Based on the costs of Denver Water's and Thornton's new treatment plants, the reduction in peak demand from the example turf replacement project could save water providers between $207 and $245 in costs to add new treatment capacity (equivalent to a one-time benefit for the water provider of between $0.41 and $0.49 per square-foot of turf replacement).

In summary, there are substantial potential financial savings for water providers from turf replacement, including estimated one-time savings of between $1.33 and $2.33 per square-foot in avoided costs for developing new water supplies and treatment capacity and ongoing annual savings in operating costs of around $0.02 per square-foot of replacement. These cost savings are an important potential benefit, though reduced water sales due to turf replacement will also reduce water provider revenues – absent changes to their rates or rate structures.

[25] Personal communication with Matt Lindburg, Brown and Caldwell, November 15, 2023.

[26] Note that recent sales of individual Colorado Big Thompson units have occurred at prices equivalent to at least $100,000 per AF. NISP buyers, however, are generally property developers buying small volumes to be dedicated to water providers in exchange for obtaining water service (rather than the water providers themselves) and the annual volumes of these transactions are quite small.

Figure 11.
Potential Cost Savings for Water Providers from 500 Square-foot Turf Replacement

	Estimated Savings	Savings per Square Foot
One-time Benefits		
Avoided Cost of New Supply	$460 to $920	$0.92 to $1.84
Avoided Cost of Added Treatment Capacity	$207 to $245	$0.41 to $0.49
Total One-time Benefits	$667 to $1,165	$1.33 to $2.33
Annual Benefits		
Reduced Operating Costs	$10.50	$0.02

5.4 Other Benefits from Incentivized Turf Replacement. As discussed earlier in Section 4.3, homeowners participating in turf replacement efforts surveyed by Resource Central and by Colorado Springs Utilities appear to expect and value environmental benefits from turf replacement, including more pollinator-friendly landscapes and reduced use of chemicals such as fertilizer and gasoline. These residents appear to recognize that water is a scarce resource in Colorado. They also believe that a lower water-use landscape can be an attractive alternative to a more traditional bluegrass lawn, potentially adding to their home's "curb appeal" and value.

The passage of HB 22-1151 in 2022 establishing State support for turf replacement efforts and the hard work of many people involved in turf replacement efforts have raised the profile of turf replacement in Colorado. Although turf replacement is accelerating in Colorado, it is unlikely that water providers and/or the State of Colorado will be willing or able to incentivize every square-foot of turf replacement necessary to create a large reduction in statewide, outdoor municipal water use. As discussed earlier in Section 3, we believe that programs funded by the Colorado Turf Replacement Program will replace at least three million square-feet of turf from 2023 to June 2025 (the duration of the current Turf Replacement Program). While that is an important achievement, three million square-feet is a little less than 70 acres, a relatively small number compared to our updated estimate of about 168,000 acres across the state that are irrigated with municipal water supplies (as discussed in Section 2). In other words, there is still much work to be done, and how much larger scale turf replacement will be financed is an open question.

Ultimately, the hope is that incentivizing turf replacement and making successful native grass and/or low-water use plant landscapes more common will help promote a shift in property owner preferences away from growing cool-season turf to cultivating landscapes that are more appropriate for our climate and more drought resistant in the face of increased aridification and climate change.[27] Considering that objective, the "neighbor effect" from proximity to properties with low-water-use landscapes will be very important. Research from

s in California and Nevada has at least partly quantified this effect,[28] and it merits additional research and quantification in Colorado as turf replacement continues to increase.

6. Summary and Key Findings

This report provides an update to the 2023 Exploratory Analysis of the potential savings, costs and benefits of turf replacement in Colorado. Important changes from the 2023 report and new analyses in this report include:

1. A revised (higher) estimate of the number of acres in Colorado that are irrigated with municipal water supplies (about 168,000 acres, predominantly planted in cool-season turf).

2. Incorporation of a new, central estimate of the water savings from turf replacement of about 12 gallons per square-foot based on data from turf replacement program grant applications and other sources. Actual savings can be higher or lower on individual projects or for different water providers for a number of reasons, but this average is consistent with the typical expectations of turf replacement efforts (as captured in the applications for turf replacement grants) and the updated estimate of statewide municipally irrigated acreage.

3. A more nuanced analysis of the costs of turf replacement based on further research and consideration of replacement with native grass as well as replacement with individual low-water use plants. This results in a wider range of estimated costs – from about $0.28 to $3.19 per square-foot for native grass replacement projects and about $2.80 to $4.63 per square-foot for turf replacement with low-water use plants. These cost estimates assume a DIY approach, with technical assistance from service providers like Resource Central or water provider conservation staff – recognizing that turf replacement using professional landscapers will generally be more expensive at the residential scale. Larger scale turf replacement on public or commercial properties can be less expensive per square-foot.

4. Revised estimates of the financial benefit for homeowners replacing turf from reduced water bills, now estimated to average about $0.10 per square-foot per year, and development of a conceptual model of the potential value of reduced homeowner maintenance for low-water use landscaping.

[27] The continuing increase in the number of cities that are limiting or prohibiting the use of cool-season turf in new developments should also help foster this cultural change.

[28] See for example Brelsford, Christa and Abbott, Joshua K. *How Smart are Water Smart Landscapes?* Journal of Environmental Economics and Management 106 (2021) and Pincetl, et.al. *Evaluating the Effects of Turf-Replacement Programs in Los Angeles County,* UCLA and University of Utah (2017).

That model suggests that the benefits from reduced maintenance may equal or exceed the financial benefit from reduced water use, if the value of the homeowner's time is included in the analysis.

5. Updated estimates of the cost savings for water providers from turf replacement, including reductions in annual variable costs such as expenses for water production, treatment, and distribution. These annual cost savings are estimated to average around $10 per year for a 500 square-foot turf replacement project (or about $0.02 per square-foot). Much larger, potential one-time cost savings from avoided costs of developing new supplies and adding treatment capacity are now estimated at between $667 and $1,165 for a 500 square-foot turf replacement project (about $1.33 to $2.33 per square-foot).

While we believe the updated research in this report will provide useful information for Colorado's incentivized turf replacement effort, significant information gaps remain. Among these gaps are a common definition of "non-essential turf," an estimate of the number of acres of non-essential turf in Colorado, and information regarding the "neighbor effect" or the spillover from incentivized turf replacement to turf replacement by other property owners not receiving an incentive. Further research to gather and analyze data on the potential homeowner benefits from reduced maintenance would also be warranted. Other benefits from turf replacement, such as greater drought resistance for urban landscapes, increased habitat for pollinators and others are also worthy of further exploration.