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COLORADO
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Barriers to Low Impact Development in Colorado

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Table of Contents

Contents

ACRONYMS

ASCE	American Society of Civil Engineers
BMP	Best Management Practices
CASFM	Colorado Association of Stormwater and Floodplain Managers
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CWP	Center for Watershed Protection
EWRI	Environmental and Water Resources Institute
HOA	Home Owners Association
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
UDFCD	Urban Drainage and Flood Control District
UWRRC	Urban Water Resources Research Council
WQCV	Water Quality Capture Volume

INTRODUCTION

To promote efforts that will help meet the measurable objectives and critical actions in the Colorado Water Plan, the Colorado Water Conservation Board established the Water Plan Grant. The Colorado Water Plan promotes sustainable water resources across Colorado. Stormwater is an important sector of water in Colorado. Even in a semi-arid region, stormwater provides runoff that feeds many of the Colorado rivers, however stormwater can also pollute local water bodies. Current stormwater management strategies involve capturing and treating the water quality capture volume and the controlled release of varying levels of design storms.

Low Impact Development (LID) is a different technique of stormwater management that provides an alternative water source for non-consumptive use, improves water quality of water bodies, restores natural hydrologic processes in the urban environment, promotes groundwater recharge, and provides several aesthetic and other benefits to communities.

The Low Impact Development Center provides the following definition of LID:

> *Low Impact Development (LID) is an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. (www.lid-stormwater.net)*

Adopting policies that promote the use of LID can lead stormwater management in a direction that is cohesive with the goals in the Colorado Water Plan. Despite the many benefits of LID, many municipalities are still hesitant to adopt LID policies. The Colorado Stormwater Center seeks to help municipalities overcome these barriers and provide examples of functioning LID sites. In order to promote LID, it must first be known what the barriers stormwater practitioners are facing in regards to LID and how those barriers have changed.

In 2008, Wright Water Engineers, partnered with the Keep It Clean Partnership, initiated a study to identify barriers to implementation of LID. This study identified what barriers were present in regard to LID and then through a survey identified which of these barriers were ranked the highest and lowest. Barriers identified were broad and included physical, institutional, technical, social and economic factors. Some of the barriers may only be perceived, while others may be actual barriers that impede the use of LID. However, for this study, there was no difference made between perceived or real barriers, but all identified barriers were evaluated based on their perceived hindrance to widespread LID adoption.

After a decade, it was then desired to evaluate how the perception of barriers to LID have changed. To accomplish this, the questionnaire that was developed and circulated as part of the 2008 study was circulated again to a similar audience to evaluate how have the barriers, or at least the perception of barriers, changed over the past 10 years. Additional interviews were also conducted with various municipalities to determine what are some of the barriers they are facing which is preventing the adoption of LID policy.

METHODOLOGY

In order to keep the study results as consistent and comparable as possible, the same list of barriers identified in 2008 was circulated in a new questionnaire. After deciding to use a similar list of barriers, another questionnaire was created and distributed throughout Colorado and the results were ranked and ordered in a similar fashion as 2008. A comparison of the ranks was then provided. Finally, interviews were conducted with municipalities across Colorado to hear about their various stormwater programs and the hindrances municipalities specifically face in adopting LID policy.

Potential Barriers to LID

The initial list of barriers was developed as a part of the 2008 study. Barriers were identified through meetings and discussions with nationally recognized experts who were members of the American Society of Civil Engineers (ASCE), Environmental and Water Resources Institute (EWRI), Urban Water Resources Research Council (UWRRC). Also, barriers were identified through discussions with local municipal reviewers, engineers, and developers. The following list of barriers were identified and included in the questionnaire.

- Fear of liability (engineers, owners, reviewers)
- Reluctance to try something new
- Lack of successful demonstration projects
- Education and training do not provide skills to design and implement LID
- Confusing nomenclature - lack of consistent names for practices (rain garden versus porous landscape detention versus bioretention)
- Limited technical design guidance
- Perceived design, construction, maintenance costs
- Safety considerations
- Public perception (temporary ponding on lots, standing water, mosquitoes, and other factors)
- LID not integrated early in planning process
- LID "recommended" in guidance rather than "required"
- Compatibility with existing developments that do not use LID practices
- Water rights considerations
- "Mixed messages" from different governmental departments (planning versus engineering versus open space versus street maintenance)
- No clear economic incentive for using LID
- Difficulty in measuring benefits of LID
- Semi-arid climate (i.e. difficulty in supporting green rain gardens)
- Maintenance and durability concerns
- Long term ownership (private versus publicly owned and maintained)
- Standing water nuisance problems

- Potentially longer review process
- Conflicts with municipal code requirements (i.e. curb and gutter required)
- American Disabilities Act considerations
- Poorly drained soils/low infiltration capacity
- High groundwater table
- Concerns with swelling soils
- Other water quality alternatives are "easier" to design, construct and maintain
- Other types of BMPs and drainage infrastructure may still be required even with LID
- Different/conflicting LID guidance or criteria from different groups (UDFCD versus Center for Watershed Protection versus others)
- Examples of LID failures
- Conflicts with landscaping requirements
- Confusing or unclear ordinances related to LID and/or disconnected impervious area
- Iterative coordination process with planners, designers, landscapers and others is required
- Specialized construction techniques may be required

Distributing the Questionnaire

The questionnaire was delivered online via google forms. Using google forms allowed for responders to quickly fill out the questionnaire while maintaining confidentiality if desired and allowed a quick analysis of the results.

The questionnaire began with optional questions about the respondent in order to ensure that similar audiences were reached with both surveys. These optional questions included:

- Name
- Organization
- Organization Type (Private, Public, Do not wish to specify)

After identifying the audience members four preliminary questions were asked before barriers were addressed. These questions included:

1. Are you familiar with the term Low Impact Development (LID)?
2. As a reviewer, designer or constructor have you ever considered LID as an alternative or complement to traditional stormwater management practice such as storm sewers and detention ponds?
3. Have you been involved in a project where LID measures were implemented?
4. Have you been involved in a project where LID measures were proposed or planned but not ultimately implemented?

Finally, responders were asked to rank each of the barriers on a scale of 1-5 where a 1 indicates it is not a significant barrier and a 5 indicates it is a very significant barrier.

The questionnaire was delivered through various outlets including the Colorado Stormwater newsletter, membership of the Colorado Stormwater Council, an email list from the Denver based Urban Drainage and Flood Control District (UDFCD), and through the Colorado Association of Stormwater and Floodplain Managers (CASFM).

Reponses from the distribution were collected, summarized, and then compared to the results from the previous study.

Municipal Interviews

Finally, after distributing the questionnaire, interviews were conducted with 10 staff from 10 different municipal separate storm sewer systems (MS4s). MS4s are the permitted agency for stormwater management, particularly considering water quality. MS4 permits are issued by Colorado Department of Public Health and Environment (CDPHE). In general, LID policy is adopted to meet requirements in MS4 permits. For this reason, MS4 staff were interviewed to determine how LID is currently being utilized in different MS4s and what are the barriers MS4s are facing in adopting LID policy.

MS4s which were interviewed included cities (Aurora, Canyon City, Colorado Springs, Fort Collins, Greeley, and Longmont), counties (Adams and Boulder), and institutions/agencies (Colorado Department of Transportation and Colorado State University). Each interview asked participants to 1) What is your disposition toward LID? 2) How does LID current fit in this program (policy, criteria, municipal code, other)? 3) Are there any additional barriers you think are hindering use of LID? 4) Are there any current LID projects occurring in your municipality? The notes taken from each of these interviews are available on request and are summarized in the results section.

RESULTS

The following section includes the results from the questionnaire from both 2008 as well as 2018. Also included in this section is the synopsis of the interviews conducted with 10 MS4s.

Participants Summary Information

The first questions that were asked of the participants concerned their affiliation. Since barriers may vary depending on which organization participants were from, this question was asked to be able to make sure that participants in 2018 were composed of a similar audience to the 2008 survey. In 2008 there were 33 responses, 40% of which were from the public sector, 30% of which were in the private sector and 30% of which were not specified (many not specified participants may be assumed to be municipal staff who were concerned about implications if their affiliation was known). In 2018 there were 46 responses, 78% in the public sector, 20% in the private sector and 2% not specified. If, from the 2008 survey, the 30% of not specified could be assumed to be in the public sector then the audience between surveys would be considered similar. **Figure 1** shows pie charts of the survey breakdown of survey particpants.

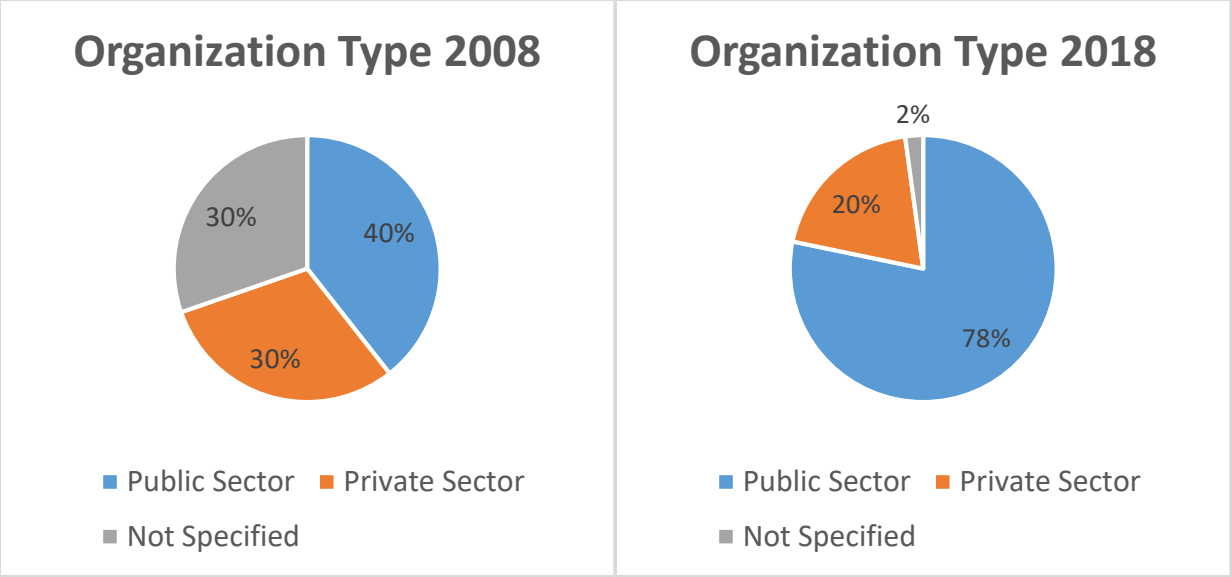


Figure 1: Pie charts showing the breakdown of survey participants for both the 2008 and 2019 studies. Assuming that most of the non-specified participants are actually from municipalities who are typically more concerned with anonymity, then a similar distribution could be assumed.

General Exposure to LID

The first four questions of the questionnaire did not actually include anything about barriers but was actually about the participants general experience and exposure to LID. **Table 1** shows the results from the four questions that were asked at the beginning of the questionnaire. For both the 2008 responses and the 2018 responses, question 2 did not receive full participation so the percentage is displayed relative to the number of people who answered. As seen in the table, LID has become a more widely known technology over the past 10 years.

Table 1: Table showing the results from the questionnaire for both 2008 and 2018.

Question	2008 Responses	2018 Responses
Are you familiar with the term Low Impact Development (LID)?	Y-31, N-2 Y – 94%	Y-46; N-0 Y – 100%
As a reviewer, designer or constructor have you ever considered LID as an alternative or complement to traditional stormwater management practice such as storm sewers and detention ponds?	Y-23; N-9 Y – 72%	Y-43; N-0 Y – 100%
Have you been involved in a project where LID measures were implemented?	Y-16; N-17 Y – 48%	Y-41; N-5 Y – 89%
Have you been involved in a project where LID measures were proposed or planned but not ultimately implemented?	Y-13; N-20 Y – 39%	Y-32; N-14 Y – 70%

Barrier Rankings

After answering the introductory questions, participants were asked to rate LID barriers on a scale of 1 to 5 where 1 is not a barrier, and 5 is a significant barrier. The average rate, number of 5 responses and number of 1 responses are summarized in **Table 2** for 2018 and **Table 3** for 2008. Also included in the table is a rank. Rank was selected based on three criteria, the highest average rate, the highest percent of 5 responses, and the lowest rate of 1 responses.

Table 2: Results from the 2018 questionnaire. Barriers are listed in the order that they were presented in the questionnaire with the average rate, % of the responses that rated the barrier as a 5 and the percent of responses that rated the barrier as a 1. The final column is the rank. Rank was selected based on three criteria, the highest average rate, the highest percent of 5 responses, and the lowest rate of 1 responses.

#	Barrier	Average	% of 5 Responses	% of 1 Responses	Rank
1	Fear of liability (engineers, owners, reviewers)	2.6	9%	20%	33
2	Reluctance to try something new	3.8	35%	4%	8
3	Lack of successful demonstration projects	3.8	30%	4%	9
4	Education and training do not provide skills to design and implement LID	3.3	15%	9%	15
5	Confusing nomenclature - lack of consistent names for practices (rain garden versus porous landscape detention versus bioretention)	2.8	2%	15%	25
6	Limited technical design guidance	3.2	11%	7%	18
7	Perceived design, construction, maintenance costs	4.2	50%	0%	2
8	Safety considerations	2.2	2%	26%	34
9	Public perception (temporary ponding on lots, standing water, mosquitoes, and other factors)	3.2	13%	7%	16
10	LID not integrated early in planning process	3.8	33%	2%	10
11	LID “recommended” in guidance rather than “required”	4.0	48%	7%	5
12	Compatibility with existing developments that do not use LID practices	2.9	9%	20%	23
13	Water rights considerations	2.7	9%	22%	30
14	“Mixed messages" from different governmental departments (planning versus engineering versus open space versus street maintenance)	3.7	28%	4%	13
15	No clear economic incentive for using LID	4.3	48%	0%	1
16	Difficulty in measuring benefits of LID	3.9	33%	0%	6
17	Semi-arid climate (i.e. difficulty in supporting green rain gardens)	3.6	24%	7%	14
18	Maintenance and durability concerns	4.1	35%	4%	4
19	Long term ownership (private versus publicly owned and maintained)	3.8	30%	4%	11
20	Standing water nuisance problems	2.8	4%	9%	26
21	Potentially longer review process	2.6	4%	9%	32
22	Conflicts with municipal code requirements (i.e. curb and gutter required)	3.1	15%	15%	20
23	American Disabilities Act considerations	2.6	7%	22%	31
24	Poorly drained soils/low infiltration capacity	3.2	17%	7%	17

25	High groundwater table	2.8	9%	11%	28
26	Concerns with swelling soils	2.7	13%	15%	29
27	Other water quality alternatives are “easier” to design, construct and maintain	4.1	43%	2%	3
28	Other types of BMPs and drainage infrastructure may still be required even with LID	3.8	24%	2%	12
29	Different/conflicting LID guidance or criteria from different groups (UDFCD versus Center for Watershed Protection versus others)	3.2	11%	9%	19
30	Examples of LID failures	2.8	11%	20%	24
31	Conflicts with landscaping requirements	2.8	2%	9%	27
32	Confusing or unclear ordinances related to LID and/or disconnected impervious area	3.0	7%	11%	21
33	Iterative coordination process with planners, designers, landscapers and others is required	3.0	9%	7%	22
34	Specialized construction techniques may be required	3.8	33%	4%	7

Table 3: Results from the 2008 questionnaire. Barriers are listed in the order that they were presented in the questionnaire with the average rate, % of the responses that rated the barrier as a 5 and the percent of responses that rated the barrier as a 1. The final column is the rank. Rank was selected based on three criteria, the highest average rate, the highest percent of 5 responses, and the lowest rate of 1 responses.

#	Barrier	Average	# of 5 Responses	# of 1 Responses	Rank
1	Fear of liability (engineers, owners, reviewers)	3.4	12%	3%	24
2	Reluctance to try something new	3.8	18%	3%	16
3	Lack of successful demonstration projects	3.9	21%	3%	9
4	Education and training do not provide skills to design and implement LID	3.4	30%	6%	22
5	Confusing nomenclature - lack of consistent names for practices (rain garden versus porous landscape detention versus bioretention)	3.0	9%	9%	29
6	Limited technical design guidance	3.8	30%	3%	14
7	Perceived design, construction, maintenance costs	4.2	45%	0%	1
8	Safety considerations	2.6	9%	9%	33
9	Public perception (temporary ponding on lots, standing water, mosquitoes, and other factors)	3.1	9%	9%	26
10	LID not integrated early in planning process	4.0	36%	0%	4
11	LID “recommended” in guidance rather than “required”	3.9	33%	0%	6
12	Compatibility with existing developments that do not use LID practices	2.9	9%	12%	32
13	Water rights considerations	3.0	12%	9%	28
14	“Mixed messages" from different governmental departments (planning versus engineering versus open space versus street maintenance)	4.2	45%	3%	2
15	No clear economic incentive for using LID	4.0	33%	0%	5
16	Difficulty in measuring benefits of LID	3.8	30%	3%	15
17	Semi-arid climate (i.e. difficulty in supporting green rain gardens)	3.6	21%	6%	20

18	Maintenance and durability concerns	4.1	42%	0%	3
19	Long term ownership (private versus publicly owned and maintained)	3.8	39%	3%	11
20	Standing water nuisance problems	3.1	18%	9%	25
21	Potentially longer review process	3.4	18%	0%	23
22	Conflicts with municipal code requirements (i.e. curb and gutter required)	3.7	21%	0%	18
23	American Disabilities Act considerations	2.4	0%	15%	34
24	Poorly drained soils/low infiltration capacity	3.8	33%	3%	12
25	High groundwater table	3.1	6%	6%	27
26	Concerns with swelling soils	3.9	30%	0%	7
27	Other water quality alternatives are "easier" to design, construct and maintain	3.8	33%	3%	13
28	Other types of BMPs and drainage infrastructure may still be required even with LID	3.9	15%	0%	10
29	Different/conflicting LID guidance or criteria from different groups (UDFCD versus Center for Watershed Protection versus others)	3.7	30%	3%	17
30	Examples of LID failures	2.9	9%	9%	31
31	Conflicts with landscaping requirements	2.9	9%	6%	30
32	Confusing or unclear ordinances related to LID and/or disconnected impervious area	3.6	24%	0%	19
33	Iterative coordination process with planners, designers, landscapers and others is required	3.6	18%	3%	21
34	Specialized construction techniques may be required	3.9	27%	0%	8

Interview Summaries

Finally, interviews were conducted with ten different municipalities and the answers to the four questions that were asked of them are summarized below.

Question 1: What is your disposition toward LID?

Everyone who was interviewed had a generally positive disposition personally toward LID. Though some of the interviewees did have a slight wariness for how LID has been promoted in the past and fear that sometimes that can turn people away from pursuing it in the future. However, when asked about the municipality's disposition toward LID, several interviewees expressed a generally positive disposition, with a desire to move toward LID, but that there were still some concerns that it would not be the most efficient and cost effective technology.

Question 2: How does LID current fit in this program (policy, criteria, municipal code, other)?

LID is only included in most programs as recommendations that are provided by stormwater departments. However, in a few municipalities it is moving toward a requirement stage which is both encouraging the use of LID while at the same time giving rise to needs within their stormwater program for additional training of municipal staff, contractors, and designers. With regards to criteria, many municipalities are currently using the UDFCD design criteria for LID

design and guidance with some small modifications. One of the few places that LID, particularly permeable pavements are not being used or being recommended for use is within CDOT, due to constraints that are unique to CDOT.

Question 3: Are there any additional barriers you think are hindering use of LID?

The main barrier that was identified was a lack of information and training to people at the various stages of development from the designers, to the design reviewers with municipalities, to contractors, and finally owners and operators. Another barrier has been the lack of a leader in LID at the various stages of design and construction that can show positive uses of LID at various sites. The final barrier that was mentioned was costs and developers not being convinced that LID is worth the investment particularly when they are not the ones who will officially own the LID (that will be the person/organization that purchases the property after it is developed).

Question 4: Are there any current LID projects occurring in your municipality?

Throughout the 10 municipalities there were only a handful of projects, mainly in Fort Collins and northern Colorado that were being evaluated and pursued.

DISCUSSION

After collecting and summarizing the results, it was determined how barriers have changed for implementing LID over the past decade. There are several observations that can be made which can be translated to both areas of success and areas for continued improvement. The results were analyzed by looking at the top ranked barriers, bottom ranked barriers as well as looking at the barriers that saw the most amount of change by either becoming a higher or lower concern.

Comparison of Highest Ranked Barriers

The top 5 barriers from the new study can be seen in **Figure 2**. Barriers were rated based on their overall rated score from the survey, the percent of participants who rated the barrier as a 5 (very important) and the percent of participants who rated the barrier as a 1 (not very important). The top 5 barriers primarily revolved around a perception of LID that it is not worth the potential risk of construction. This is evident in the top barrier being a lack of economic incentive to use LID and the fifth rated barrier being LID is only recommended not required. This shows that at its current state, LID does not have a natural market to compete with other stormwater practices. The main reasons for this lack of competition may be articulated by the top barriers 2, 3, and 4, which are all based on the concerns with the performance of LID, particularly compared to currently used practices. What the top five barriers demonstrate is that without regulatory drivers, it is difficult to have LID compete with traditional practices.

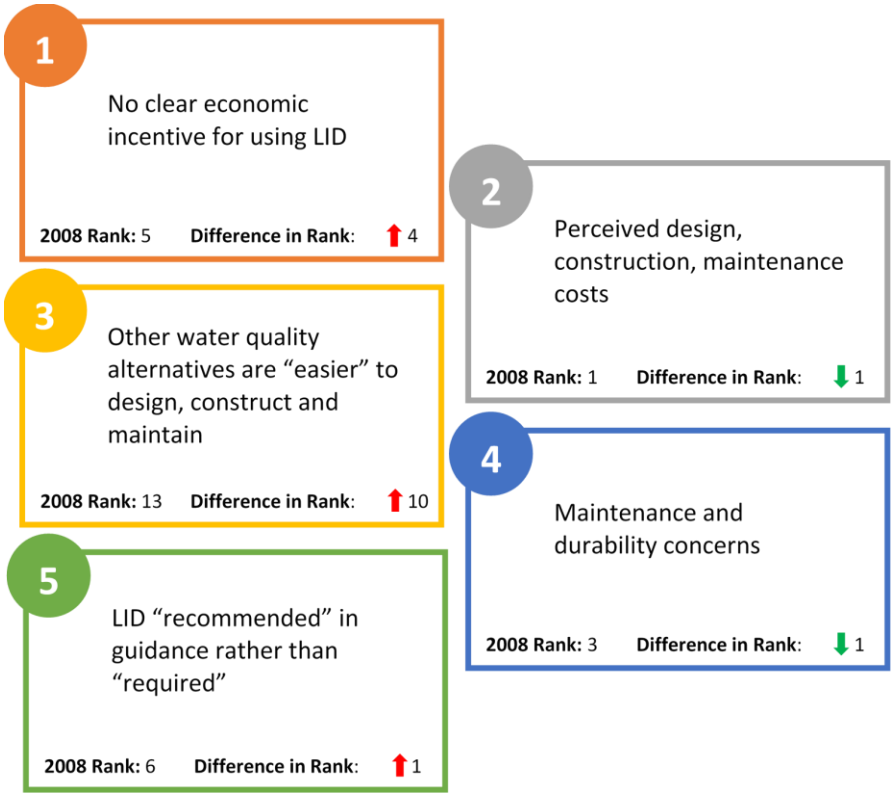


Figure 2: Top 5 barriers from the 2018 survey. Each barrier is listed by its 2018 rank and includes the barrier, the 2008 rank, and the difference in rank (including an arrow showing a rise or fall).

The question then may be asked, should there be regulatory drivers requiring LID. By requiring LID from a regulatory perspective, you circumvent several of the barriers regarding the fears of LID performance, costs, durability, and ease of use. However, this could give rise to other challenges in exacerbating fears of LID as more examples of poorly designed, constructed, and/or operated LID are present when regulations occur before the expertise is available. As many people expressed, the main concern with LID is a fear of how LID will perform and if LID is worth the additional cost of installation. However, as tools continue to develop to better quantify the benefits achieved by LID, and as expertise does continue to grow in the field, the cost should continue to decrease and the understanding of the value of LID should continue to increase.

Also, as identified by the interviews, many municipalities are aware of the primary barrier that developers and contractors do not want to use LID because of the unknowns, misconceptions, and in some cases, actual negative examples. Despite this barrier, municipalities are still trying to incentive, rather than mandate LID which is helping to encourage more people to try LID in a way that will lead to positive experiences and lessons. Though this methodology of incentives as opposed to regulation takes longer to yield a result, it hopefully will result in a more responsible research and deployment of LID while simultaneously avoiding scenarios of poor exposure. This is a situation that was commonly seen in Fort Collins as regulations outpaced expertise and research and has resulted in some practices being constructed incorrectly. This has led to many lessons learned but has also resulted in practitioners becoming strongly opposed to LID.

Comparison of Lowest Ranked Barriers

The bottom 5 barriers from the new study can be seen in **Figure 3**. The bottom 5 barriers primarily revolved around the fear of use of LID potentially overlapping with other regulatory requirements such as the American Disabilities Act (ADA), or water rights considerations, a very important topic in Colorado. Seeing these barriers fall to the bottom of the list demonstrates an important point that many of the barriers to LID are inherent within the performance of LID in their capacity of managing stormwater and the direct benefits they provide. This was also corroborated with the interviews as concerns with water rights, ADA, other safety concerns, additional liability, or a longer review process were not barriers that municipalities were concerned with.

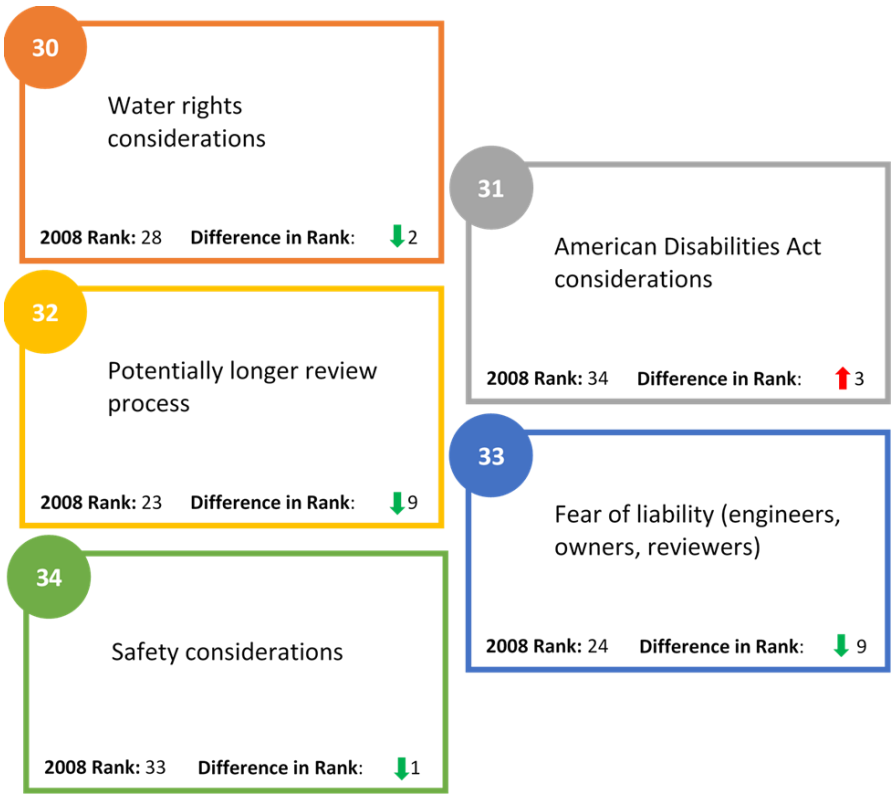
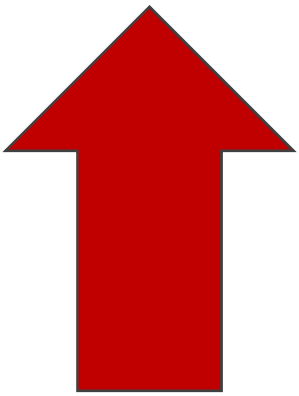


Figure 3: Bottom 5 barriers from the 2018 survey. Each barrier is listed by its 2018 rank and includes the barrier, the 2008 rank, and the difference in rank (including an arrow showing a rise or fall).

Barriers of Greatest Change

Understanding the ranking of barriers is important to be able to evaluate the current state of LID in Colorado. However, it is also interesting to evaluate which barriers have changed the most over the past decade. This not only shows what has changed but can also demonstrate the trajectory of LID and its potential future in Colorado. **Figure 4** shows the 5 barriers which increased the most in rank, and the 5 barriers which decreased the most in rank.



+11: Public perception (temporary ponding on lots, standing water, mosquitoes, and other factors)

+10: Other water quality alternatives are "easier" to design, construct and maintain

+ 9: Education and training do not provide skills to design and implement LID

+ 9: Compatibility with existing developments that do not use LID practices

+ 9: Difficulty in measuring benefits of LID

- 6: LID not integrated early in planning process

- 9: Potentially longer review process

-10: Fear of liability (engineers, owners, reviewers)

-11: Mixed messages from different governmental departments (planning versus engineering versus open space versus street maintenance)

-22: Concerns with swelling soils

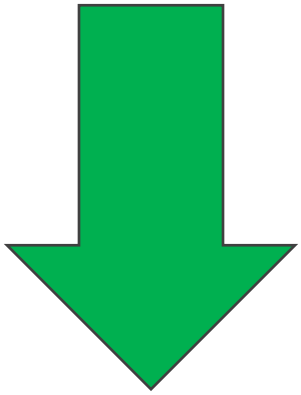


Figure 4: Barriers showing the greatest change in ranks between 2008 and 2011. A positive number means that the rank increased thus becoming more important; a negative number means that the rank has decreased and become less important.

After reviewing how LID barriers have changed over the past decade, it was observed that the barriers which increased the most in rank dealt with the performance, perception, and understanding of LID practices. Concurrently many of the barriers which decreased the most in rank were concerned with policy, process, or liability concerns of LID. Interpreting these results indicates that municipalities have made progress in removing many of the process or institutional barriers that have inhibited the use of LID. Currently the biggest barrier for LID is the performance of LID itself and not the process from municipalities. It was also noted that the swelling soils decreased the most in rank as LID technology has been shown to not be a recommended practice when swelling soils are present and thus are no longer a concern.

CONCLUSION

After distributing a questionnaire regarding the barriers of LID and conducting interviews with municipalities there were three main conclusions.

1) Barriers in 2018 primarily revolve around a lack of understanding or expertise relating to LID
2) LID is not perceived to be significantly inhibited by other regulatory requirements such as ADA or water law concerns
3) Municipalities have made progress toward removing institutional barriers for the use of LID

In order to overcome the barriers facing LID it is recommended that research continue to be done to help demonstrate the benefits of LID as well as help to quantify those benefits in a simple but meaningful way. Also, additional trainings should be pursued for municipal and private audiences to help educate engineers, landscape architects, contractors, and maintenance staff how to properly design, construct and operate LID so that they continue to be a useful commodity in the future.