White Paper

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Breaking Down the Barriers to Low Impact Development in Colorado

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Introduction

The Keep it Clean Partnership (KICP) is a group of municipalities including Boulder, Erie, Longmont, Louisville and Superior and Boulder County in the Boulder and St. Vrain watersheds that are permittees under the Phase II Stormwater National Pollutant Discharge Elimination System (NPDES) Program. Recognizing that infiltration-based best management practices (BMPs) are often not planned and implemented in situations where they potentially could be successfully used, KICP initiated a study to identify barriers to implementation of Low Impact Development (LID) practices in their watersheds. Barriers identified are broad and include physical, institutional, technical, social and economic factors, some perceived and some real, which act as impediments to more widespread implementation of LID.

The KICP study has included development of a questionnaire that has been circulated to municipal staff, engineers, developers and other parties involved in the development review and approval process. As a part of the study, KICP has developed a checklist for use by developers and by municipal staff reviewing plans to identify potential opportunities for LID and to be sure that the relevant factors that can lead to success or failure of a LID approach are considered in the development review process. Checklists were applied to several proposed development projects to refine the checklists and to identify additional barriers to LID based on "real world" projects. This paper presents the results of the KICP study. Major components of the study included the following:

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1. Identification of potential barriers to design and implementation of LID practices. This was accomplished through a series of several meetings in which participants identified barriers they had encountered and through interviews with planners, engineers and developers.

2. Development of questionnaire based on barriers identified by the group. The questionnaire was distributed to municipal staff involved in KICP as well as to engineers and developers working in the KICP watersheds. The Homebuilders Association (HBA) of Metropolitan Denver also distributed the questionnaire to members of its water quality committee.

3. Checklist development and application to "real world" development submittals. Projects reviewed included Boulder Manor in the City of Boulder, Sandstone Marketplace in Longmont and Redstone Ranch in Erie. The checklist was refined through these reviews to create a tool that will be useful to municipal reviewers as well as developers and engineers to encourage incorporation of LID into drainage design.

4. Identification of conceptual level strategies to address barriers identified as a part of the study.

The following sections provide an overview of LID and discuss the primary components of the project.

What is LID?

The Low Impact Development Center provides the following definition for 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. Techniques are based on the premise that stormwater management should not be seen as stormwater disposal. Instead of conveying and managing/treating stormwater in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small, cost-effective landscape features located at the lot level. These landscape features, known as Integrated Management Practices (IMPs), are the building blocks of LID. Almost all components of the urban environment have the potential to serve as an IMP. This includes not only open space, but also rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally*

well to new development, urban retrofits, and redevelopment/ revitalization projects. (http://www.lid-stormwater.net).

Table 1 provides some additional resources that provide information on LID. LID is currently included in the water quality guidance published by the Denver Urban Drainage and Flood Control District (UDFCD), a reference used by many municipalities in the area. The LID concept of runoff volume reduction is the first step in the "Four Step Process" for design of best management practices in Volume 3 of the UDFCD Urban Storm Drainage Criteria Manual. LID practices currently included in Volume 3 are planning, minimization of directly connected impervious area, infiltration practices, porous landscape detention, grassed swales and buffers and pervious pavement practices. UDFCD is currently in the process of updating Volume 3 of the USDCM to place more emphasis on volume reduction/LID practices.

Photographs 1 through 6 show examples of LID practices from Colorado. Additional photographs of LID practices are available on the Colorado Association of Stormwater and Floodplain Managers (CASFM) website:

http://www.casfm.org/stormwatercommittee/LID-00.htm.

Photograph 1. LID Landscaping for Roof/Building Runoff Boulder, Colorado

Photograph 2. Bioretention/Porous Landscape Detention, Aurora, Colorado

Photograph 3. Bioswale at Wal-Mart, Tower Road and Interstate 70, Aurora, Colorado

Photograph 4. Grass Buffer Strip, Aurora, Colorado

Photograph 5. Parking Areas with Modular Block Pavers, Wenk Associates, Denver Colorado

Photograph 6. Pervious Asphalt at Wal-Mart, Tower Road and Interstate 70, Aurora, Colorado

Table1. Resources for More Information on LID

U.S. Environmental Low Impact Development Web Page: http://www.epa.gov/owow/nps/lid/

Low Impact Development Center: http://www.lowimpactdevelopment.org/

University of New Hampshire Stormwater Center: http://www.unh.edu/erg/cstev/

National LID Clearinghouse: http://www.lid-stormwater.net/clearinghouse/index.html

North Carolina State University/North Carolina Cooperative Extension Stormwater Engineering Group: http://www.bae.ncsu.edu/stormwater/

Puget Sound Partnership Resource Center: http://www.psparchives.com/our_work/stormwater/lid.htm

Villanova Urban Stormwater Partnership: http://www3.villanova.edu/vusp/

Prince George's County, Maryland: http://www.goprincegeorgescounty.com/government/agencyindex/der/lid/bioretention.asp

Jordan Cove Urban Watershed Project: http://www.jordancove.uconn.edu/jordan_cove/about.html

Street Edge Alternatives (SEA Streets) Project: http://www.seattle.gov/UTIL/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/index.asp

Acronyms

ASCE	American Society of Civil Engineers
AWARE	Addressing Water and Natural Resources Education
BMPs	Best Management Practices
CASFM	Colorado Association of Stormwater and Floodplain Managers
CWP	Center for Watershed Protection
EDB	Extended Dry Detention Basin
EURV	Excess Urban Runoff Volume
EWRI	Environmental and Water Resources Institute
FEMA	Federal Emergency Management Agency
HBA	Homebuilders Association of Metropolitan Denver
HSG	Hydrologic Soils Group
IMPs	Integrated Management Practices
KICP	Keep it Clean Partnership
LID	Low Impact Development
MDCIA	Minimize Directly Connected Impervious Area
NPDES	National Pollutant Discharge Elimination System
RCP	Reinforced Concrete Pipe
UDFCD	Denver Urban Drainage and Flood Control District
UWRRC	Urban Water Resources Research Council
WQCV	Water Quality Capture Volume

Identification of Potential Barriers to LID

Through meetings with KICP, discussions with nationally recognized experts who are members of the American Society of Civil Engineers (ASCE) Environmental and Water Resources Institute (EWRI) Urban Water Resources Research Council (UWRRC), discussions with local municipal reviewers, engineers and developers, the following were identified as potential barriers to implementation of LID in the Front Range of Colorado:

- Fear of liability (engineers, owners, reviewers approving design)
- Reluctance to try something new/lack of demonstration projects
- Lack of education and training
- Lack of common nomenclature (rain garden versus porous landscape detention)
- Limited design examples/good technical documentation
- Costs—design, construction, operation and maintenance, life cycle
- Safety concerns
- Public perception
- LID not integrated early in planning process
- Guidance versus requirements
- Compatibility with existing developments
- Water rights
- Potential for mixed messages from government (different departments)
- No clear economic incentive for using LID
- Difficulty in measuring benefits of LID
- Semi-arid area hydrology
- Maintenance and durability
- Long term ownership/maintenance
- Standing water “nuisance” problems
- Fear of lengthening review process

- Conflicts with municipal code requirements
- American Disabilities Act considerations
- Poorly drained soils
- High groundwater table
- Expansive soils and construction defect lawsuits
- Other alternatives are “easier”
- LID does not altogether eliminate need for other types of BMPs and drainage infrastructure
- HOA or covenant restrictions (i.e. requirement for irrigated blue grass versus xeriscaped bioretention area)
- Different guidance/criteria from different groups (Center for Watershed Protection [CWP] versus UDFCD versus others)
- Examples of LID failures
- Conflicts with landscaping requirements (i.e. sensitivity of some types of plants to periodic inundation)
- Confusing ordinances
- Iterative versus linear process in coordination with landscapers, planners and others
- Criteria for individual LID BMPs versus overall LID design philosophy
- Requires specialized construction techniques

Many of these barriers were identified as a part of an initial set of workshops with input from KICP and participants from the development community, and others emerged as a part of the development review case studies. For example, in the review of the Redstone Ranch development in Erie a suggested opportunity for improving implementation of LID was limiting sidewalks to one side of the street in selected areas to reduce the overall site imperviousness. Participants in the design review indicated that this would not likely be feasible because a goal of municipal officials and an expectation of the public was to have an easily accessible integrated trail system for pedestrians and cyclists, while minimizing street crossings to get from one trail to another to avoid conflicts with motorized traffic.

Questionnaire

To assess the relative importance of each of these barriers, the project team created a questionnaire to gage participants' experience level with LID and to examine the relative importance of each of these barriers. The questionnaire also requested that participants note their role in the development process (municipal, engineer, developer, etc.) and to rank the significance of barriers on a scale of 1 to 5, with 1 corresponding to a minor barrier and 5 corresponding to a significant barrier. Overall, there were 33 responses to the one page questionnaire, predominantly municipal respondents, but with good representation from the development community as well. A breakdown of respondents is shown in Figure 1, and Table 2 shows the overall results of the questionnaire.

Figure 1. Questionnaire Respondents

Questionnaire results in Table 2 are sorted from those identified as most significant barriers to least significant barriers. In addition, the table shows the number of "1" and "5" responses for each barrier to illustrate which barriers received the most extreme ratings.

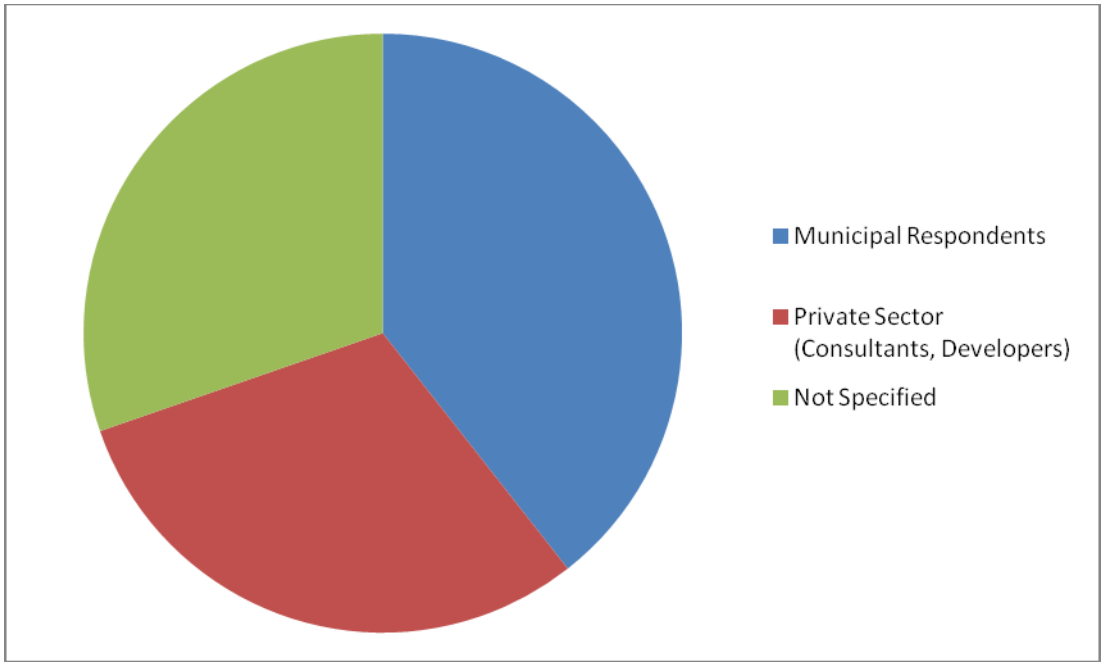

Table 2. Summary of Questionnaire Results

Participant Information				
Name (optional):	**Results**			
Organization (optional):	**Results**			
Email (optional to receive survey results):	**Results**			
Municipal Respondents:	**13**			
Private Sector (Consultants, Developers):	**10**			
Not Specified:	**10**			
General questions--Please answer yes or no. If filling out electronically please indicate selection with larger font.	**Answer**			**Responses**
Are you familiar with the term Low Impact Development (LID)?	Y		N	31 Y, 2 N
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		N	23 Y, 9 N
Have you been involved in a project where LID measures were implemented?	Y		N	16 Y, 17 N
Have you been involved in a project where LID measures were proposed or planned but not ultimately implemented?	Y		N	13 Y, 20 N

Table 2. Summary of Questionnaire Results (Continued 2 of 4)

Which of the following do you see as barriers to implementation of LID? Please rate on scale of 1 to 5. 1 = not at all, 5 = Very much.	Not at All				Very Much	Average	No. of 1 Responses	No. of 5 Responses
Perceived design, construction, maintenance costs	1	2	3	4	5	4.2	0	15
"Mixed messages" from different governmental departments (planning versus engineering versus open space versus street maintenance)	1	2	3	4	5	4.2	1	15
Maintenance and durability concerns	1	2	3	4	5	4.1	0	14
No clear economic incentive for using LID	1	2	3	4	5	4.0	0	11
LID not integrated early enough in planning process	1	2	3	4	5	4.0	0	12
Other types of BMPs and drainage infrastructure may still be required even with LID	1	2	3	4	5	3.9	0	5
LID "recommended" in guidance rather than "required"	1	2	3	4	5	3.9	0	11
Lack of successful demonstration projects in area	1	2	3	4	5	3.9	1	7
Concerns with swelling soils	1	2	3	4	5	3.9	0	10
Specialized construction techniques may be required	1	2	3	4	5	3.9	0	9
Other water quality alternatives are "easier" to design, construct and maintain	1	2	3	4	5	3.8	1	11
Long term ownership (private versus publicly owned and maintained)	1	2	3	4	5	3.8	1	13
Difficulty in measuring benefits of LID	1	2	3	4	5	3.8	1	10
Reluctance to try something new	1	2	3	4	5	3.8	1	6
Limited technical design guidance	1	2	3	4	5	3.8	1	10

Table 2. Summary of Questionnaire Results (Continued 3 of 4)

Which of the following do you see as barriers to implementation of LID? Please rate on scale of 1 to 5. 1 = not at all, 5 = Very much.	Not at All				Very Much	Average	No. of 1 Responses	No. of 5 Responses
Poorly drained soils/low infiltration capacity	1	2	3	4	5	3.8	1	11
Conflicts with municipal code requirements (i.e. curb and gutter required)	1	2	3	4	5	3.7	0	7
Different or conflicting LID guidance or criteria from different groups (UDFCD versus Center for Watershed Protection versus others)	1	2	3	4	5	3.7	1	10
Semi-arid climate (i.e. difficulty in supporting green rain gardens)	1	2	3	4	5	3.6	2	7
Iterative coordination process with planners, designers, landscapers and others is required	1	2	3	4	5	3.6	1	6
Confusing or unclear ordinances related to LID and/or disconnected impervious area	1	2	3	4	5	3.6	0	8
Education and training do not provide skills to design and implement LID	1	2	3	4	5	3.4	2	10
Potentially longer review process	1	2	3	4	5	3.4	0	6
Fear of liability (engineers, owners, reviewers)	1	2	3	4	5	3.4	1	4
Standing water nuisance problems	1	2	3	4	5	3.1	3	6
Public perception (temporary ponding on lots, standing water, mosquitoes and other factors)	1	2	3	4	5	3.1	3	3
High groundwater table	1	2	3	4	5	3.1	2	2
Water rights considerations	1	2	3	4	5	3.0	3	4
Confusing nomenclature--lack of consistent names for practices (rain gardens versus porous landscape detention versus bioretention)	1	2	3	4	5	3.0	3	3
Compatibility with existing developments that do not use LID practices	1	2	3	4	5	2.9	4	3

Table 2. Summary of Questionnaire Results (Continued 4 of 4)

Which of the following do you see as barriers to implementation of LID? Please rate on scale of 1 to 5. 1 = not at all, 5 = Very much.	Not at All				Very Much	Average	No. of 1 Responses	No. of 5 Responses
Examples of LID failures	1	2	3	4	5	2.9	3	3
Conflicts with landscaping requirements	1	2	3	4	5	2.9	2	3
Safety considerations	1	2	3	4	5	2.6	3	3
Americans with Disabilities Act considerations	1	2	3	4	5	2.4	5	0

Checklist and Development Reviews

To develop a tool to encourage wider implementation of LID, the KICP group developed a checklist to be used by developers, engineers and municipal staff to identify potential opportunities for LID for proposed development and redevelopment projects. The checklist covers topics related to administrative considerations (relevant to multiple jurisdictions); site resources and characteristics; proposed site layout including streets and driveways, parking and landscaping; LID opportunities; structural BMPs; and construction and maintenance. The checklist was designed for "yes/no" responses and provides an area for users of the checklist to provide comments. The checklist also includes comments on applicability of each of the questions and considerations for LID to assist users in selecting appropriate responses and providing comments.

Initially a "master checklist" was created consisting of more than eighty questions. Through the review process and based on comments from initial reviewers of the checklist, checklists consisting of a sub-set of the master checklist were developed for various stages of the review process including sketch plan, preliminary plan, final plat and during construction. The goal of subdividing the master checklist in this way was to provide a tool for municipal reviewers, developers and engineers that could be introduced early in project planning stages and continually applied as the project design evolves. Checklists that were developed are included as Appendix A.

The checklists were "test driven" and refined based on application to three "real world" projects, these meetings with KICP community representatives are described below. Completed master checklists for each project are provided in Appendix B.

Project Name: Boulder Mobile Manor

Overview of Project Design Objectives, Constraints and Goals

The Boulder Mobile Manor project is located at 2637 Valmont Road in Boulder, Colorado. The property is approximately 4.7 acres and is currently developed as a 66-unit mobile home park. The existing site includes a laundry/office building, a playground, 53 storage units, onsite street parking, and mature trees. The existing topography generally slopes south along grades averaging between 0.5% and 1.0%. The onsite soils consist of Valmont Clay Loam (HSG C) and groundwater table was encountered approximately 8.5 to 11 feet below ground surface. The project site is not located within a FEMA designated 100-year floodplain, and there are no impacted wetlands.

For developed conditions, there is no below grade outfall (e.g. existing storm drain infrastructure) to discharge into without making major off-site improvements. In order to meet stormwater quality requirements, the developer has considered porous pavers, grass swales and a small extended detention facility. The porous pavers are proposed along parallel parking spaces. Grass swale sedimentation basins are proposed along the center of the site and along the east side of the site. An extended detention basin is proposed in the southeast corner of the site. On-site flood control detention is not required because the developed imperviousness (proposed) of 59.6% is less than the existing condition imperviousness of 62.9%.

Observations and Comments from Checklist Review

After completing the LID Barriers Checklist for Boulder Mobile Manor, several observations were made including:

1. Mature tree stands will be mostly removed. An attempt should be made to preserve mature trees where possible.
2. Because of Type C soils on-site, underdrains are recommended for porous paver areas and potential porous landscape detention areas.
3. Stockpiling of topsoil should be considered during demolition of existing site.
4. Porous pavers were only considered on selected parking spaces. All parking spaces could utilize porous pavers.
5. The total WQCV provided should be calculated including EDB and the effect of non-volumetric BMPs such as porous pavers and grass swales.
6. Roadside swales are not feasible, but porous landscape detention could be provided between the curb and sidewalk by using curb cuts or by installing depressed tree planters.
7. Paver stones could be used for sidewalks.
8. Gravel driveways or driveway strips could reduce site imperviousness.
9. Effective imperviousness was not calculated in the report for Level 1 MDCIA.

10. Porous paver detention could be utilized to increase WQCV provided.
11. Consider including a micro-pool in the EDB.

Barriers to LID Implementation Suggestions

Several barriers to the observations listed above were discussed at the meeting. These barriers are listed below by the corresponding observation number above.

1. Dense develop precluded preserving existing mature trees. New trees will be planted throughout the site following construction.
2. Existing clay soils required that underdrains and impermeable liners were recommended for all porous paver areas limiting infiltration.
3. The City does not have the authority to require stockpiling of topsoil prior to grading but will encourage this takes place.
4. Porous pavers were implemented in locations where adequate elevation allowed positive drainage in underdrains.
5. The UDFCD criteria currently do not provide a comprehensive method to quantify these non-volumetric effects.
6. Concerns with porous landscape detention and depressed tree planters included aesthetic and nuisance concerns such as standing water and expansive clay soils damaging sidewalks and curbs. Cost of these features was also a concern.
7. Cost of materials as compared to limited hydrologic benefit. Not a common practice for narrow sidewalks, more commonly used on wider pedestrian paths or plazas.
8. Concerns with gravel being pushed into streets. Driveway strips may be an alternative.
9. Water quality calculations were based on total impervious area rather than effective impervious area, resulting in larger WQCV than would be dictated if Level 1 MDCIA was considered.
10. City of Boulder does not approve parking lot detention for nuisance reasons.
11. Depth constraints and small size of EDB may limit potential benefits.

Identification of Additional LID Opportunities for Developer/Engineer/ Planner to Consider

There were a few additional LID opportunities discussed at the meeting. The use of sidewalk chases at a few different locations would allow street drainage to be conveyed into the grass swale along the eastern property boundary. This has the added benefits of directing impervious area across pervious area, increasing infiltration potential, and providing filtration. However, the City of Boulder typically does not approve sidewalk chases due to maintenance concerns with clogging.

Project Name: Sandstone Marketplace

Overview of Project Design Objectives, Constraints and Goals

The Sandstone Marketplace Project is located at the southeast corner of Hwy 119 and County Line Road. The property is approximately 21.5 acres and is currently undeveloped with vegetation consisting of native grasses and weeds. The existing topography of the site indicates that the northeast corner of the site generally slopes east at 1% to 2% and that the western portion of the site generally slopes south at 1% to 3%. The onsite soils consist of Colby Loam (HSG B) and Weld Loam (HSG C). The project site is located within Flood Zone C (areas of minimal flooding) as designated by FEMA.

The project site will be developed as a commercial site consisting of two retail buildings (20,000 sq.ft.), three restaurants, and parking. Additional future commercial development is planned within the project site, therefore the fully developed imperviousness level for proposed building pads was assumed to be 80% based on the requirement of 20% landscaping. A Sam's Club development project (by others) is planned at the southeast boundary of the site and construction was originally planned prior to Sandstone Marketplace being constructed. A storm sewer system is planned to collect runoff from the 100-year event and convey it to two different detention facilities which then discharge into the proposed Sam's Club storm sewer infrastructure. The southeast detention pond will include an extended detention basin (EDB) and trash rack for water quality. The northeast detention pond will include a hydraulically connected 72-inch RCP for additional detention volume storage followed by an outlet structure which includes a 10-inch orifice pipe, overflow weir and 100-year orifice pipe. The outlet structure discharges to an inline Contech Vortechs System (3-chamber vault for sedimentation and oil separation) for water quality treatment.

Specific Observations and Comments from Checklist Review

After completing the LID Barriers Checklist for Sandstone Marketplace, several observations were made including:

1. There is potential to preserve existing vegetation on portions of the site that are not currently planned for development. Grading for these areas could be phased to occur later when future development plans are ready for construction.
2. The northeast corner of the site consists of Type B soils which are conducive to infiltration practices. The western portion of the site consists of Type C soils which would likely require underdrains for infiltration BMPs.
3. There does not appear to be any attempt to reduce impervious areas or to minimize directly connected impervious areas. Slotted drains and area inlets are used to collect runoff from the project boundaries and all rooftop runoff is piped directly to the storm sewer system.

4. There are no infiltration BMPs for volume reduction provided at the site.
5. The northeast detention pond does not provide peak flow attenuation for storms smaller than the 10-year event. However, the discharge from the pond will be routed through an inceptor into a Wal-Mart pond.
6. All inlets and storm pipes are sized for the 100-year event, so no parking lot detention is provided.
7. Parking lot islands and medians are all elevated. These could be depressed to provide porous landscape detention.
8. Vegetated swales could be incorporated along property boundaries and in parking medians.
9. Porous pavement (concrete or asphalt) could be integrated at several locations across the site. Porous pavement detention could also be included.
10. Southeast EDB volume could be significantly reduced by integrating porous landscape detention, grass swales and porous pavement. In addition, a micro-pool could be incorporated into the pond design to reduce clogging and mosquito problems.
11. A trash rack is not provided on the outlet pipe from the northeast pond. This poses significant safety and maintenance concerns since there is underground storage (72" RCP) and a water quality vault (Vortechs System) downstream.

Barriers to LID Implementation Suggestions

A few barriers to the implementation of LID practices were discussed at the meeting including aesthetic, nuisance and maintenance concerns. The use of a micro-pool on the southeast EDB was discussed and concerns about improper grading and standing water were raised. It is important that the micro-pool be designed and constructed properly to avoid nuisance problems. Questions were also raised about the maintenance of sand filter EDBs as compared to traditional EDBs. Maintenance costs for sand filters would likely be higher and would require special equipment.

Identification of Additional LID Opportunities for Developer/Engineer/ Planner to Consider

Sandstone Marketplace is in the final stages of plan review and it would be difficult to incorporate the LID techniques discussed above this late in the review process.

Project Name: Redtail Ranch

Overview of Project Design Objectives, Constraints and Goals

The Redtail Ranch Project is located north of Weld County Road 4, south of Weld County Road 6, east of the Vista Parkway and west of Weld County Road 5 in Erie, Colorado. The property is approximately 289.9 acres and is currently agricultural land with light vegetation consisting of native grasses. The existing topography of the site indicates that the majority of the site slopes from northeast to southwest at slopes ranging between 0 and 20%. The onsite soils consist of five different classifications of clay loam with some HSG B soils, but mostly HSG C and D soils. The geotechnical report states that sandy clay is present from 0 to 15 feet deep.
The project site is not located within a FEMA designated floodplain. One jurisdictional wetland is located in the southwest corner of the site. Existing landfills border the project site on the east and west. An abandoned coal mine is located below the site at a depth of approximately 270 feet.

The project site will be developed as a 579-lot residential development consisting of clustered residential areas with an extensive open space, parks and trail system, and a network of public streets. The development will include front load and alley load lots and a cluster of duplex lots. The project density will be approximately 2 dwelling units per acre with 1/3 of the site preserved as open space. There are no major drainageways within the development, runoff drains into two tributaries of Coal Creek. The December 2007 Outfall Systems Plan was utilized in sizing conveyance and detention facilities for the project site. Onsite runoff will be captured by curb and gutter and conveyed to storm sewer inlets. The storm sewers drain to one of several onsite WQ ponds or to the regional detention facility. The full-spectrum excess urban runoff volume (EURV) method was used to determine the WQCV and flood control volumes required.

Specific Observations and Comments from Checklist Review

After completing the LID Barriers Checklist for Redtail Ranch, several observations were made including:

1. Avoid disturbing park and open space areas during construction where possible. This will prevent soil compaction and preserve native vegetation.
2. Grading should occur in phases to reduce erosion potential. Also topsoil should be stockpiled separately so that it can be used again during final grading.
3. The current report does not provide a lot of specifics on ways to minimize directly connected impervious area (MDCIA). Reducing DCIA would result in smaller detention ponds. The project does call for a landscaped area between sidewalks and curb and gutter that will contribute to reducing directly connected impervious area.
4. Roof top drains should be routed across pervious areas.
5. Consider depressed porous landscape detention islands in cul-de-sacs and round-abouts to reduce impervious area and promote infiltration.

6. Consider roadside swales and median swales instead of curb and gutter draining to storm sewer.
7. Consider sidewalks on only one side of the street along the main thoroughfare.
8. Consider porous pavement in alleys.
9. Consider using retention or wetland ponds in southwest corner of site where wetlands currently exist.

Barriers to LID Implementation Suggestions

During the meeting, several concerns were raised regarding the implementation of LID practices at Redtail Ranch, including:

1. Roof downspout details are typically not included in drainage reports, and review is done separately by the building department as part of architectural drawing reviews. This makes it difficult to ensure the plans are consistent. However, disconnecting roof downspouts to drain across pervious areas was generally acceptable, as long as foundation concerns were adequately addressed. There is a concern that homeowners will modify the roof downspouts after construction is completed. For lots backing to open space, all agreed that roof downspouts should be directed to back lots.
2. Roadside swales along the main collector street in sections adjacent to open space areas are a feasible alternative. This concept would tie into the Vista Ridge Parkway setting well.
3. Median swales along the main collector street were less desirable for safety and maintenance reasons.
4. Removing sidewalks from one side of the street along the main collector to reduce impervious area was not accepted. The group agreed that it was more important to maintain continuity in the trail system and avoid unnecessary crosswalks.
5. Alternative driveways are unlikely for this development. The group agreed that shared driveways are not agreeable to homeowners.
6. Parking on one side of the street is difficult to enforce and therefore not recommended.
7. Providing depressed porous landscape detention in round-about islands was discussed. Primary concerns were maintenance of sand media to prevent clogging, ponding of water, etc.
8. Modular block porous pavement is suitable for the alleys in the multi-family area. An underdrain would be necessary due to Type D soils and the proximity to building foundations. The use of porous concrete pavement was discussed, and the concerns with durability and construction issues were mentioned.

Identification of Additional LID Opportunities for Developer/Engineer/ Planner to Consider

In general, the opinion of the group was that the site was relatively well designed from a water quality perspective and there was not much incentive for additional LID features. The primary benefit would be the potential reduction in WQCV required by implementing Level 1 MDCIA (e.g. disconnecting roof downspouts and providing roadside swales where feasible). The primary LID features that would be feasible for this site include:

- Minimizing directly connected impervious area (MDCIA) by directing roof downspouts to pervious areas.
- Providing grass swales along shoulder of main collector street adjacent to open space areas.
- Installing depressed porous landscape detention in round-about islands.
- Providing modular block porous pavement in alleys.
- Additional site preservation measures during construction including phasing and topsoil stockpiling.

Conceptual Strategies for Addressing Barriers

Although the scope of work for the KICP Barriers Identification project was limited to identification of barriers, development of the checklist and conducting design reviews using the checklist, the project team developed conceptual approaches for beginning to address barriers. Conceptual strategies are listed in Table 3.

Table 3. Conceptual Strategies for Addressing LID Barriers

Identified Barriers	Conceptual Strategies
Perceived design, construction, maintenance costs	Examples of successful LID pilot studies in the Rocky Mountain Region including economic analysis and long-term performance monitoring and documentation of maintenance.
"Mixed messages" from different governmental departments (planning versus engineering versus open space versus street maintenance)	Development of improved regional guidance (Volume 3), model ordinances and criteria, better coordination between engineering, planning, parks and recreation, etc.
Maintenance and durability concerns	Long-term performance monitoring and documentation of maintenance activities for existing LID installations.
No clear economic incentive for using LID	Develop incentives for LID implementation (reduced storage requirements for water quality event and potentially larger events) to provide credit. Consider expedited variances to shorten review process for proven methods. Documentation of savings on LID projects in region.
LID not integrated early enough in planning process	Checklist at pre-application meeting to identify opportunities for LID.
Other types of BMPs and drainage infrastructure may still be required even with LID	Examine potential reduced sizing of other "traditional" BMPs when LID measures are adopted.
LID "recommended" in guidance rather than "required"	Evaluate ordinances and requirements in other communities where LID has been more widely adopted.
Lack of successful demonstration projects in area	Consider municipal demonstration projects to "showcase" LID.
Concerns with swelling soils	Better coordination with geotechnical engineers and consideration of soil treatment and amendments.
Specialized construction techniques may be required	Examine construction techniques used for successful LID projects and construction techniques that have contributed to LID failures. Consider contractor education programs and/or certification.
Other water quality alternatives are "easier" to design, construct and maintain	Emphasize importance of "Step 1--Volume Reduction" from UDFCD Manual. Provide updated design details, specifications.
Long term ownership (private versus publicly owned and maintained)	Evaluate need for easements, deed restrictions, public authority to maintain/repair LID BMPs on private property and back-charge owners. Public education for property owners.
Difficulty in measuring benefits of LID	Increased monitoring of LID hydrologic and water quality benefits on individual BMP and site scales (local data). Develop tools for quantifying effects of LID on sizing of other drainage facilities.
Reluctance to try something new	Municipal examples to lead the way. Publicity of successful implementation of LID.
Limited technical design guidance	Updated criteria and focus on planning and volume reduction. Development of detailed specifications templates. More involvement of engineers for construction observation/clarifications during construction.
Poorly drained soils/low infiltration capacity	Better coordination with geotechnical engineers and consideration of soil treatment and amendments. Understand there are some circumstances where LID is not feasible.

Table 3. Conceptual Strategies for Addressing LID Barriers (Continued)

Identified Barriers	Conceptual Strategies
Conflicts with municipal code requirements (i.e. curb and gutter required)	Consider expedited variance requirements where LID features are desired and conflict with standard code requirements.
Different or conflicting LID guidance or criteria from different groups (UDFCD versus Center for Watershed Protection versus others)	Develop LID criteria specific to semi-arid region and incorporate into regional guidance (UDFCD Manual).
Semi-arid climate (i.e. difficulty in supporting green rain gardens)	Use drought tolerant species. Do not expect "green" rain gardens. More emphasis on xeriscaping coupled with infiltration.
Iterative coordination process with planners, designers, landscapers and others is required	Early coordination between developers, engineer and municipal staff from multiple departments to define LID approach for project and identify specific barriers.
Confusing or unclear ordinances related to LID and/or disconnected impervious area	Improved model ordinances and criteria.
Education and training do not provide skills to design and implement LID	Expanded training courses through municipalities and professional organizations. Consider webinars, field tours, symposia.
Potentially longer review process	Integrate LID concepts as early as feasible in planning process. Improved familiarity of municipal reviewers with LID concepts and methods.
Fear of liability (engineers, owners, reviewers)	More local examples of successful LID implementation, Consider in municipal projects to set example for private development community.
Standing water nuisance problems	Include underdrains in designs. Clearly define maintenance requirements. Avoid grading plans that specify very mild (unconstructable slopes).
Public perception (temporary ponding on lots, standing water, mosquitoes and other factors)	Public education on benefits of LID. Better LID design can reduce nuisance water.
High groundwater table	Require submittal of geotechnical information including groundwater levels early in review process. Recognize that LID may not be feasible in all situations.
Water rights considerations	Avoid storage/harvesting of runoff for beneficial use. Directing downspouts from roof to pervious areas is not a problem for water rights (incidental use), but collecting runoff from downspouts, storing it (i.e. rain barrels, then beneficially applying the collected water is not legal.
Confusing nomenclature--lack of consistent names for practices (rain gardens versus porous landscape detention versus bioretention)	Develop glossary of LID terminology as a part of regional guidance.
Compatibility with existing developments that do not use LID practices	Involvement of Landscape Architects and Planners to better define "community identity and character."
Examples of LID failures	Forensic investigation of LID failures. Identify specific factors leading to unsuccessful applications and learn from mistakes.
Conflicts with landscaping requirements and ordinance requirements	Better coordination with Landscape Architects.
Safety considerations	Generally not considered a major barrier, but evaluate safety, especially in areas where the general public will be in close physical proximity to LID BMPs (e.g. Drop off into infiltration swale between sidewalk and street in areas where street parking is likely).
Americans with Disabilities Act considerations	Provide alternate surfaces for disabled access if there is potential for pervious surface to impede mobility.

Conclusion

The results of this project demonstrate that there are many significant barriers to implementation of LID in the Front Range of Colorado, some very real and some largely perceived. Identification of these barriers is an important first step in encouraging wider use of LID practices in this region, because once barriers are identified, strategies can be developed to overcome the barriers. Strategies may include improved communication between municipal departments (engineering, planning, parks and recreation, etc.), updated design guidance and details for developers and engineers, increased public education efforts and other outreach programs. Communities' will also need to determine how LID supports their development and water quality goals - as any new standards will need to be approved by policy boards (councils, advisory boards, etc.)

Fortunately in Colorado, there are a number of organizations ranging from watershed groups to Colorado AWARE (Addressing Water and Natural Resources Education) to municipal permittees such as KICP and governmental organizations such as UDFCD and the Colorado Department of Public Health and Environment that are keenly interested in encouraging the use of LID. Additional efforts by these groups, potentially in collaboration with one another, has great potential to overcome many of the barriers identified in this study.

Appendix A. LID Checklists for Use by Municipal Staff, Engineers, and Developers

Master Checklist

MASTER LIST--ALL QUESTIONS

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

QUESTION	YES	NO	COMMENTS	APPLICABILITY
ADMINISTRATIVE				
Does the project fall under more than one jurisdiction?				When multiple jurisdictions are involved agreeing on applicable criteria (and allowable variances) early in the process can simplify review and approval.
Are variances required to permit LID measures proposed for site?				Examples of variances may include reduced street widths, reduced parking requirements, curb and gutter alternatives, alternative design criteria for BMPs.
SITE RESOURCES AND CHARACTERISTICS				
Will floodplain delineation boundaries been encroached upon?				Preservation of floodplains is beneficial for buffering of receiving waters as well as flood control.
Will sensitive areas be protected from encroachment?				Sensitive areas may include wetlands and waterbodies, riparian corridors, mature tree stands, wildlife habitat, etc. Buffers may be an effective tool for protection.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?				Leaving areas undisturbed may promote infiltration and will reduce erosion potential during construction.
Is phased grading planned to reduce potential soil erosion?				
Has development on steep slopes been avoided?				Steep slopes pose a greater potential for erosion and can be difficult to revegetate. Infiltration potential is limited on steep slopes.
Can cut and fill volumes be reduced?				
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?				HSG A and B are favorable for infiltration/LID. Type C and D soils may limit potential for LID or require the use of an underdrain.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?				Shallow groundwater or bedrock may limit ability to infiltrate runoff.
Is there potential for groundwater pollution at the site?				If groundwater pollution is a concern, liners with underdrains that daylight may be appropriate for infiltration practices.
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?				If adequate water is available to support wetland growth, soil amendments also could be considered.
Is there any indication that topsoil will be removed and set aside prior to grading?				Stockpiling and reusing topsoil may improved success of revegetation.

PROPOSED SITE LAYOUT				
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?				Imperviousness may be specified in zoning. UDFCD Stormwater Master Plans may also contain information on assumed impervious levels.
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?				The goal is to maximize pervious portions of the site that can infiltrate runoff.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?				MDCIA may include disconnected downspouts, directing drainage from impervious areas to pervious areas and using pervious conveyances (i.e. swales) rather than storm sewer.
Is there potential for better integration of cluster development techniques?				Cluster developments concentrate buildings in specific areas on a site, leaving remaining land for common open space and reducing impervious surface area.
Are rooftop drains disconnected from impervious surfaces and pipes (e.g. draining to lawns, porous landscape detention, grass swales, etc.)?				This is a fundamental principal of MDCIA. Gutter extenders may be used to provide distance between foundation backfill zone and discharge point.
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?				Approximately 75% of runoff events in the Denver Metropolitan area are 0.5 inches or less. Controlling small frequently occurring runoff events provides water quality treatment for the bulk of the annual pollutant load and is beneficial for channel geomorphology.
Have split flow scenarios been considered where small storm events are directed to small spatially distributed LID features and larger storm events spill over to larger flood control facilities?				Can the water quality event be infiltrated using LID techniques with a storm sewer to convey larger events? Using LID may reduce size and cost of storm sewer infrastructure.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?				Selection of BMPs should be based on the pollutants desired to control. A "treatment train" of multiple BMPs may be necessary to control multiple pollutants.
Streets and Driveways				
Could site design or frontage requirements be modified to reduce street length?				Maximize efficiency of street layout to reduce impervious area.
Could narrower streets be used to reduce impervious area?				May require a variance.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?				Alternative layouts may reduce impervious area, and features such as sunken islands can potentially be used as porous landscape detention areas.
Are roadside swales a viable alternative to traditional storm sewer?				Roadside swales can be used in conjunction with curb and gutter if curb cuts or slotted curbs are used.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?				May require a variance.
Could setbacks be modified to reduce driveway length?				May require a variance.
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?				Shared driveways may work well with clustered development.

Parking				
Could parking be provided only on one site of the street?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking alternatives (fewer spaces or smaller spaces) feasible?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking lot islands elevated or depressed?				Depressed parking islands may be used for porous landscape detention.
Can parking lot landscaping and LID be integrated?				LID infiltration areas likely will help to satisfy landscaping requirements.
Is there potential for porous pavement in low use parking areas?				Less frequently used sections of parking areas (away from store) or lower-traffic areas may be suitable candidates.
Landscaping				
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?				This practice may reduce nuisance irrigation return flows and is beneficial for water conservation.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?				Overwatering may saturate soil and limit infiltration capabilities during runoff events. Low water plants can most effectively be watered using drip irrigation rather than spray/rotor irrigation.
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?				Preserving existing trees protects pervious areas of site and new trees for canopy will improve rainfall interception and reduce effective impervious area.
Can site runoff be directed to landscaped areas?				State Engineers Office guidance prohibits collecting and applying water for irrigation; however, runoff that is directed to vegetated areas as "incidental" water may help to satisfy irrigation requirements.
LOW IMPACT DEVELOPMENT OPPORTUNITIES				
Are green incentives available for the proposed project?				Examples from other municipalities may include reduced parking requirements, additional building space, reduced WQCV and/or detention requirements.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?				MDCIA and other LID practices may decrease effective impervious area, runoff coefficient, runoff volume and peak flow rates.
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?				Many non-volumetric BMPs may reduce directly connected impervious area and promote infiltration.
Will LID practices assist with LEED certification?				LEED points may be awarded for runoff reduction and water quality treatment measures.
Do plans differentiate between total impervious area and effective impervious area?				Using effective imperviousness versus total imperviousness in runoff and WQCV calculations may reduce runoff rates and storage volumes.

STRUCTURAL BMPS				
Does the site plan identify stormwater best management practices (BMPs)?				Even when a regional water quality facility serves a development, onsite practices including MDCIA, infiltration practices, swales, buffers, etc. may be required for water quality enhancement to comply with MS4 Permit. On site measures may reduce conveyance costs.
Are there any uniformly sloped areas (< 4%) where grass buffers could be implemented for sheet flow but are not?				Vegetated buffers provide opportunity to slow runoff, "strain out" coarse pollutants and enhance infiltration.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?				This is only suitable for sites with ground slopes < 5%. The longitudinal slope of the swale should be < 1%, which may necessitate grade control checks.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?				Porous pavement may be used to disconnect impervious areas. Porous pavement may not be applicable to all paved areas of site (especially high-traffic/high-wear areas).
In areas where porous pavement is planned, is there potential to incorporate detention storage (approx. 2") above the porous pavement?				Allowing temporary ponding above the paved surface may help reduce site detention requirements and provide a higher degree of water quality treatment.
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?				Consider features including depressed islands and medians.
Has an extended detention basin been incorporated on the site?				Not likely to infiltrate a lot of runoff but may provide good sedimentation and peak flow control for small, water quality events.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?				Have infiltration basins been considered? Porous landscape detention? There are many alternative BMPs that have a larger infiltration component than an extended detention basin.
Is an appropriate trash rack provided for the basin outlet structure?				Trash racks and screening can reduce potential for clogging of outlet works.
Is a micro-pool provided as part of the outlet for the basin?				Micropools help to prevent clogging of the trash rack and reduce mosquito problems.
Is there sufficient base flow to support a retention pond (wet basin)?				Advantages over dry basin include increased pollutant removal, aquatic habitat, recreation and aesthetics.
Is there potential for a sand filter extended detention basin to be implemented on the site?				Even with Type C and D soils, this BMP can be implemented using an underdrain.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?				A continuous base flow is necessary to support a constructed wetland channel.
Will material storage and handling areas be covered?				Plans submitted should include materials handling and storage BMPs and "good housekeeping" practices.
Has spill containment and control been provided where necessary?				Sill Protection Control and Countermeasure (SPCC) Plan may be required for industrial sites and BMPs for spill control during construction should be provided in Stormwater Management Plan (SWMP) required by the Colorado Department of Public Health and Environment.

CONSTRUCTION AND MAINTENANCE				
Are planned construction methods and equipment suitable to limit the compaction of soils?				Overlot grading with heavy equipment may compact soils and reduce infiltration.
Does contractor have past experience with phased grading and/or construction of LID BMPs?				A common reason for "failed" LID projects is that they are not constructed in accordance with the intent of the design.
Are there plans to amend existing soils with organic matter to help improve infiltration capacity?				Soil amendments can increase infiltration capacity of Type C and D soils and also may be beneficial for soil moisture retention and vegetative growth.
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?				If BMPs are to be considered as a part of regional master planning by UDFCD, long-term operation and maintenance must be assured.
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?				Regional facilities designed in accordance with UDFCD criteria may be eligible for the UDFCD Maintenance Program.
Have decentralized maintenance concerns and life-cycle cost been considered?				Items include costs maintaining multiple small BMPs versus a single larger BMP and potentially reduced capital costs for some LID measures relative to traditional extended detention basins.
Have winter sanding effects on BMPs been considered?				Sanding can "choke out" vegetation.
FOLLOW UP QUESTIONS				
Have safety concerns been addressed for all of the above LID methods?				Drop-offs adjacent to pedestrian areas, public access to areas if standing water, potential mosquitoes/West Nile, etc.
Are there any water rights implications due to the above LID concepts?				Water rights may be required if water is stored for more than 72 hours (State Engineers Office rule of thumb). Water cannot be collected, stored and put to a beneficial use without a water right.
Are the above LID concepts appropriate for the semi-arid climate of Colorado?				Consider water requirements of planned vegetation and performance of practices in times of drought.
Has the public perception of the above LID concepts been considered?				Will property owners and neighbors be accepting of standing water frequently for relatively short periods or will it be seen as a "nuisance." Consider opportunities for public education.

Conceptual Plan Checklist

CONCEPTUAL PLAN REVIEW

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

QUESTION	YES	NO	COMMENTS	APPLICABILITY
ADMINISTRATIVE				
Does the project fall under more than one jurisdiction?				When multiple jurisdictions are involved agreeing on applicable criteria (and allowable variances) early in the process can simplify review and approval.
Are variances required to permit LID measures proposed for site?				Examples of variances may include reduced street widths, reduced parking requirements, curb and gutter alternatives, alternative design criteria for BMPs.
SITE RESOURCES AND CHARACTERISTICS				
Will floodplain delineation boundaries been encroached upon?				Preservation of floodplains is beneficial for buffering of receiving waters as well as flood control.
Will sensitive areas be protected from encroachment?				Sensitive areas may include wetlands and waterbodies, riparian corridors, mature tree stands, wildlife habitat, etc. Buffers may be an effective tool for protection.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?				Leaving areas undisturbed may promote infiltration and will reduce erosion potential during construction.
Has development on steep slopes been avoided?				Steep slopes pose a greater potential for erosion and can be difficult to revegetate. Infiltration potential is limited on steep slopes.
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?				HSG A and B are favorable for infiltration/LID. Type C and D soils may limit potential for LID or require the use of an underdrain.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?				Shallow groundwater or bedrock may limit ability to infiltrate runoff.
Is there potential for groundwater pollution at the site?				If groundwater pollution is a concern, liners with underdrains that daylight may be appropriate for infiltration practices.
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?				If adequate water is available to support wetland growth, soil amendments also could be considered.
PROPOSED SITE LAYOUT				
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?				Imperviousness may be specified in zoning. UDFCD Stormwater Master Plans may also contain information on assumed impervious levels.
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?				The goal is to maximize pervious portions of the site that can infiltrate runoff.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?				MDCIA may include disconnected downspouts, directing drainage from impervious areas to pervious areas and using pervious conveyances (i.e. swales) rather than storm sewer.
Is there potential for better integration of cluster development techniques?				Cluster developments concentrate buildings in specific areas on a site, leaving remaining land for common open space and reducing impervious surface area.
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?				Approximately 75% of runoff events in the Denver Metropolitan area are 0.5 inches or less. Controlling small frequently occurring runoff events provides water quality treatment for the bulk of the annual pollutant load and is beneficial for channel geomorphology.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?				Selection of BMPs should be based on the pollutants desired to control. A "treatment train" of multiple BMPs may be necessary to control multiple pollutants.

Streets and Driveways				
Could site design or frontage requirements be modified to reduce street length?				Maximize efficiency of street layout to reduce impervious area.
Could narrower streets be used to reduce impervious area?				May require a variance.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?				Alternative layouts may reduce impervious area, and features such as sunken islands can potentially be used as porous landscape detention areas.
Are roadside swales a viable alternative to traditional storm sewer?				Roadside swales can be used in conjunction with curb and gutter if curb cuts or slotted curbs are used.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?				May require a variance.
Could setbacks be modified to reduce driveway length?				May require a variance.
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?				Shared driveways may work well with clustered development.
Parking				
Could parking be provided only on one site of the street?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking alternatives (fewer spaces or smaller spaces) feasible?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking lot islands elevated or depressed?				Depressed parking islands may be used for porous landscape detention.
Can parking lot landscaping and LID be integrated?				LID infiltration areas likely will help to satisfy landscaping requirements.
Is there potential for porous pavement in low use parking areas?				Less frequently used sections of parking areas (away from store) or lower-traffic areas may be suitable candidates.
Landscaping				
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?				This practice may reduce nuisance irrigation return flows and is beneficial for water conservation.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?				Overwatering may saturate soil and limit infiltration capabilities during runoff events. Low water plants can most effectively be watered using drip irrigation rather than spray/rotor irrigation.
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?				Preserving existing trees protects pervious areas of site and new trees for canopy will improve rainfall interception and reduce effective impervious area.
Can site runoff be directed to landscaped areas?				State Engineers Office guidance prohibits collecting and applying water for irrigation; however, runoff that is directed to vegetated areas as "incidental" water may help to satisfy irrigation requirements.
LOW IMPACT DEVELOPMENT OPPORTUNITIES				
Are green incentives available for the proposed project?				Examples from other municipalities may include reduced parking requirements, additional building space, reduced WQCV and/or detention requirements.
Will LID practices assist with LEED certification?				LEED points may be awarded for runoff reduction and water quality treatment measures.

STRUCTURAL BMPS				
Does the site plan identify stormwater best management practices (BMPs)?				Even when a regional water quality facility serves a development, onsite practices including MDCIA, infiltration practices, swales, buffers, etc. may be required for water quality enhancement to comply with MS4 Permit. On site measures may reduce conveyance costs.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?				This is only suitable for sites with ground slopes < 5%. The longitudinal slope of the swale should be < 1%, which may necessitate grade control checks.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?				Porous pavement may be used to disconnect impervious areas. Porous pavement may not be applicable to all paved areas of site (especially high-traffic/high-wear areas).
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?				Consider features including depressed islands and medians.
Has an extended detention basin been incorporated on the site?				Not likely to infiltrate a lot of runoff but may provide good sedimentation and peak flow control for small, water quality events.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?				Have infiltration basins been considered? Porous landscape detention? There are many alternative BMPs that have a larger infiltration component than an extended detention basin.
Is there sufficient base flow to support a retention pond (wet basin)?				Advantages over dry basin include increased pollutant removal, aquatic habitat, recreation and aesthetics.
Is there potential for a sand filter extended detention basin to be implemented on the site?				Even with Type C and D soils, this BMP can be implemented using an underdrain.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?				A continuous base flow is necessary to support a constructed wetland channel.
FOLLOW UP QUESTIONS				
Have safety concerns been addressed for all of the above LID methods?				Drop-offs adjacent to pedestrian areas, public access to areas if standing water, potential mosquitoes/West Nile, etc.
Are there any water rights implications due to the above LID concepts?				Water rights may be required if water is stored for more than 72 hours (State Engineers Office rule of thumb). Water cannot be collected, stored and put to a beneficial use without a water right.
Are the above LID concepts appropriate for the semi-arid climate of Colorado?				Consider water requirements of planned vegetation and performance of practices in times of drought.
Has the public perception of the above LID concepts been considered?				Will property owners and neighbors be accepting of standing water frequently for relatively short periods or will it be seen as a "nuisance." Consider opportunities for public education.

Preliminary Plan Checklist

PRELIMINARY PLAN REVIEW

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

QUESTION	YES	NO	COMMENTS	APPLICABILITY
ADMINISTRATIVE				
Does the project fall under more than one jurisdiction?				When multiple jurisdictions are involved agreeing on applicable criteria (and allowable variances) early in the process can simplify review and approval.
Are variances required to permit LID measures proposed for site?				Examples of variances may include reduced street widths, reduced parking requirements, curb and gutter alternatives, alternative design criteria for BMPs.
SITE RESOURCES AND CHARACTERISTICS				
Will floodplain delineation boundaries been encroached upon?				Preservation of floodplains is beneficial for buffering of receiving waters as well as flood control.
Will sensitive areas be protected from encroachment?				Sensitive areas may include wetlands and waterbodies, riparian corridors, mature tree stands, wildlife habitat, etc. Buffers may be an effective tool for protection.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?				Leaving areas undisturbed may promote infiltration and will reduce erosion potential during construction.
Is phased grading planned to reduce potential soil erosion?				
Has development on steep slopes been avoided?				Steep slopes pose a greater potential for erosion and can be difficult to revegetate. Infiltration potential is limited on steep slopes.
Can cut and fill volumes be reduced?				
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?				HSG A and B are favorable for infiltration/LID. Type C and D soils may limit potential for LID or require the use of an underdrain.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?				Shallow groundwater or bedrock may limit ability to infiltrate runoff.
Is there potential for groundwater pollution at the site?				If groundwater pollution is a concern, liners with underdrains that daylight may be appropriate for infiltration practices.
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?				If adequate water is available to support wetland growth, soil amendments also could be considered.
PROPOSED SITE LAYOUT				
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?				Imperviousness may be specified in zoning. UDFCD Stormwater Master Plans may also contain information on assumed impervious levels.
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?				The goal is to maximize pervious portions of the site that can infiltrate runoff.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?				MDCIA may include disconnected downspouts, directing drainage from impervious areas to pervious areas and using pervious conveyances (i.e. swales) rather than storm sewer.
Is there potential for better integration of cluster development techniques?				Cluster developments concentrate buildings in specific areas on a site, leaving remaining land for common open space and reducing impervious surface area.
Are rooftop drains disconnected from impervious surfaces and pipes (e.g. draining to lawns, porous landscape detention, grass swales, etc.)?				This is a fundamental principal of MDCIA. Gutter extenders may be used to provide distance between foundation backfill zone and discharge point.
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?				Approximately 75% of runoff events in the Denver Metropolitan area are 0.5 inches or less. Controlling small frequently occurring runoff events provides water quality treatment for the bulk of the annual pollutant load and is beneficial for channel geomorphology.
Have split flow scenarios been considered where small storm events are directed to small spatially distributed LID features and larger storm events spill over to larger flood control facilities?				Can the water quality event be infiltrated using LID techniques with a storm sewer to convey larger events? Using LID may reduce size and cost of storm sewer infrastructure.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?				Selection of BMPs should be based on the pollutants desired to control. A "treatment train" of multiple BMPs may be necessary to control multiple pollutants.

Streets and Driveways				
Could site design or frontage requirements be modified to reduce street length?				Maximize efficiency of street layout to reduce impervious area.
Could narrower streets be used to reduce impervious area?				May require a variance.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?				Alternative layouts may reduce impervious area, and features such as sunken islands can potentially be used as porous landscape detention areas.
Are roadside swales a viable alternative to traditional storm sewer?				Roadside swales can be used in conjunction with curb and gutter if curb cuts or slotted curbs are used.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?				May require a variance.
Could setbacks be modified to reduce driveway length?				May require a variance.
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?				Shared driveways may work well with clustered development.
Parking				
Could parking be provided only on one site of the street?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking alternatives (fewer spaces or smaller spaces) feasible?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking lot islands elevated or depressed?				Depressed parking islands may be used for porous landscape detention.
Can parking lot landscaping and LID be integrated?				LID infiltration areas likely will help to satisfy landscaping requirements.
Is there potential for porous pavement in low use parking areas?				Less frequently used sections of parking areas (away from store) or lower-traffic areas may be suitable candidates.
Landscaping				
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?				This practice may reduce nuisance irrigation return flows and is beneficial for water conservation.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?				Overwatering may saturate soil and limit infiltration capabilities during runoff events. Low water plants can most effectively be watered using drip irrigation rather than spray/rotor irrigation.
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?				Preserving existing trees protects pervious areas of site and new trees for canopy will improve rainfall interception and reduce effective impervious area.
Can site runoff be directed to landscaped areas?				State Engineers Office guidance prohibits collecting and applying water for irrigation; however, runoff that is directed to vegetated areas as "incidental" water may help to satisfy irrigation requirements.
LOW IMPACT DEVELOPMENT OPPORTUNITIES				
Are green incentives available for the proposed project?				Examples from other municipalities may include reduced parking requirements, additional building space, reduced WQCV and/or detention requirements.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?				MDCIA and other LID practices may decrease effective impervious area, runoff coefficient, runoff volume and peak flow rates.
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?				Many non-volumetric BMPs may reduce directly connected impervious area and promote infiltration.
Will LID practices assist with LEED certification?				LEED points may be awarded for runoff reduction and water quality treatment measures.
Do plans differentiate between total impervious area and effective impervious area?				Using effective imperviousness versus total imperviousness in runoff and WQCV calculations may reduce runoff rates and storage volumes.

STRUCTURAL BMPS				
Does the site plan identify stormwater best management practices (BMPs)?				Even when a regional water quality facility serves a development, onsite practices including MDCIA, infiltration practices, swales, buffers, etc. may be required for water quality enhancement to comply with MS4 Permit. On site measures may reduce conveyance costs.
Are there any uniformly sloped areas (< 4%) where grass buffers could be implemented for sheet flow but are not?				Vegetated buffers provide opportunity to slow runoff, "strain out" coarse pollutants and enhance infiltration.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?				This is only suitable for sites with ground slopes < 5%. The longitudinal slope of the swale should be < 1%, which may necessitate grade control checks.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?				Porous pavement may be used to disconnect impervious areas. Porous pavement may not be applicable to all paved areas of site (especially high-traffic/high-wear areas).
In areas where porous pavement is planned, is there potential to incorporate detention storage (approx. 2") above the porous pavement?				Allowing temporary ponding above the paved surface may help reduce site detention requirements and provide a higher degree of water quality treatment.
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?				Consider features including depressed islands and medians.
Has an extended detention basin been incorporated on the site?				Not likely to infiltrate a lot of runoff but may provide good sedimentation and peak flow control for small, water quality events.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?				Have infiltration basins been considered? Porous landscape detention? There are many alternative BMPs that have a larger infiltration component than an extended detention basin.
Is an appropriate trash rack provided for the basin outlet structure?				Trash racks and screening can reduce potential for clogging of outlet works.
Is a micro-pool provided as part of the outlet for the basin?				Micropools help to prevent clogging of the trash rack and reduce mosquito problems.
Is there sufficient base flow to support a retention pond (wet basin)?				Advantages over dry basin include increased pollutant removal, aquatic habitat, recreation and aesthetics.
Is there potential for a sand filter extended detention basin to be implemented on the site?				Even with Type C and D soils, this BMP can be implemented using an underdrain.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?				A continuous base flow is necessary to support a constructed wetland channel.
Will material storage and handling areas be covered?				Plans submitted should include materials handling and storage BMPs and "good housekeeping" practices.
Has spill containment and control been provided where necessary?				Sill Protection Control and Countermeasure (SPCC) Plan may be required for industrial sites and BMPs for spill control during construction should be provided in Stormwater Management Plan (SWMP) required by the Colorado Department of Public Health and Environment.
CONSTRUCTION AND MAINTENANCE				
Are there plans to amend existing soils with organic matter to help improve infiltration capacity?				Soil amendments can increase infiltration capacity of Type C and D soils and also may be beneficial for soil moisture retention and vegetative growth.
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?				If BMPs are to be considered as a part of regional master planning by UDFCD, long-term operation and maintenance must be assured.
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?				Regional facilities designed in accordance with UDFCD criteria may be eligible for the UDFCD Maintenance Program.
Have decentralized maintenance concerns and life-cycle cost been considered?				Items include costs maintaining multiple small BMPs versus a single larger BMP and potentially reduced capital costs for some LID measures relative to traditional extended detention basins.
Have winter sanding effects on BMPs been considered?				Sanding can "choke out" vegetation.
FOLLOW UP QUESTIONS				
Have safety concerns been addressed for all of the above LID methods?				Drop-offs adjacent to pedestrian areas, public access to areas if standing water, potential mosquitoes/West Nile, etc.
Are there any water rights implications due to the above LID concepts?				Water rights may be required if water is stored for more than 72 hours (State Engineers Office rule of thumb). Water cannot be collected, stored and put to a beneficial use without a water right.
Are the above LID concepts appropriate for the semi-arid climate of Colorado?				Consider water requirements of planned vegetation and performance of practices in times of drought.
Has the public perception of the above LID concepts been considered?				Will property owners and neighbors be accepting of standing water frequently for relatively short periods or will it be seen as a "nuisance." Consider opportunities for public education.

Final Plat Checklist

FINAL PLAT REVIEW

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

QUESTION	YES	NO	COMMENTS	APPLICABILITY
ADMINISTRATIVE				
Are variances required to permit LID measures proposed for site?				Examples of variances may include reduced street widths, reduced parking requirements, curb and gutter alternatives, alternative design criteria for BMPs.
PROPOSED SITE LAYOUT				
Streets and Driveways				
Could site design or frontage requirements be modified to reduce street length?				Maximize efficiency of street layout to reduce impervious area.
Could narrower streets be used to reduce impervious area?				May require a variance.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?				May require a variance.
Could setbacks be modified to reduce driveway length?				May require a variance.
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?				Shared driveways may work well with clustered development.
Parking				
Could parking be provided only on one site of the street?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
Are parking alternatives (fewer spaces or smaller spaces) feasible?				May require a variance. Could be used as an incentive when practices such as good public transportation access or car sharing are planned.
LOW IMPACT DEVELOPMENT OPPORTUNITIES				
Are green incentives available for the proposed project?				Examples from other municipalities may include reduced parking requirements, additional building space, reduced WQCV and/or detention requirements.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?				MDCIA and other LID practices may decrease effective impervious area, runoff coefficient, runoff volume and peak flow rates.
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?				Many non-volumetric BMPs may reduce directly connected impervious area and promote infiltration.
Will LID practices assist with LEED certification?				LEED points may be awarded for runoff reduction and water quality treatment measures.
Do plans differentiate between total impervious area and effective impervious area?				Using effective imperviousness versus total imperviousness in runoff and WQCV calculations may reduce runoff rates and storage volumes.

Construction Checklist

CONSTRUCTION AND MAINTENANCE				
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?				If BMPs are to be considered as a part of regional master planning by UDFCD, long-term operation and maintenance must be assured.
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?				Regional facilities designed in accordance with UDFCD criteria may be eligible for the UDFCD Maintenance Program.
Have decentralized maintenance concerns and life-cycle cost been considered?				Items include costs maintaining multiple small BMPs versus a single larger BMP and potentially reduced capital costs for some LID measures relative to traditional extended detention basins.
FOLLOW UP QUESTIONS				
Have safety concerns been addressed for all of the above LID methods?				Drop-offs adjacent to pedestrian areas, public access to areas if standing water, potential mosquitoes/West Nile, etc.
Are there any water rights implications due to the above LID concepts?				Water rights may be required if water is stored for more than 72 hours (State Engineers Office rule of thumb). Water cannot be collected, stored and put to a beneficial use without a water right.
Are the above LID concepts appropriate for the semi-arid climate of Colorado?				Consider water requirements of planned vegetation and performance of practices in times of drought.
Has the public perception of the above LID concepts been considered?				Will property owners and neighbors be accepting of standing water frequently for relatively short periods or will it be seen as a "nuisance." Consider opportunities for public education.

Appendix B. Completed Checklists for Projects Reviewed

Boulder Mobile Manor

Boulder, Colorado

MASTER LIST--ALL QUESTIONS

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

Project Name: **Boulder Mobile Manor**

QUESTION	YES	NO	COMMENTS
ADMINISTRATIVE			
Does the project fall under more than one jurisdiction?		X	City of Boulder
Are variances required to permit LID measures proposed for site?		X	Several variances are included in this project including street widths, raised pedestrian crossings, WQCV requirements, etc.
SITE RESOURCES AND CHARACTERISTICS			
Will floodplain delineation boundaries be encroached upon?		X	Not within designated FEMA 100-year floodplain
Will sensitive areas be protected from encroachment?		X	Mature tree stands will be mostly removed. No wetlands, water bodies, or riparian areas will be impacted.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?	X		Maintain areas of mature tree stands where possible. This was discussed as part of the landscaping plan for the site.
Is phased grading planned to reduce potential soil erosion?		X	Relatively small site (4.7 acres) with low potential for phasing due to demolition work.
Has a Geotechnical Engineer been consulted to provide detailed information on soil types and groundwater elevations.	X		Scott, Cox & Associates prepared a preliminary subsurface investigation in May 2008.
Has development on steep slopes been avoided?	X		Average slope on site is only 0.5% to 1.0%
Can cut and fill volumes be reduced?		X	Very little cut and fill, if any
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?	X		HSG C (Valmont Clay Loam), slow infiltration rate when thoroughly wetted. Underdrains recommended.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?		X	Depth to bedrock is 7 to 16 feet. Depth to groundwater table is 8.5 to 11 feet. Does not present any concerns.
Is there potential for groundwater pollution at the site?		X	Deep groundwater table coupled with residential land use.
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?		X	No suitable areas for constructed wetlands
Is there any indication that topsoil will be removed and set aside prior to grading?		X	Should be considered, could require Contractor in specifications.

PROPOSED SITE LAYOUT			
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?	X		Report states the developed imperviousness is slightly lower than existing imperviousness.
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?	X		Additional porous paver areas are limited due to limited grade drop for underdrains across the site.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?	X		Directing roof downspouts to vegetated buffers and grass swales
Are rooftop drains disconnected from impervious surfaces and pipes (e.g. draining to lawns, porous landscape detention, grass swales, etc.)?	X		
Is there potential for better integration of cluster development techniques?		X	Development is clustered well with only a few driveways
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?		X	No flood control detention provided. However, runoff for smaller events will be attenuated by the LID features and the EDB.
Have split flow scenarios been considered where small storm events are directed to small spatially distributed LID features and larger storm events spill over to larger flood control facilities?		X	All flows are conveyed through LID features.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?		X	Residential land use
Streets and Driveways			
Could site design or frontage requirements be modified to reduce street length?		X	Efficient street layout
Could narrower streets be used to reduce impervious area?		X	A variance has already been approved to use narrow streets with one-way traffic.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?		X	Already included.
Are roadside swales a viable alternative to traditional storm sewer?		X	Roadside swales would be difficult to implement, however porous landscape detention or depressed tree planters could be used between curb and sidewalk.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?		X	Consider paver stones
Could setbacks be modified to reduce driveway length?		X	There are only a few driveways, limited benefit
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?	X		Shared driveways and on-street parking included. Variance may be approved for ribbon drives or gravel drives.

Parking			
Could parking be provided only on one site of the street?		X	Would not provide enough parking
Are parking alternatives (fewer spaces or smaller spaces) feasible?		X	Compact spaces have already been included.
Are parking lot islands depressed to promote infiltration?		X	There is potential to depress tree planters between parallel parking spaces.
Can parking lot landscaping and LID be integrated?	X		Porous landscape areas could be designed betweent the curb and sidewalk as well as depressed tree planters.
Is there potential for porous pavement in low use parking areas?	X		Porous pavers are used for some parking spaces where underdrain elevations are compatable.
Landscaping			
Has a Landscape Architect been consulted to assist in site layout and vegetation selection?	X		A Landscape Architect has been selected to assist with grass swale design, park grading and vegetation selection.
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?	X		Use of vegetation appropriate for local climate is discussed in report, landscape architect will be consulted.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?		X	Irrigation system not discussed in report
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?	X		Limited amount of existing trees will be preserved. New trees will be planted per landscaping requirements.
Can site runoff be directed to landscaped areas?	X		Runoff in Basins B2 and B5 directed to grass swales. Additional porous landscape detention areas or depressed tree planters could be provided between the curb and sidewalk.
LOW IMPACT DEVELOPMENT OPPORTUNITIES			
Are green incentives available for the proposed project?	X		Variances will be approved for several issues due to overall improvement of site and affordable housing goal.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?	X		Porous pavement was included to determine effective imperviousness (preliminary calculations)
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?	X		Required WQCV will be reduced to account for combined effect of buffer strips, vegetative swales, porous pavers and the small EDB.
Will LID practices assist with LEED or other certifications?	X		Potentially
Do plans differentiate between total impervious area and effective impervious area?		X	Effective imperviousness is accounted for in terms of porous pavers, but not in terms of Level 1 MDCIA for directing roof downspouts across pervious areas.

STRUCTURAL BMPS			
Does the site plan identify stormwater best management practices (BMPs)?	X		Porous pavers, grass swales, vegetated buffers and and EDB are identified on the site plan.
Are there any uniformly sloped areas (< 4%) where grass buffers could be implemented for sheet flow but are not?		X	Grass buffers are used appropriately between the sidewalk and streets and in back yards.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?	X		Storm sewer is not used, runoff is carried in streets and grass swales. Curbs cuts could be used to provide porous landscape detention between the streets and sidewalks or tree planters.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?	X		Porous pavers are used for some parking spaces where underdrains can be positively drained.
In areas where porous pavement is planned, is there potential to incorporate detention storage (approx. 2") above the porous pavement?	X		There are several areas where porous pavement detention could be utilized. Would require a City of Boulder variance.
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?	X		Porous landscape areas could be designed betweent the curb and sidewalk or in depressed tree planters.
Has an extended detention basin been incorporated on the site?	X		Small shallow EDB due to grade constraints and lack of a below-grade discharge point.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?	X		Several BMPs (grass swales, porous pavers) are included to supplement the EDB and reduce WQCV requirements.
Is an appropriate trash rack provided for the basin outlet structure?	X		UDFCD approved trash rack design.
Is a micro-pool provided as part of the outlet for the basin?		X	Not shown in preliminary plans
Is there sufficient base flow to support a retention pond (wet basin)?		X	
Is there potential for a sand filter extended detention basin to be implemented on the site?		X	Difficult due to grade constraints and lack of a below-grade discharge point.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?		X	No base flow present
Will material storage and handling areas be covered?	X		Discussed briefly in the preliminary plan
Has spill containment and control been provided where necessary?		X	Not included in preliminary plan

CONSTRUCTION AND MAINTENANCE			
Are planned construction methods and equipment suitable to limit the compaction of soils?			
Does contractor have past experience with phased grading and/or construction of LID BMPs?			
Are there plans to amend existing soils with organic matter to help improve infiltration capacity?		X	Underdrains will most likely be implemented instead.
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?			
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?		X	
Have decentralized maintenance concerns and life-cycle cost been considered?		X	
Have winter sanding effects on BMPs been considered?		X	Should not be sanded due to potential clogging of porous concrete pavement.
FOLLOW UP QUESTIONS			
Have safety concerns been addressed for all of the above LID methods?			
Are there any water rights implications due to the above LID concepts?		X	There is no intent to store the water for more than 72 hours or to put it to beneficial use
Are the above LID concepts appropriate for the semi-arid climate of Colorado?	X		Vegetation type has been considered
Has the public perception of the above LID concepts been considered?			

Sandstone Marketplace

Longmont, Colorado

MASTER LIST--ALL QUESTIONS

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

Project Name: **Sandstone Marketplace - Longmont, CO**

QUESTION	YES	NO	COMMENTS
ADMINISTRATIVE			
Does the project fall under more than one jurisdiction?		X	City of Longmont, Colorado
Are variances required to permit LID measures proposed for site?	X		Variances would be required for depressed paking lot islands and reduction in pond volumes.
SITE RESOURCES AND CHARACTERISTICS			
Will floodplain delineation boundaries be encroached upon?		X	Project is located in Zone C (Areas of minimal flooding)
Will sensitive areas be protected from encroachment?	X		No sensitive areas were identified in the report. The site currently consists of native grasses and weeds.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?	X		Several areas of the site do not have development plans currently. These areas should remain undisturbed where possible.
Is phased grading planned to reduce potential soil erosion?		X	There is no indication in the plans that the 21.5 acre site will be developed in phases. As mentioned above, areas not currently planned should remain undisturbed where possible.
Has development on steep slopes been avoided?	X		There are no existing steep slopes on the site.
Can cut and fill volumes be reduced?		X	There does not appear to be any areas of significant cut and fill with the exception of the detention ponds.
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?	X		Colby Loam (HSG C) located in the northeast corner of the site. Weld Loam (HSG B) located in the western portion of the site.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?			Groundwater depth not indicated in Final Drainage Report. City has recently required groundwater information in plan submittals.
Is there potential for groundwater pollution at the site?	X		Potentially, depending on groundwater elevation and future development plans.
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?		X	There is no indication of any baseflows at the site. However, the site is relatively flat with loam soils.
Is there any indication that topsoil will be removed and set aside prior to grading?		X	There is no indication in the plans that topsoil will be stockpiled separately.

PROPOSED SITE LAYOUT			
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?		X	Commercial zoning requirements require 20% landscaped area, resulting in 80% imperviousness for proposed builidng pads. The total for planned and proposed areas is 69% (SE) and 60% (NE).
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?		X	It does not appear that any attempt has been made to reduce impervious areas on the site.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?		X	Slotted drains and area inlets are used on the few pervious areas to quickly convey water downstream to the storm sewer system.
Are rooftop drains disconnected from impervious surfaces and pipes (e.g. draining to lawns, porous landscape detention, grass swales, etc.)?		X	All rooftop drains are connected to the storm sewer system with 6" PVC pipe.
Is there potential for better integration of cluster development techniques?	X		Very little common open space with the exception of the southeast pond.
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?		X	Northeast pond does not provide peak flow control for events smaller than the 10-year event. However, the discharge is routed through a Wal-Mart pond subsequently. The southwest pond does include and EDB with a 40-hour drain time.
Have split flow scenarios been considered where small storm events are directed to small spatially distributed LID features and larger storm events spill over to larger flood control facilities?		X	All inlets and storm sewers are sized to pass the 100-year event to the two detention ponds.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?	X		Current development plans include retail and restaurants, however future development may include gas stations, oil change stations, etc.
Streets and Driveways			
Could site design or frontage requirements be modified to reduce street length?		X	Unlikely for commercial development.
Could narrower streets be used to reduce impervious area?		X	Unlikely for commercial development.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?		X	N/A
Are roadside swales a viable alternative to traditional storm sewer?	X		Swales could be used along property boundaries with major roads and between parking pads to replace raised islands.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?		X	Sidewalks all drain directly to parking areas, slotted drains, or area inlets. Paver stones not considered.
Could setbacks be modified to reduce driveway length?		X	N/A
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?		X	N/A

Parking			
Could parking be provided only on one side of the street?		X	N/A
Are parking alternatives (fewer spaces or smaller spaces) feasible?		X	Site is already at minimum number of spaces required.
Are parking lot islands depressed to promote infiltration?		X	All parking lot islands are raised and drain to parking areas and storm sewer inlets. Could be depressed for infiltration benefit.
Can parking lot landscaping and LID be integrated?	X		There are several locations where LID could be integrated into the parking lot.
Is there potential for porous pavement in low use parking areas?	X		There are several areas where porous pavement (concrete or asphalt) could be used.
Landscaping			
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?	X		Developer has worked with City to select native grass species for continuity with Wal-Mart site development. Presented separately in Landscape and Planning Review.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?	X		Will be sized appropriately.
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?		X	No existing trees on the site.
Can site runoff be directed to landscaped areas?	X		Potentially, would require creating depressed parking islands and removal of curb and gutter.
LOW IMPACT DEVELOPMENT OPPORTUNITIES			
Are green incentives available for the proposed project?	X		City would consider variances for appropriate LID practices.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?		X	LID not considered
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?		X	Not in current design plan
Will LID practices assist with LEED certification?		X	Not in current design plan
Do plans differentiate between total impervious area and effective impervious area?		X	Imperviousness calculations are not provided in Final Drainage Report.

STRUCTURAL BMPS			
Does the site plan identify stormwater best management practices (BMPs)?	X		EDB located at southeast corner of site. Contech Vortechs System (3-chamber vault) located at northeast corner of site.
Are there any uniformly sloped areas (< 4%) where grass buffers could be implemented for sheet flow but are not?	X		Several locations where grass buffers and swales could be implemented but are not.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?	X		Along property boundaries and in parking medians.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?	X		Several locations (e.g. remote parking spaces, sidewalks, northwest courtyard) where porous pavement could be used.
In areas where porous pavement is planned, is there potential to incorporate detention storage (approx. 2") above the porous pavement?	X		None currently planned, but detention storage could be incorporated into parking spaces.
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?	X		Several locations where depressed islands and medians could be used.
Has an extended detention basin been incorporated on the site?	X		Southeast pond includes and EDB.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?	X		Porous landscape detention could significantly reduce EDB volume required.
Is an appropriate trash rack provided for the basin outlet structure?		X	Southeast pond includes a trash rack. However, the northeast pond does not include a trash rack prior to underground storage and water quality treatment. This could cause significant safety and maintenance issues.
Is a micro-pool provided as part of the outlet for the basin?		X	Lowest water quality orifice is only 4 inches above the bottom of the pond. Clogging and mosquito problems are more likely.
Is there sufficient base flow to support a retention pond (wet basin)?		X	There is no indication in the drainage plan that significant baseflow is present at the site.
Is there potential for a sand filter extended detention basin to be implemented on the site?	X		Southeast pond would likely require an underdrain. Northeast pond would not need an underdrain.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?		X	There is no indication in the drainage plan that significant baseflow is present at the site.
Will material storage and handling areas be covered?		X	Not included in Final drainage Plan
Has spill containment and control been provided where necessary?		X	Not included in Final drainage Plan

CONSTRUCTION AND MAINTENANCE			
Are planned construction methods and equipment suitable to limit the compaction of soils?			
Does contractor have past experience with phased grading and/or construction of LID BMPs?			
Are there plans to amend existing soils with organic matter to help improve infiltration capacity?		X	Not included in Final drainage Plan
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?			
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?			
Have decentralized maintenance concerns and life-cycle cost been considered?			
Have winter sanding effects on BMPs been considered?			
FOLLOW UP QUESTIONS			
Have safety concerns been addressed for all of the above LID methods?			
Are there any water rights implications due to the above LID concepts?			
Are the above LID concepts appropriate for the semi-arid climate of Colorado?			
Has the public perception of the above LID concepts been considered?			

Redtail Ranch

Erie, Colorado

MASTER LIST--ALL QUESTIONS

KEEP IT CLEAN PARTNERSHIP

LOW IMPACT DEVELOPMENT OPPORTUNITY CHECKLIST

The following checklist is intended to provide a qualitative evaluation of potential runoff reduction practices and water quality treatment facilities that could be implemented on a site and the perceived barriers to pursuing these practices. Additional information on the practices listed below is presented in the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) Volume 3 - Best Management Practices and in the AWARE Colorado Water Protection Toolkit for Local Officials.

Project Name: **Redtail Ranch - Erie, CO**

QUESTION	YES	NO	COMMENTS
ADMINISTRATIVE			
Does the project fall under more than one jurisdiction?		X	Town of Erie
Are variances required to permit LID measures proposed for site?	X		Variances may be required for reduced sidewalks or curb and gutter alternatives.
SITE RESOURCES AND CHARACTERISTICS			
Will floodplain delineation boundaries be encroached upon?		X	Outside of FEMA designated floodplains
Will sensitive areas be protected from encroachment?	X		The designated wetland located in the SW corner will be preserved as public open space. However, the tributaries to this reach (see aerial) will not be preserved.
Is there potential for existing areas of the site to be preserved during construction to maintain uncompacted soils, existing vegetation and tree cover?	X		All pocket parks and the neighborhood park could remain undisturbed to avoid soil compaction and maintain vegetation.
Is phased grading planned to reduce potential soil erosion?		X	Not discussed in Phase I drainage plan, but is highly recommended for a site this size.
Has a Geotechnical Engineer been consulted to provide detailed information on soil types and groundwater elevations.	X		A geotechnical report was included to evaluate soil types and discuss subsidence concerns related to the abandoned mine below the property. No mention of water table elevation.
Has development on steep slopes been avoided?	X		A site analysis (sheet 2 of 4) shows areas with steeper slopes. Most of these areas have been preserved as open space.
Can cut and fill volumes be reduced?		X	Proposed grading plan not included in report.
Have NRCS Hydrologic Soil Groups (A, B, C, D) been identified?	X		Some Type B soils, mostly Type C and D soils.
Is the depth to bedrock (or low permeability soil) or seasonal high water table shallow?		X	Bedrock is approximately 15' bgs. However, the seasonal high water table is unknown.
Is there potential for groundwater pollution at the site?		X	Unlikely, due to soil types and land use
Does the site have a flat area with baseflow and loamy soils suitable to support a constructed wetlands basin?	X		The southwest corner has existing wetlands, therefore a wetland basin could potentially be incorporated in this area.
Is there any indication that topsoil will be removed and set aside prior to grading?		X	Not indicated in this report but highly recommended.

PROPOSED SITE LAYOUT			
Is the proposed level of impervious cover for the site consistent with applicable zoning requirements?	X		The OSP lists the future imperviousness at 30% for rural residential which covers the majority of the site with the remaining area listed at 50% for medium density residential. The ponds are sized on impervious values ranging from 22% to 45%.
Have paved areas, roofs, walks and other impervious areas been reduced to the maximum extent practical?	X		There are considerable amounts of pervious open space provided.
Has an attempt been made to Minimize Directly Connected Impervious Area (MDCIA)?		X	There is no indication in the report that DCIA have been minimized. For example the full-spectrum detention assumes MDCIA level 0.
Are rooftop drains disconnected from impervious surfaces and pipes (e.g. draining to lawns, porous landscape detention, grass swales, etc.)?		X	Not discussed in current report.
Is there potential for better integration of cluster development techniques?		X	The site currently includes a cluster approach leaving several open space corridors.
Will project provide control of peak flow rates for smaller, more-frequent storms (water quality event, 1-yr, 2-yr)?	X		Ponds are designed using the full-spectrum excess urban runoff volume method.
Have split flow scenarios been considered where small storm events are directed to small spatially distributed LID features and larger storm events spill over to larger flood control facilities?		X	Current report does not include specific routing paths for storm sewer and street bypass flows.
Are there specific pollutants of concern associated with the proposed land use (e.g. gas stations, industrial sites)?		X	Typical residential land use pollutants (e.g. nutrients)
Streets and Driveways			
Could site design or frontage requirements be modified to reduce street length?		X	Street layout has been set up to maximize the number of lots accessible. Alleyways have been included to reduce street length.
Could narrower streets be used to reduce impervious area?	X		Main street widths could be reduced, probably would require a variance.
Is there potential to replace traditional cul-de-sacs with alternative designs (e.g. landscaped island in cul-de-sac, smaller radius, T-shaped hammerhead, loop road)?	X		Consider landscape islands in cul-de-sacs and in main street round-abouts.
Are roadside swales a viable alternative to traditional storm sewer?	X		Roadside swales and depressed median swales are viable alternatives to storm sewer along the main street.
Have alternative sidewalk layouts been considered (e.g. paver stones, one side of street, drain to buffer strips, gravel)?		X	Sidewalks on only one side of the main street should be considered. Would most likely require a variance.
Could setbacks be modified to reduce driveway length?	X		Would most likely require a variance.
Have alternative driveways been considered (e.g. narrowed, ribbon driveways, porous pavement, minimize length, shared)?		X	Several options available to reduce impervious area.

Parking			
Could parking be provided only on one site of the street?	X		May require a variance.
Are parking alternatives (fewer spaces or smaller spaces) feasible?		X	N/A
Are parking lot islands depressed to promote infiltration?		X	Median swales could be depressed along main street.
Can parking lot landscaping and LID be integrated?		X	N/A
Is there potential for porous pavement in low use parking areas?		X	N/A
Landscaping			
Has a Landscape Architect been consulted to assist in site layout and vegetation selection?		X	A Landscape architect should be consulted to assist with layout of vegetated swales and porous landscape detention.
Have native planting species (drought tolerant) or xeriscaping been utilized to reduce irrigation requirements?		X	Not included in current report, but should be considered to reduce nuisance irrigation return flows.
If more drought tolerant species have been utilized, has the irrigation system been designed accordingly?		X	Not addressed in this report.
Are existing trees protected and adequate new trees provided to establish a healthy tree canopy?		X	There are no trees on the existing site.
Can site runoff be directed to landscaped areas?	X		Several areas where lots could drain across pervious areas instead of directing runoff to the streets.
LOW IMPACT DEVELOPMENT OPPORTUNITIES			
Are green incentives available for the proposed project?	X		Incentives include providing variances for LID practices.
Have hydrologic effects of LID measures been accounted for in runoff and WQCV calculations?		X	Full-spectrum detention sized assuming Level 0 MDCIA.
Can the required WQCV be reduced due to non-volumetric BMPs such as swales and buffer strips?	X		Could implement Level 1 or 2 MDCIA and could include porous pavement for driveways.
Will LID practices assist with LEED or other certifications?		X	Would require a significant level of LID implementation
Do plans differentiate between total impervious area and effective impervious area?		X	Not in current report.

STRUCTURAL BMPS			
Does the site plan identify stormwater best management practices (BMPs)?	X		Lists general location of ponds.
Are there any uniformly sloped areas (< 4%) where grass buffers could be implemented for sheet flow but are not?	X		Along backs of lots draining to open space areas.
Are there potential locations where grass swales could be implemented instead of curb and gutter and storm sewer?	X		Median swales and/or shoulder swales along main street.
Are there areas (e.g. roadway shoulders, driveways, parking lots, parking lanes, trails, emergency access lanes) where porous pavement could be implemented?	X		Could potentially implement modular block porous pavement in alleys.
In areas where porous pavement is planned, is there potential to incorporate detention storage (approx. 2") above the porous pavement?		X	Not suitable for alleys.
Are there potential locations (e.g. parking lot islands, street medians, roadside swales, buffer strips) where porous landscape detention can be implemented?	X		Median swales along main street or in round-abouts.
Has an extended detention basin been incorporated on the site?	X		Several full-spectrum EDBs onsite.
Could alternate BMPs be used in place of, or as a supplement to, an extended detention basin to reduce runoff volume?	X		MDCIA and PLD could reduce the volume required in the EDB.
Is an appropriate trash rack provided for the basin outlet structure?		X	Not included in current report.
Is a micro-pool provided as part of the outlet for the basin?		X	Not included in current report.
Is there sufficient base flow to support a retention pond (wet basin)?	X		Southwest corner has existing wetlands indicating there is potential baseflow to support a wet basin.
Is there potential for a sand filter extended detention basin to be implemented on the site?	X		In the upper ponds, sand filters are vialble alternatives. However, an underdrain would most likely be necessary.
Are there proposed swales or channels on the site that could be enhanced as part of a constructed wetland channel?	X		Southwest corner has existing wetlands indicating there is potential baseflow to support constructed wetland channels.
Will material storage and handling areas be covered?		X	Not included in current report.
Has spill containment and control been provided where necessary?		X	Not included in current report.

CONSTRUCTION AND MAINTENANCE			
Are planned construction methods and equipment suitable to limit the compaction of soils?			N/A
Does contractor have past experience with phased grading and/or construction of LID BMPs?			N/A
Are there plans to amend existing soils with organic matter to help improve infiltration capacity?			N/A
Has a maintenance agreement been developed to determine what entity will be responsible for long-term maintenance of BMPs?			N/A
Are BMPs planned for the project eligible for maintenance assistance from UDFCD?			N/A
Have decentralized maintenance concerns and life-cycle cost been considered?			N/A
Have winter sanding effects on BMPs been considered?			N/A
FOLLOW UP QUESTIONS			
Have safety concerns been addressed for all of the above LID methods?			N/A
Are there any water rights implications due to the above LID concepts?			N/A
Are the above LID concepts appropriate for the semi-arid climate of Colorado?			N/A
Has the public perception of the above LID concepts been considered?			N/A