Quantifying the Benefits of Low Impact Development: A GIS Analysis of Impervious Surfaces and Informational Design Charette Workshop

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Submitted by:
Central Vermont Regional Planning Commission
29 Main St, Suite 4
Montpelier, VT 05602
(802)229-0389
www.centralvtplanning.org

Overview

The Central Vermont Region encompasses almost the entire Upper Winooski Watershed, which drains westward into Lake Champlain. Our most urbanized areas are located in the middle of the region and include the following municipalities: Barre Town, Barre City, Berlin and Montpelier (figure 1.) This core region contains the highest regional population densities and the majority of the Region's employment opportunities. CVRPC focused efforts on promoting low impact development (LID) practices in the Central Vermont core region. To achieve this goal, CVRPC utilized both the 2009 ARRA 604b and the 2009 Clean Water Act Section 604b funding.

Figure 1: Map of Central Vermont Core Region: Barre Town, Barre City, Berln and Montpelier

From 2002-2008 CVRPC collected impervious surface data for each municipality within the Central Vermont Region. CVRPC updated this data with ARRA grant funding and performed a series of analyses to quantify the benefits of incorporating LID strategies. CVRPC developed a model which utilized impervious surface data, GIS build-out analysis data and average rainfall amounts to demonstrate the increases in stormwater run-off if development continued to occur without LID strategies in place. An alternate model was created to illustrate the amount of stormwater runoff if development incorporated LID techniques.

CVRPC also partnered with the State and regional organizations (Lake Champlain Sea Grant/NEMO Program, Friends of the Winooski River watershed organization, Winooski Natural Resources Conservation District and VT DEC) to organize and facilitate a LID design workshop for designers, engineers and municipal officials in Central Vermont. CVRPC staff also presented the GIS analysis results to the public during the workshop.

GIS Analysis and Results

Utilizing the ARRA grant, the CVRPC first updated the impervious surface data for each municipality in the Central Vermont Region. The impervious surface update included gathering information on new roads, driveways, residential/commercial/municipal developments, sidewalks, gravel/sand pits, rail lines and parking lots (figure 2.) The update of this data was critical to provide a quality analysis of implementation of LID techniques in Central Vermont's core region.

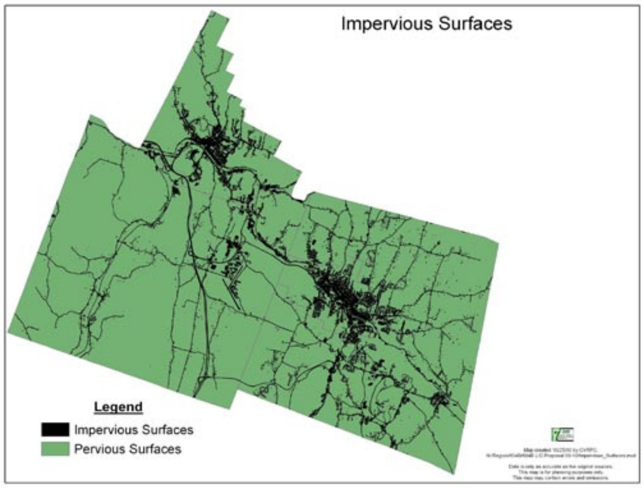


Figure 2: Map of Impervious Surfaces in Central Vermont's Urban Core

Once the impervious surface data had been updated, the CVRPC proceeded with the analysis. In the analysis, impervious surface, soil values, and land cover/land use data were utilized for the creation of the model. Two equations were utilized in our analysis. The first was the Natural Resources Conservation Service Runoff Equation. This equation calculated the volume of water runoff from permeable and impervious surfaces (figure 3.) The second equation was the LID Technique Equation. This equation calculated a revised volume of water runoff from impervious surfaces when a LID technique was utilized (figure 4.)

Natural Resources Conservation Service Runoff Equation

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

where $S = \frac{1000}{CN} - 10$

Total Volume = (Q)(Area)

Volume in Acre Feet
Area in Acres

Q = depth of runoff, in inches
P = depth of rainfall, in inches
S = maximum potential retention, in inches
CN = curve number

Figure 3 : NRCS Runoff Equation

Notation:

P: Design Precipitation Depth (in),
A_{LID}: The Surface Area of the LID-IMP (sq.ft),
A_{IMP}: The Area of the Impervious Surface Connected tot the LID-IMP (sq.ft),
Qr: Revised Runoff Depth (in),
d = Depth of the LID-IMP (in),
VR = Void Ratio of the Fill Material in LID-IMP,
CNr = Revised CN of the Impervious Area Connected to the LID-IMP.

Equations:

$$Q_r = \{ (P-0.0408)^2 / (P+0.1632) \} - (d\ VR\ (A_{LID}/A_{IMP}))$$

$$CN_r = 100 / (0.5\ P + Q_r - (1.25\ P\ Q_r + Q_r^2)^{(0.5)} + 1)$$

Figure 4: LID Technique Equation

The soils hydrologic groups, land cover and impervious data were combined together. The result was a one data layer with all the unique combinations of soil hydrologic groups, land cover, and impervious surfaces. These unique areas were then run through the NRCS runoff equation, which calculated the volume of stormwater runoff for all permeable and impervious areas (see figure 5.)

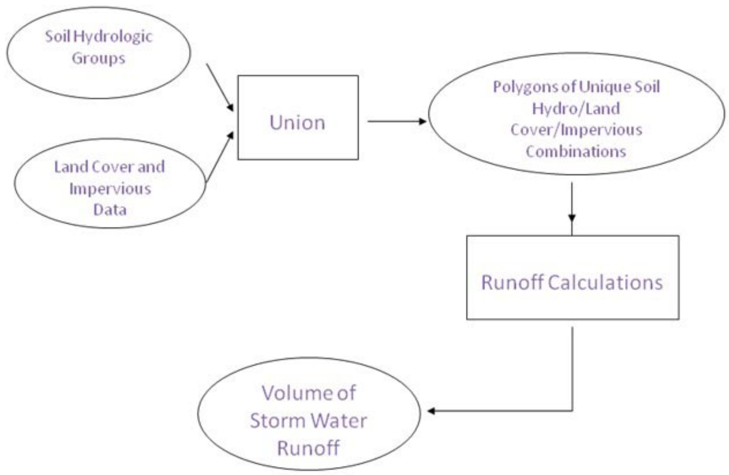


Figure 5: Simplified GIS Model of the Runoff Equation

With the new data layer, the amount of runoff from all impervious surfaces in the study area during a 2.2" rainfall event was calculated. Currently, 5% of the study area is impervious surfaces. Future development (to 2060) would increase the area of impervious surfaces to 7.5%.

Currently, during a 2.2" rainfall event, 16% of the run-off is generated by the 5% of impervious surfaces (table 1.) This amount is roughly 419 acre/feet or roughly 4,900 school buses full of water. In the future, 24% of the run-off will be generated by the 7.5% of the impervious surfaces (table 2.) The additional run off from new development is 237 acre feet or the equivalent to an additional 2850 school buses full of water.

Table 1: Volume of Runoff from Current Development without LID Techniques

Surface Type	Acres	% of Acres	Volume Runoff (Acre Feet)	% Volume Runoff
Permeable	49794	95.2%	2102	83.7%
Impervious	2494	4.8%	410	16.3%
Total Area	52288		2512	

Table 2: Volume of Runoff from Future Development without LID Techniques

Surface Type	Acres	% of Acres	Volume Runoff (Acre Feet)	% Volume Runoff
Permeable	48357	92.5%	2048	76.1%
Impervious	3931	7.5%	646	23.9%
Total Area	52288		2694	

In Montpelier, the model reported 9% of the area to be impervious. That area generated 30% of the runoff. In the future, 16% of the area will be responsible for 45% of the runoff (figures 6 and 7.) Although the average percentages may seem small, it is important to remember that the numbers generated were for a one time storm event and not cumulative totals.

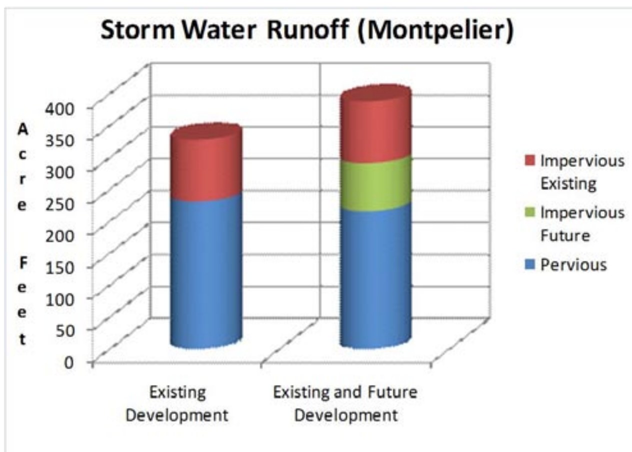


Figure 6: Chart of Exisitng and Future Stormwater Volumes in Montpelier

Figure 7: Map of Future Impervious Surfaces in Montpelier – Darker areas indicated greater volumes of runoff

A second model was run which utilized the installation of a hypothetical LID technique. This model possessed the ability to change the size of the LID technique. The relation between the size of the technique and the amount of stormwater retained was linear. Therefore when a “larger” technique was implemented, less runoff from the impervious surfaces was generated. Although not all LID techniques may have a linear relation, the model relayed the point that LID techniques of various sizes were effective at slowing the release of stormwater into the environment.

When building GIS models, it is important to remember that the model is just a model and results will vary from real life events. The model is only for one size storm. It also does not take into account seasonal absorption variations of the soils, previous soil saturation levels, impacts of climate change, or specific LID techniques. The model does however indicate that LID techniques are an important and effective solution to mitigate stormwater issues. Please see appendix A for the methodology.

LID Workshop

The LID workshop, held on November 4th at the Central Vermont Chamber of Commerce in Berlin was funded with the annual 604b grant. The participants learned about the benefits of LID, implementation considerations in Vermont and the impacts of impervious surfaces on our region. The workshop was geared towards town managers, municipal public works departments, planning and conservation commissions, site designers, engineers, developers and property owners. There were over 25 people in attendance. The workshop started with presentations by Laura Killian from UVM’s Lake Champlain Sea Grant/NEMO Program, Paul Boisvert from the Burlington-based firm Engineering Ventures and Dan Currier from CVRPC. The presentations included important points about cost savings for LID projects, and helped dispel misconceptions about LID use in Vermont.

After the presentations the group broke up into five smaller groups to retrofit the Vermont Granite Museum site with LID techniques. Patricia Meriam from the Museum was present and gave a brief history of the property and stormwater issues the site is currently facing. Each group was facilitated by a leader who was knowledgeable regarding LID techniques and implementation. The facilitator was given a list of questions to incorporate into the exercise regarding the appropriateness of the technique (retention or infiltration), overall flow of the site, hazardous substances located on the site etc (see appendix B). Each group was provided an 11 x 17” ortho map of the site, a large scaled site map with topographic marks and building outlines, and materials with information on different LID techniques. The groups had about an hour to retrofit the site. Short presentations of the designs were held after.

Figure 6: Participants at the LID Workshop

Overall, the workshop was very well received. Attendees commented on the high quality of the presentations. Also, the retrofit design activity allowed attendees to apply what they learned in the presentations and be creative without limitations.

In the spring, the Vermont Granite Museum is planning to hold a LID implementation workshop to further expand on the ideas presented at the CVRPC's workshop. The workshop is dependent on grant funding from the Lake Champlain River Basin Program. The Vermont Granite Museum's intent to implement some of the LID techniques has allowed for an extension of their stormwater permit deadline. The Vermont Granite Museum and Stone Arts School is partnering with the Friends of the Winooski River to make improvements to the property in the spring such as building rain gardens and incorporating granite into the landscape.

For the workshop several pieces of literature were developed and printed - a four page handout called "Promoting LID in your Community" by the New England Finance Center; a tri-fold pamphlet "Municipal Guide to LID" by the National Association of Homebuilders; and a 4" x 8" bookmark called "Put a LID on it" developed by the CVRPC, which contains links to local and regional resources. Please see appendix C for the literature provided during the workshop.

Recommendations and Possible Future Efforts

The GIS analysis and design charette brought to light several areas where LID information could be shared further, and where changes in regulations and communication amongst parties could be improved. The CVRPC has developed recommendations in several areas which could improve the development and implementation of LID techniques in the Central Vermont Region.

GIS Modeling

- Implementation of the GIS model in other Central Vermont core towns, especially those expected to have large population growths in the next 50 years

- Further refinement of the LID technique model to include quantifying specific LID techniques
- Continual updates of impervious surface data for the Region

Community Outreach and Education

- Survey of developers, residents, local officials etc on their ideas and opinions regarding LID
- LID activities and education to school aged children (rain barrel workshops, field trips to existing LID areas etc)
- Development of a LID course offering at area universities
- Demonstration installations of LID projects in town centers

Government and Regulations

- Incorporation of LID techniques into town stormwater plans and development codes (or development of a stormwater plan)
- Working with public safety and road officials to craft creative solutions to traditional road building and engineering to allow for incorporation of LID techniques
- Working with State level stormwater officials to review and revise the State Stormwater Manual

Appendix A

GIS Model Building & Storm Water Runoff Volume Analysis Methodology

Introduction

CVRPC developed the following methodology to calculating the volume of runoff from existing development, potential future development under existing development techniques, and potential future development utilizing Low Impact Development (LID) techniques.

Data Needs

CVRPC utilized the following data sets in our analysis.

- Impervious Surface
- Driveway Centerlines
- Road Centerlines
- Railroad Centerline
- Sidewalks
- Soils
- Land Cover and Land Use

CVRPC GIS staff updated existing impervious surface data against the 2009 USGS orthophotos at 0.3 meter spatial resolution. The driveway centerlines were downloaded from Vermont E911 Board and included only very long driveways, CVRPC staff utilizing the 2009 USGS orthophotos to digitize add all the shorter driveways. Road centerline data was created by the Vermont Agency of Transportation and downloaded from VCGI.org. The road centerline data from VTrans was chosen because it has the official road class and a more reliable road surface type category. Railroad centerline data was created by the Vermont Agency of Transportation and downloaded from VCGI.org. Sidewalks were digitized from scratch utilizing the USGS orthophotos. Soils data is current through 2008 and is part of the Natural Resources Conservation Service soil survey and was downloaded from VCGI.org. Land cover/land use data was digitized by CVRPC from two sets of photos; 1:5000 orthophotos from 1979, and 1:40,000 CIR aerial photographs from 1992.

Methods

Pre-Processing:

In order to more accurately represent developed land cover, more detailed spatial data of all impervious or nearly impervious surfaces was used. This refines the information found in the Land Cover/Land Use data that delineates developed areas as homogeneous polygons. Footprints accurate to 0.3 meters define more clearly the extent of the infrastructure largely responsible for creating problem storm water runoff. The Impervious Surface and Roads, Driveways, Sidewalks and Railroad Centerlines constitute this data.

Certain editing was required before the data could be used in analysis. All data was projected into the Vermont State Plane projection for consistency. The pre-processing started by taking all the line features (roads, railroads, sidewalks, and driveways) and buffering them to create polygons.   Sidewalks were assigned a width of 4 feet, driveways a width of 18 feet, and railroad beds a width of 20 feet. The road centerline data was buffered based on the road class, table 1 outlines and classes and widths used.

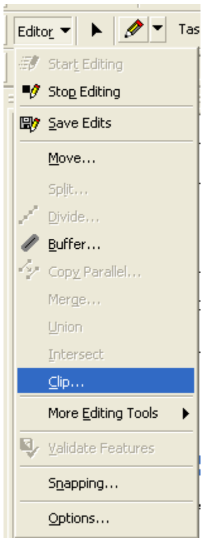
Road Class	Width (Feet)
1, 2, 15, and 25	33
3	30
4 and 7	24
8 and 9	18
30 through 40	40
50 -59	55

Table 1

With the road centerline data buffered it was then necessary to created two layers from the buffered centerlines one representing paved road the second representing gravel/sand roads. The Surface type in the road data was used to determine the surface types and created these two layers.

The next step was to clean all the impervious data to guarantee there was no overlapping data. Each of the six impervious layers (Impervious Surface, Driveway Centerline buffers, Paved Road Centerline buffers, gravel road centerline buffers, railroad Centerline buffers, and sidewalk centerline buffers) were each run through a dissolved (make sure that multi part features is selected) to reduce the number of feature in each of these layers to one. Each feature was then clipped based on their impervious surface priority. 1) Impervious surfaces, 2) paved road centerline buffer, 3) Sidewalk Centerline buffers, 4) gravel roads centerline buffer, 5) Railroad Centerline buffers, 6) driveway centerline buffers. The clip tool that was used can be found under the Editor Tool bar in ArcMap (Figure 1).

The following steps should be following when using this clip option.



1) All the various impervious surface data needs to be save in the same folder and all added to an ArcMap project.

2) Once the data is added start editing.

3) In order of impervious surface priority one at a time select all the features in the surface, go to Clip under the Editor tool bar, select discard the area that intersects, and hit OK. Repeat for each of the six surfaces

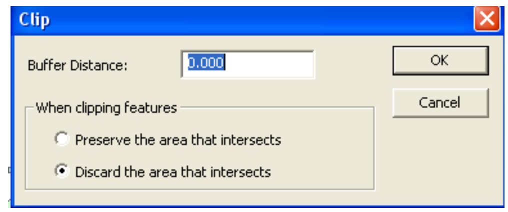


Figure 1.

The clip will clip all the non-selected features by a selected feature. This will remove all the overlapping data layers and resolve possible geoprocessing errors.

Theoretical Model:

The storm water runoff calculations are based upon an equation developed by the Natural Resources Conservation Service (NRCS) to estimate direct runoff from storm rainfall. After initial editing for improved accuracy, the ModelBuilder model is run to perform a Union combining all of the data inputs needed for the equation. The automated processing is then “broken” to allow for manual sorting of one of the runoff equation variables. Once sorted, a second automated model calculates the runoff volume results.

The runoff equation determines the runoff depth, Q, for the total precipitation that has fallen during a storm (P). The runoff depth, in inches, is the precipitation that was not retained where it fell, and thus leaves the area as runoff. Multiplying this depth times the area over which the rainfall occurred measures the total volume of runoff water. The equation appears as follows:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

where $S = \frac{1000}{CN} - 10$

Total Volume = (Q)(Area)

Volume in Acre Feet
Area in Acres

Q = depth of runoff, in inches
P = depth of rainfall, in inches
S = maximum potential retention, in inches
CN = curve number

(HydroCAD, 2004)

For the purposes of this project, the “S” parameter, potential maximum retention, is utilized only as an intermediate factor for calculating Q.

In calculating a revised runoff value a second equation is utilized. This equation calculates a revised CN value for impervious surfaces based on a LID technique that is installed to collect water directly off of the impervious surfaces. Below is the equation and the variable notations. Please note that the “P” value in both equations was 2.2 inches. This value represents the rain depth for a one year 24 hour storm as calculated in the Vermont Stormwater Management Manual, Table 1.2, page 14-15, for Washington County VT.

Notation:

P: Design Precipitation Depth (in),
A_{LID}: The Surface Area of the LID-IMP (sq.ft),
A_{IMP}: The Area of the Impervious Surface Connected tot the LID-IMP (sq.ft),
Qr: Revised Runoff Depth (in),
d = Depth of the LID-IMP (in),
VR = Void Ratio of the Fill Material in LID-IMP,
CNr = Revised CN of the Impervious Area Connected to the LID-IMP.

Equations:

$$Q_r = \{ (P-0.0408)^2 / (P+0.1632) \} - (d\ VR\ (A_{LID}/A_{IMP}))$$

$$CN_r = 100 / (0.5\ P + Q_r - (1.25\ P\ Q_r + Q_r^2)^{(0.5)} + 1)$$

(Kaveh Zomorodi, Ph.D. 2004)

The key components to both of these equations are the curve number (CN), which quantifies the capacity of a surface to retain rain water. Certain land cover and soils will retain more water than others, depending on the soil’s capacity to infiltrate water, abundance of surface depressions, vegetation, and other factors (HydroCAD, 2004). The NRCS has published tables for looking up curve numbers based on land cover type and soil hydrologic group (see Appendix A). Higher curve numbers have a lesser ability to retain water, and thus a greater potential for producing runoff. Completely impervious surfaces, such as asphalt and building roofs, have a CN value of 98, for example. Lower curve numbers indicate better retention of rainfall and less potential to create runoff. Wooded areas with certain hydrologic groups can have CN values in the thirties.

Model Builder Processing:

The Model Builder processing helps to combine the land cover/use data layers with soils data in such a way that land cover type and soil hydrologic group can be noted in all of their unique combinations. Appropriate CN values can then be assigned to each combination and the Runoff equation calculated. The “BaselineCNs” model delineates polygon areas of unique land cover/hydrogroup combinations (Figure 2). After CN values are sorted manually, the "Runoff Volume Equation" model uses those CN values to create a table of runoff volume results (Figure 3).

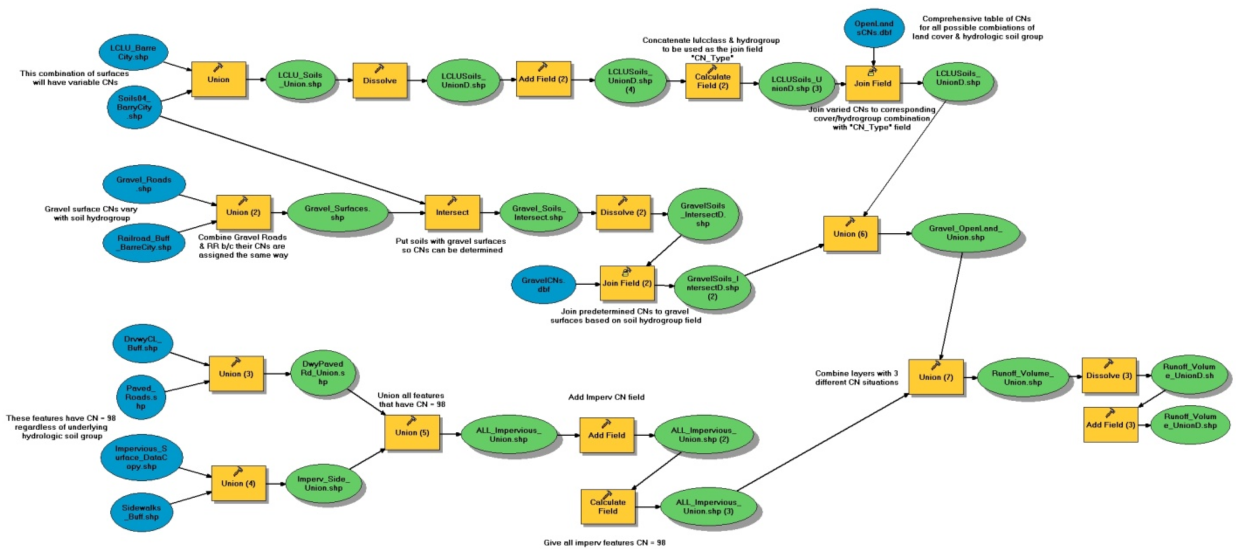


Figure 2. "BaselineCNs" model. See Appendix C for a larger version of this image.

The "Revise CN Value Equation" model (Figure 4) is run on the data from the Baseline CNs model. Again this model helps to recalculate the CN values for only the impervious surfaces based on an LID technique/s that is utilizing. For our purpose we calculated the volume of runoff based on the existing CN values and then on a revised impervious surfaces CN values.

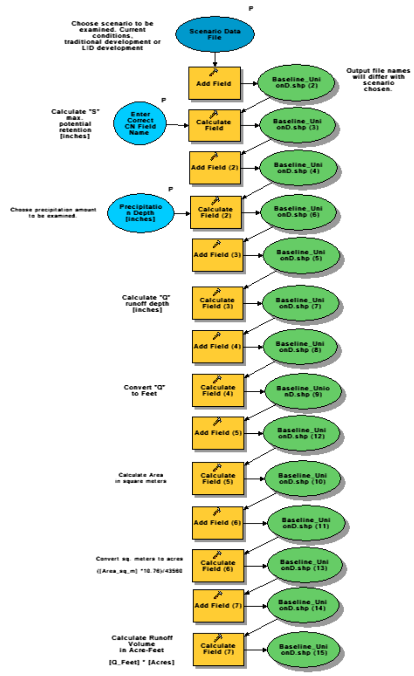


Figure 3. "Runoff Volume Equation" model. See Appendix C for a larger version of this image.

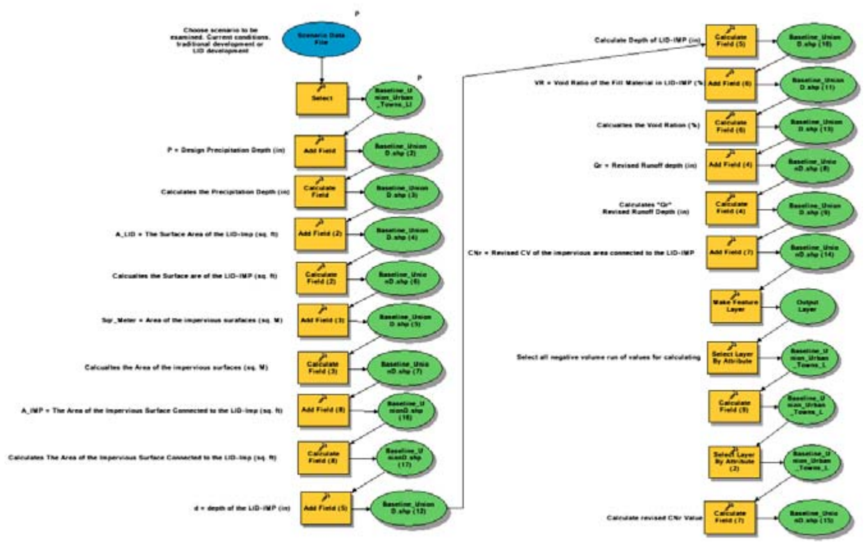


Figure 4. "Revise CN Value Equation" model. See Appendix C for a larger version of this image.

"BaselineCNs" begins by combining data layers of similar land cover types through a series of Unions. Driveway buffers, paved road buffers, sidewalk buffers and other impervious surface data are all combined because they are completely impervious. Soil hydrologic group does not factor in to assigning their CN values. Gravel roads and railroad beds are combined in another group, because they are somewhat pervious, and will need to be overlaid with soils data. The LCLU data is also combined with the soils data layer through a Union in the first cycle of processing.

The nearly impervious gravel/railroad surfaces data layer is combined with an Intersect to the soils data. A Union in this case would have preserved all soils polygons, creating redundant data in later processing. The two data groups combined with soils next underwent a Dissolve (separately) to combine all records and features with the same combination of land cover and soil hydrologic group. This simplifies the data and makes subsequent processing and analysis easier to conceptualize. The completely impervious data does not undergo a Dissolve, but immediately has a field added to its attribute table and populated with the CN value of 98.

When underlying soils are considered, areas will have varying CN values, and cannot be assigned the value in such a straightforward manner as impervious surfaces. The non-impervious data layers are each combined with an outside table to assign their CN values (See table Appendix B). The tables list all possible land cover/soil hydrogroup combinations and the corresponding CN value for each combination. When these tables are joined to each respective Union file of non-impervious data with the Join Field tool, each record gets the correct CN value.

The table of possible open land combinations and CN values is joined to the LCLUSoils_UnionD shapefile with the "CN_Type" field. This field concatenates the values in land cover/land use and soil hydrogroup fields to create a list of all of their combinations. This matches each record to the corresponding CN value in the outside table. The gravel roads/railroad beds data layer does not need to be concatenated because it involves only one land cover type. Its outside table is simply joined using the soil hydrogroup field.

Once all CN values are assigned, all three data groups; LCLU/Soils, Gravel/Railroad/Soils and Impervious Surfaces, are combined in a final series of Unions. This data layer will become the one file all baseline runoff volume analysis is conducted upon. The final step of the "BaselineCNs" model adds a field for sorting out the CN values of any overlapping polygons created in the final series of Unions. This sorting method will be explained in the next section of the Methods description.

With this field of sorted CN values, the runoff equation itself is executed with the "Runoff Volume Equation" model. This model uses only the Add Field and Calculate Field tools. It allows three parameters to be set. The first is the precipitation depth, in inches, for which resulting runoff volumes would like to be calculated. The second parameter sets the file representing the particular scenario under analysis. The name of the CN value field from that file then needs to be input into the expression for calculating the "S" variable field.

The remainder of the model is a succession of adding and calculating fields, implementing the mathematics of the runoff equation. The "S" field is determined by dividing 1000 by the CN and subtracting ten. The precipitation field, P, is populated with the amount set in the parameters. The expression for populating the Q field is the runoff equation itself. This Q in inches is converted into a Q_Feet by dividing by twelve. A field for area of each polygon is calculated with a simple Visual Basic script as the Calculate Field expression. This area is calculated in square meters and then converted into acres by multiplying by 10.76 square feet per square meter and dividing that result by 43,560 square feet per acre. Multiplying the area field times Q lastly fills in the Volume field. The results of runoff volume for each record in the data layer are thus in units of Acre-Feet.

The “Revise CN Value Equation” model also uses the Add Field and Calculate Field tools along with one Select command to select only the impervious surfaces to calculate a revised CN value for. The following parameters are set in the model precipitation depth in inches, the surface area of the LID strategy being implemented in square feet, the area of the impervious surface connected to the LID implementation in square feet, a revised runoff depth in inches, depth of the LID implementation in inches, the void ratio of the fill material in LID implementation and finally a revised CN value for the impervious area connected to the LID implementation is calculated. This calculated CN value is then used in the “Runoff Volume Equation” model and provides us with a revised runoff value based on our LID implementation.

Manual Sorting of CN Values:

Data was grouped by rainfall retention characteristics to facilitate assignment of CN values. Thus after CN assignment, the three data groups needed to be combined in a final Union. This Union would include a CN field from each group. When overlaying polygons in a Union, features receive attributes from each input data layer. As a surface can only have one CN value, the three fields of CN values needed to be sorted to extract the value of the feature that actually exists on the ground. As all impervious and gravel features are built on top of open land features, those infrastructure curve numbers represent the actual fate of rain falling upon them. Thus any record containing an open land curve number and an infrastructure curve number was ultimately assigned the curve number of the grave or impervious surface. Impervious features were assumed to always be built over any other features, such as a paved road over a railroad crossing, or a roof within a forested area. Therefore all records containing the impervious CN of 98 were assigned 98 as their final curve number. Any records that received neither an impervious curve number nor a gravel curve number were finally assigned the curve number of the open land feature.

Imperv_CN	GravelCNs	OpenLnd_CN	Final_CN
0	98	98	98
0	91	78	91

0	**91**	**84**	**91**
98	**91**	**84**	**98**
0	**91**	**84**	**91**
98	**91**	**84**	**98**
98	**91**	**84**	**98**
98	**91**	**84**	**98**
0	**0**	**30**	**30**
98	**0**	**30**	**98**
0	**0**	**58**	**58**
98	**0**	**58**	**98**

Figure 5. Example of curve number fields in attribute table of Baseline_UnionD.shp

Conclusion

The curve number methodology lends itself to incorporation into ArcMap processing, as well as automation in Model Builder. We were able to answer the question of how much storm water runoff is created in our study area given the storm event. The results of our analysis indicate that reducing impervious surface coverage in the future should significantly reduce the contribution of development to stormwater runoff.

References

Central Vermont Regional Planning Commission. 2009 ARRA 604b and 2009 Clean Water Act Section 604b Proposal Promoting Low Impact Development practices in the Central Vermont Core Region. Internal document. 2009.

HydroCAD Software Solutions, LLC. (2004). *HydroCAD Stormwater Modeling System Version 7 Owner's Manual* (2nd ed.). Chocorua, NH.

Natural Resources Conservation Service (NRCS). (2004). Estimation of Direct Runoff from Storm Rainfall. In *National Engineering Handbook, Part 630 Hydrology* (pp. 9-1-9-14).

Natural Resources Conservation Service (NRCS). (2004). Hydrologic Soil-Cover Complexes. In *National Engineering Handbook, Part 630 Hydrology* (pp. 10-1-10A-51).

Vermont Stormwater Management Manual. (2002). Table 1.2 Rainfall Depths Associated with the 1-Year, 2-Year, 10-Year, and 100-Year, 24-Hour Storm Event, (pp. 14-15).

Curve Number and Groundwater Recharge Credits for LID Facilities in New Jersey. (Kaveh Zomorodi, Ph.D. 2004). Table 1. Curve Number Credit Equations for Deep Infiltration LID-IMPs (pp. 5).

Appendix A:

Natural Resources Conservation Service Runoff Curve Number Tables

Table 9–1 Runoff curve numbers for agricultural lands 1/ — Continued

Cover description: cover type	treatment 2/	hydrologic condition 3/	CN for hydrologic soil group: A	B	C	D
Pasture, grassland, or range-continuous forage for grazing 4/		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element 5/		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 6/	48	65	73
Woods-grass combination (orchard or tree farm) 7/		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods 8/		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead–buildings, lanes, driveways, and surrounding lots		---	59	74	82	86
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

1/ Average runoff condition, and $I_a = 0.2s$.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).
For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 9–5 Runoff curve numbers for urban areas [1/]

Cover description cover type and hydrologic condition	Average percent impervious area [2/]	-- CN for hydrologic soil group -- A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

1/ Average runoff condition, and $I_a = 0.2S$.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3/ CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

Gravel Surfaces Curve Numbers

HYDROGROUP	Curve Number
A	76
B	85
C	89
D	91
W	98
not rated	91

Open Land Curve Numbers

CN_Type	Curve Num.
AGRICULTURE & OPEN LAND A	30
AGRICULTURE & OPEN LAND B	58
AGRICULTURE & OPEN LAND C	71
AGRICULTURE & OPEN LAND D	78
AGRICULTURE & OPEN LAND not rated	78
AGRICULTURE & OPEN LAND W	98
CEMETERY A	39
CEMETERY B	61
CEMETERY C	64
CEMETERY D	80
CEMETERY not rated	80
CEMETERY W	98
COMMERCIAL\SERVICE A	49
COMMERCIAL\SERVICE B	69
COMMERCIAL\SERVICE C	79
COMMERCIAL\SERVICE D	84
COMMERCIAL\SERVICE not rated	84
COMMERCIAL\SERVICE W	98
FOREST LAND A	36
FOREST LAND B	60
FOREST LAND C	73
FOREST LAND D	79
FOREST LAND not rated	79
FOREST LAND W	98
GOVERNMENT A	49
GOVERNMENT B	69
GOVERNMENT C	79
GOVERNMENT D	84
GOVERNMENT not rated	84
GOVERNMENT W	98

CN_Type	Curve Num.
INDUSTRIAL A	68
INDUSTRIAL B	79
INDUSTRIAL C	86
INDUSTRIAL D	89
INDUSTRIAL not rated	89
INDUSTRIAL W	98
INSTITUTIONAL A	49
INSTITUTIONAL B	69
INSTITUTIONAL C	79
INSTITUTIONAL D	84
INSTITUTIONAL not rated	84
INSTITUTIONAL W	98
MIXED RESI. & COMM A	49
MIXED RESI. & COMM B	69
MIXED RESI. & COMM C	79
MIXED RESI. & COMM D	84
MIXED RESI. & COMM not rated	84
MIXED RESI. & COMM W	98
OUTDOOR RECREATION A	39
OUTDOOR RECREATION B	61
OUTDOOR RECREATION C	74
OUTDOOR RECREATION D	80
OUTDOOR RECREATION not rated	80
OUTDOOR RECREATION W	98
RESIDENTIAL A	39
RESIDENTIAL B	61
RESIDENTIAL C	74
RESIDENTIAL D	80
RESIDENTIAL not rated	80
RESIDENTIAL W	98

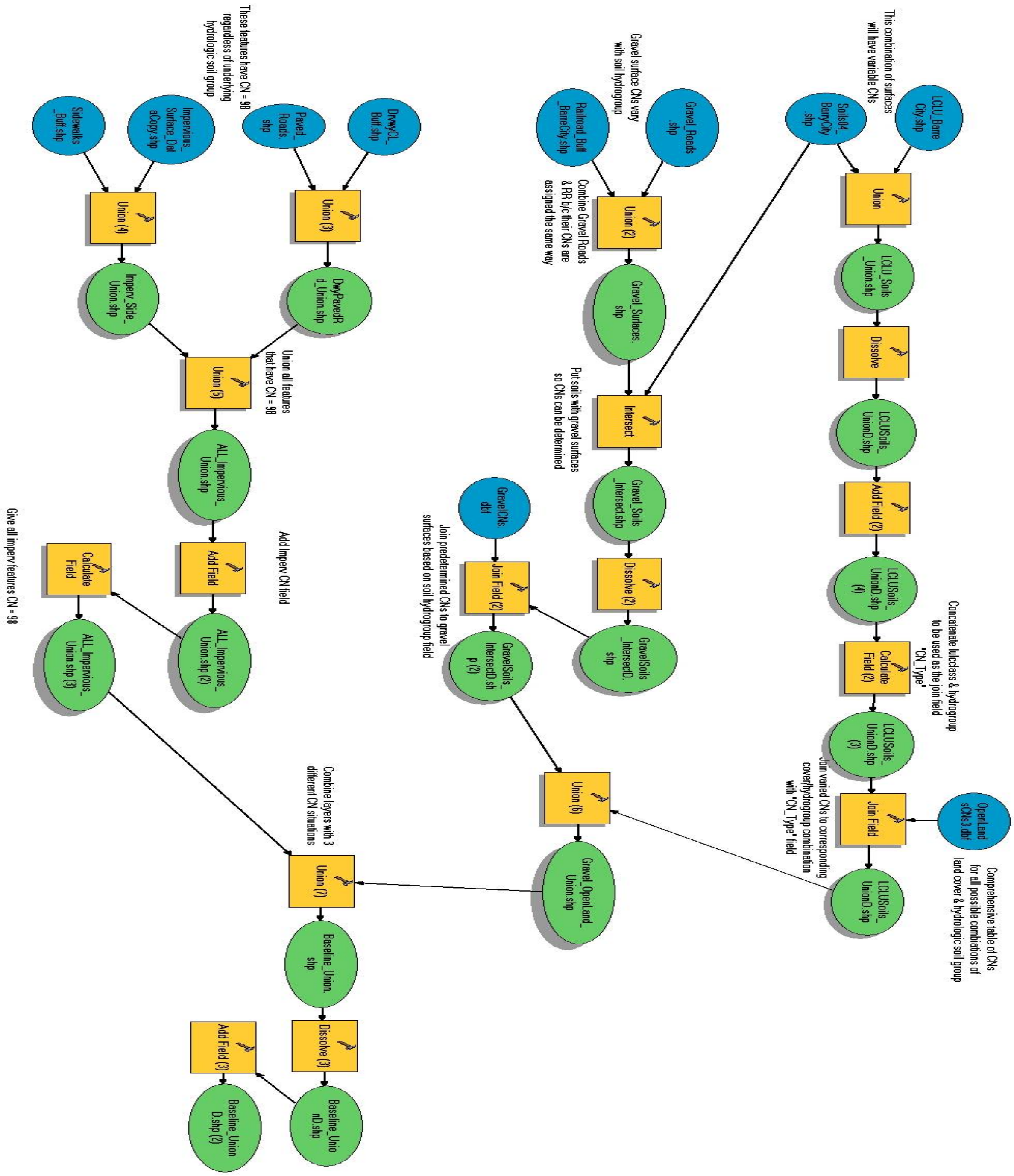
Open Land Curve Numbers (Cont.)

CN_Type

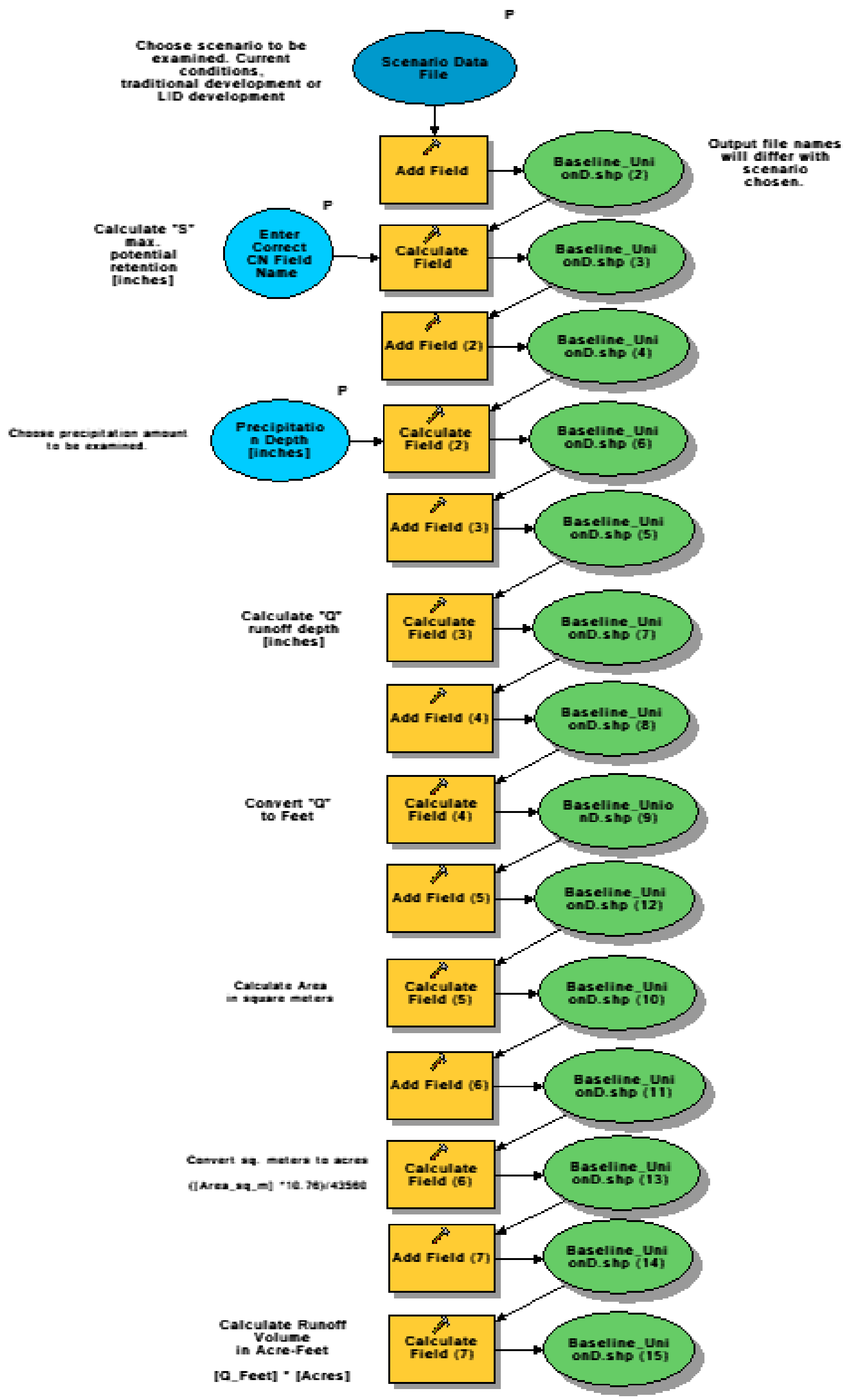
ROADS & PARKING LOTS A	**Curve Num.**
ROADS & PARKING LOTS B	68
ROADS & PARKING LOTS C	79
ROADS & PARKING LOTS D	86
ROADS & PARKING LOTS not rated	89
ROADS & PARKING LOTS W	89
SAND & GRAVEL PITS A	98
SAND & GRAVEL PITS B	30
SAND & GRAVEL PITS C	48
SAND & GRAVEL PITS D	65
SAND & GRAVEL PITS not rated	73
SAND & GRAVEL PITS W	73
SCHOOLS A	98
SCHOOLS B	39
SCHOOLS C	61
SCHOOLS D	74
SCHOOLS not rated	80
SCHOOLS W	80
SCRUB\SHRUB A	98
SCRUB\SHRUB B	35
SCRUB\SHRUB C	56
SCRUB\SHRUB D	70
SCRUB\SHRUB not rated	77
SCRUB\SHRUB W	77
SURFACE WATERS A	98
SURFACE WATERS B	98
SURFACE WATERS C	98
SURFACE WATERS D	98
SURFACE WATERS not rated	98
SURFACE WATERS W	98
	98

Appendix C

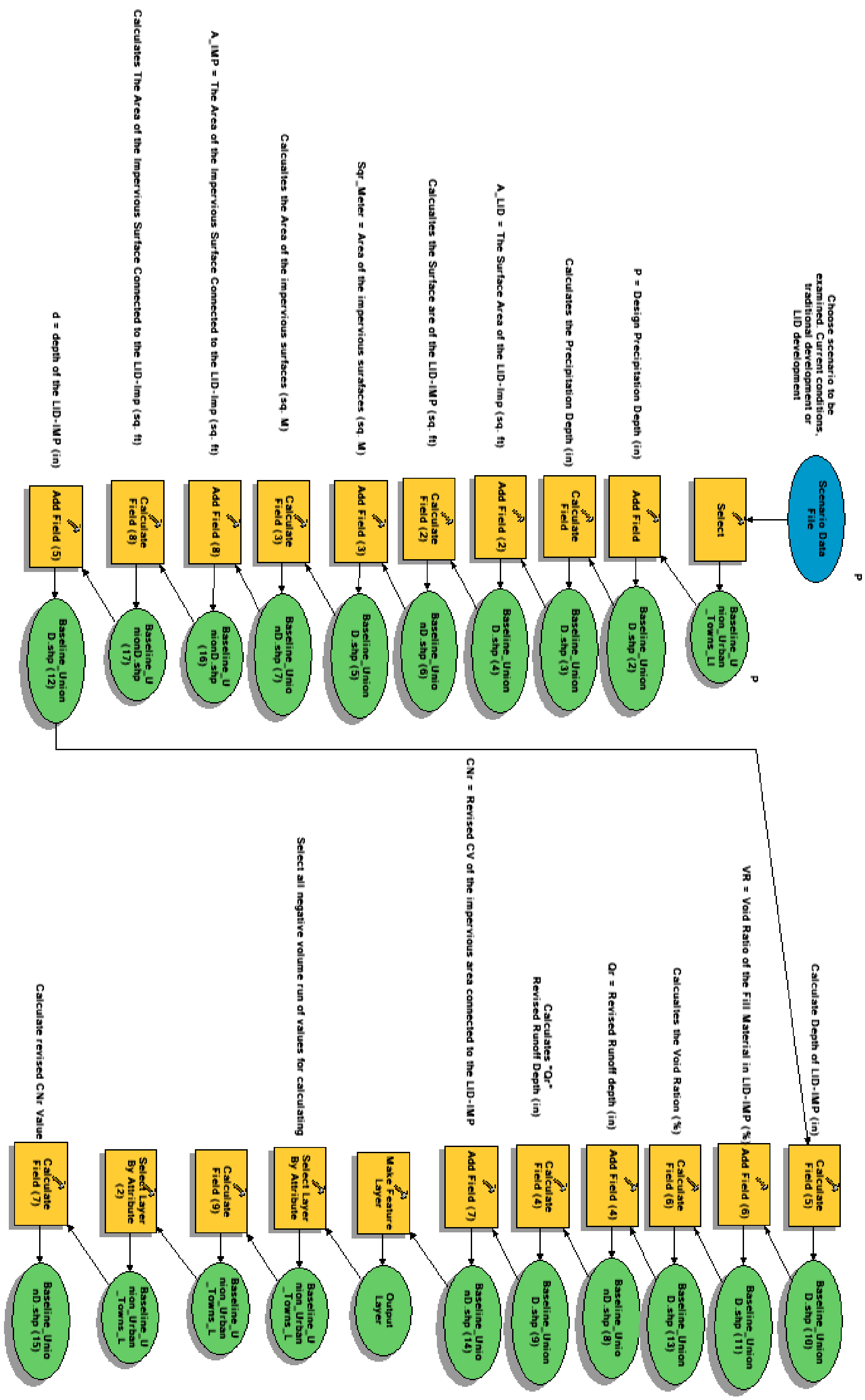
“Baseline CNs” Model



"Runoff Volume Equation" Model



“Revise CN Value Equation” Model



Appendix B

Low Impact Development Workshop

November 4, 2010

Design Instructions

Objective:
Redesign existing site to incorporate Low Impact Development features.

- Groups will be asked to present one design solution to the rest of workshop participants.
- One group representative will have two minutes to present design solution.
- Groups are encourage to work together to produce two to three design solutions and may then incorporate favorite features into one final design to present.
- Group facilitators are tasked with time-keeping and assisting group with identification of appropriate LID techniques and incorporating ideas into one final design which will be presented at the one of the workshop.
- Groups are encouraged to be ***creative***. Groups are not required to work within proposed future development constraints.

Questions to consider:
What existing site feature would you retain? What would you change?
What regulatory hurdles would have to overcome?
What additional information about the site would be helpful?

Site information:

Site	Former granite shed Approx 18 acre site Design area approx 10 acres Building approx 27,000 sq ft Located on banks of Stevens Branch (100 yr floodplain mapped)
Context	Located in river valley, surrounding land uses include commercial, mid density residential and vegetated hill side.
Current Use	Granite Museum and Stone Arts School
Future Development	Building addition, increased parking area, sculpture garden, bike path, river access.
Soils	"Not Rated" heavily disturbed/ urban fill No records of soil contamination (no hazard substance release or petrol spill)
Existing drainage	No storm drains or major catchment areas Swale-like earth berm along south east end of building

Appendix C

- Municipal Guide to LID
- Promoting LID in Your Community
- Put a LID on it!

What is Low Impact Development (LID)?

LID is an ecologically friendly approach to site development and storm water management that aims to mitigate development impacts to land, water, and air. The approach emphasizes the integration of site design and planning techniques that conserve natural systems and hydrologic functions on a site. The practice has been successfully integrated into many municipal development codes and storm water management ordinances throughout the United States. Specifically, LID aims to:

- Preserve Open Space and Minimize Land Disturbance;
- Protect Natural Systems and Processes (drainage ways, vegetation, soils, sensitive areas);
- Reexamine the Use and Sizing of Traditional Site Infrastructure (lots, streets, curbs, gutters, sidewalks) and Customize Site Design to Each Site;
- Incorporate Natural Site Elements (wetlands, stream corridors, mature forests) as Design Elements; and
- Decentralize and Micromanage Storm Water at its Source.

Source: City of Portland, BES

Courtyard with Bioretention Areas

Buckman Heights Community
Portland, OR

Cover Photo: R. Arendt

Questions and Answers

Information on the most frequently asked low impact development questions.

Public Safety

Q. I am aware that in some instances, LID advocates the reduction of street widths and the reduced use of sidewalks to decrease impervious surfaces. Isn't this a threat to public safety?

A. No. Studies have shown that reduced street widths still provide all the functions of access, parking, and circulation for residents and emergency vehicles alike. Depending on density, minimizing the use of sidewalks may help to reduce development costs, increase housing affordability, and reduce impervious surfaces.

Q. Don't LID storm water management practices increase the likelihood of flooding?

A. No. LID designs provide adequate conveyance of storm water by using designs that maintain predevelopment volumes and rates of runoff. Since bioretention areas are designed to completely drain within a specified period of time, they do not provide breeding grounds for mosquitos. Overflow controls within bioretention areas control the risk of flooding.

Public Perception

Q. Aren't homeowners concerned about maintaining storm water controls on their properties?

A. Environmental stewardship is everyone's responsibility. Most homeowners view these systems as additional landscaping and once they are aware of the benefits that these systems provide to local hydrology, few remain opposed.

Maintenance

Q. LID practices sound great, but who maintains all of the open space and various storm water controls?

A. Communities designed using LID practices often rely on a combination of homeowner stewardship and maintenance agreements. When designed correctly, most homeowners perceive these systems as value-added builder amenities and actively provide for their maintenance.

For More Information

- Low Impact Development Center
  http://www.lowimpactdevelopment.org
- Prince George's County, Maryland
  http://www.goprincegeorgescounty.com
- NAHB Research Center Toolbase Services
  http://www.toolbase.org
- U.S. EPA
  http://www.epa.gov/owow/nps/urban.html

*Assumes paving costs of $15/sq. yd.

Printed on recycled paper with soy ink

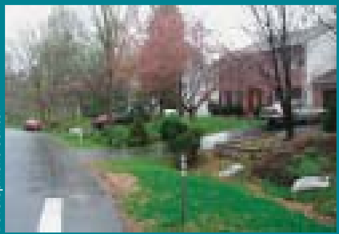
Municipal Guide to Low Impact Development

Would you be interested in saving upwards of $70,000* per mile in street infrastructure costs by eliminating one lane of on-street parking on residential streets?

Did you know that communities designed to maximize open space and preserve mature vegetation are highly marketable and command higher lot prices?

Are you aware that most homeowners perceive Low Impact Development practices, such as bioretention, as favorable since such practices are viewed as additional builder landscaping?

Did you know that by reducing impervious surfaces, disconnecting runoff pathways, and using on-site infiltration techniques, you can reduce or eliminate the need for costly storm water ponds?



Source: Low Impact Development Center

Grassed Swale and Narrow Street

Montgomery County, MD

Source: Applied Ecological Services, Inc.

Bioretention with Native Vegetation

Prairie Crossing Grayslake, IL

LID Benefits

In addition to the practice just making good sense, low impact development techniques can offer many benefits to a variety of stakeholders.

Municipalities

- Protect regional flora and fauna
- Balance growth needs with environmental protection
- Reduce municipal infrastructure and utility maintenance costs (streets, curbs, gutters, sidewalks, storm sewer)
- Increase collaborative public/private partnerships

Developers

- Reduce land clearing and grading costs
- Potentially reduce infrastructure costs (streets, curbs, gutters, sidewalks)
- Reduce storm water management costs
- Potentially reduce impact fees and increases lot yields
- Increase lot and community marketability

Environment

- Preserve integrity of ecological and biological systems
- Protect site and regional water quality by reducing sediment, nutrient, and toxic loads to water bodies
- Reduce impacts to local terrestrial and aquatic plants and animals
- Preserve trees and natural vegetation

Case Study

Somerset is an 80-acre development in Prince George's County, Maryland consisting of 199 homes on 10,000-square-foot lots. During its creation, the developer used LID practices to reduce the storm water management burden. By using LID, the developer:

- Eliminated the need for storm water ponds by using bioretention techniques saving approximately $300,000;
- Gained six additional lots and their associated revenues; and
- Reduced finished lot cost by approximately $4,000.

Lot with Bioretention

Grassed Swale and Street without Curb and Gutter

Bioretention Area and Open Space

Photos: Low Impact Development Center

Description	Conventional Design	Bioretention System
Engineering Redesign	0	$110,000
Land Reclamation (6 lots x $40,000 Net)	0	<$240,000>
Total Costs	$2,457,843	$1,541,461
Total Costs (-Land Reclamation + Redesign Costs)	$2,457,843	$1,671,461
Total Cost Savings = $916,382		
Cost Savings Per Lot = $4,604		

Source: D. Winogradoff

Cost Comparison: Conventional Design vs. Bioretention

Aerial View of Somerset Development Site Plan, Prince George's County, MD

Hydrologic Comparison between Conventional Storm Water Management and LID

Hydrologic alterations within the landscape occur whenever land is developed. Conventional development approaches to storm water management have used practices to quickly and efficiently convey water away from developed areas. Usually these practices are designed to control the peak runoff rate for predetermined storm events, usually the 2- and 10-year storms. While these systems have worked to some degree, they still have not accounted for the increased runoff rates and volumes from smaller, more frequent storms, nor have they addressed the larger watershed functions of storage, filtration, and infiltration.

In contrast, LID utilizes a system of source controls and small-scale, decentralized treatment practices to help maintain a hydrologically functional landscape. The conservation of open space, the reduction of impervious surfaces, and the use of small-scale storm water controls, such as bioretention, are just a few of the LID practices that can help maintain predevelopment hydrological conditions.

PROMOTING LOW IMPACT DEVELOPMENT IN YOUR COMMUNITY

Low Impact Development (LID) is an approach to stormwater management and site development that is gaining popularity throughout the country. Its attractiveness lies in its potential to lessen off-site stormwater impacts, reduce costs to municipalities and developers, and promote development that is "softer on the land" compared with typical traditional development. The approach, which is applicable to residential, commercial and industrial projects, and in urban, suburban and rural settings, often is linked with efforts by governments and citizens to foster more sustainable communities.

Bio-retention Area at Staples Parking Lot Branford,Connecticut

On the national and state levels, a focus in promoting LID to date has been on providing technical guidance on the approach – in the form of publications and training sessions. A tremendous amount of information on LID is now available online and elsewhere. While this is a positive development, the extent and detail of these resources can easily overwhelm public officials and citizens being introduced to the approach, especially those with non-technical backgrounds. If LID truly is to take hold in communities, there must be broad understanding of and support for the approach among local decision-makers and the public at large. In New England, educational and outreach efforts must also effectively address the suitability of the approach given the region's harsh climate and some of its unique political characteristics.

This fact sheet is intended as a resource for those interested in promoting LID in their communities. It offers concise information on the approach and how to promote it, providing online links for users wishing to access more detailed guidance. It may be particularly helpful to professional municipal staff seeking to spread the word regarding LID. It is also geared to other LID proponents – whether they are volunteer members of town boards or local citizens.

The fact sheet is divided into three sections. The first section describes what LID is and its benefits. The second section lists five general steps you can take to promote LID in your community. The final section provides five pointers for making your local land use regulations more "LID friendly."

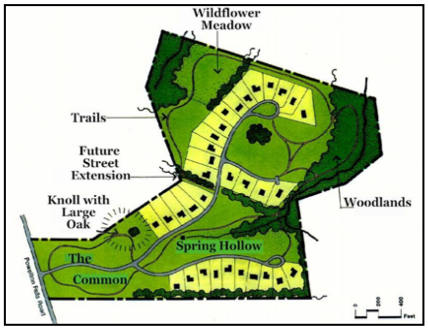
WHAT IS LOW IMPACT DEVELOPMENT?

East End Community School Green Roof, Portland, Maine

Low Impact Development (LID) is an approach to site planning, design and development that reduces stormwater impacts. LID aims to mimic pre-development hydrology, treat stormwater as close to its source as possible, preserve natural drainage systems and open space, and incorporate small-scale controls that replicate natural processes in detaining and filtering stormwater. LID uses the "divide and conquer" theory to treat relatively small amounts of stormwater and utilize it in beneficial ways. This contrasts with conventional stormwater management approaches geared to concentrating and collecting runoff and exporting it off-site as a waste product.

Typical LID Techniques (Suitable for Cold Climates)

☑ **LID Site Planning and Design:** Involves designing stormwater management systems that work with the site's natural hydrology by minimizing land disturbance and locating buildings and other improvements in a sensitive manner. Conservation subdivisions and "clustering" are common approaches for achieving these objectives, but there a number of other techniques that can be employed as well.



☑ **Reduced Impervious Surfaces:** As part of site planning and design, finding opportunities for reducing new roads, parking areas and other impervious surfaces. This includes sharing of parking lots and driveways.

☑ **Permeable Paving:** Where parking and drives are needed, using new products that allow rainwater to percolate into the ground while providing surface stability.

Bio-retention, also known as "rain gardens": Landscape features used to collect, treat, and infiltrate rainwater.

☑ **Vegetated Swales**: Shallow drainage channels usually located adjacent to roadways (as an alternative to typical curb and gutter treatments) used to convey and filter stormwater.

☑ **Grassed Filter Strips:** Low-angle vegetated slopes, usually located adjacent to parking areas and other large impervious surfaces, that slow flows and treat stormwater.

☑ **Green Roofs**: Vegetated roof systems that capture rainfall and return it to the atmosphere.

☑

Other LID measures are well-suited to cold climates as well. An excellent summary of techniques can be found at the Massachusetts LID Toolkit at http://www.mapc.org/regional_planning/LID/LID_FAQs.html.

SUMMARY OF LID BENEFITS

- **Environmental Benefits**: Improved stormwater management; reduced impacts on wetlands, streams, lakes and coastal waters; enhanced water quality (both surface and groundwater); better protection of ecological and biological systems; and preservation of open space.
- **Benefits to Municipalities**: Reduced costs for new or expanded infrastructure and for maintenance of stormwater structures.
- **Benefits to Developers**: Cost savings as a result of reduced infrastructure (extent of stormwater structures, streets, curbs, gutters) and less clearing and grading. Also increased marketability of lots and projects.

See *The Municipal Guide to Low Impact Development* for a good overview of LID benefits.
http://www.toolbase.org/PDF/DesignGuides/Municipal_LID.pdf

5 ☑ Things You Can Do Promote LID in Your Community

LID makes good sense, but new ideas sometimes need help taking hold. Below are five general steps you can take to help promote LID in your community.

1. ***Learn More about the Approach*** *(and become an LID Advocate)*

Although Low Impact Development is gaining popularity, it is still a relatively new approach. Learning more about it and how it might best work in your community is a good first step, allowing you to become an informed advocate of the approach. A number of excellent websites – with information ranging from the general to the specific – now exist on LID, including:

- ***Introduction to Low Impact Development***. Helpful FAQs and other information from the Low Impact Development Center. http://www.lid-stormwater.net/intro/background.htm
- ***Municipal Guide to Low Impact Development***. A good 2-page summary of LID benefits and principles. http://www.toolbase.org/PDF/DesignGuides/Municipal_LID.pdf
- ***Massachusetts Low Impact Development Toolkit.*** Contains a suite of materials focused on LID techniques. http://www.mapc.org/LID.html
- ***The Practice of Low Impact Development***. An in-depth treatment of LID techniques from U.S. HUD. http://www.huduser.org/Publications/PDF/practLowImpctDevel.pdf

You can also learn more about the approach at one of the LID conferences or training sessions which are periodically held throughout New England and elsewhere. View the following sites for upcoming LID and stormwater-related events:

- Mass Coastal Zone Management Office – *Coastal Calendar page*: http://www.mass.gov/czm/calendar.htm
- Maine DEP – *Nonpoint Source Training and Resource Center page*: http://www.maine.gov/dep/blwq/training/index.htm
- Stormwater Authority – *Events/Education page*: http://www.stormwaterauthority.org/events_education

2. ***Spread the Word*** *(particularly to those who will be most involved in LID decision-making)*

Once people learn about the multiple benefits of LID, they often become strong advocates themselves. You can help spread the word in several ways:

- Inform people about the approach in general, and pass along good websites (including this one) and upcoming training sessions either informally or through targeted outreach efforts.
- Request a presentation or information from an organization in your area with expertise in LID. Try:
  - Connecticut. CT NEMO (Nonpoint Education for Municipal Officials). Website: http://nemo.uconn.edu/. Contact: John Rossum (860) 345-5225 or nemo@uconn.edu.
  - Rhode Island. URI Seagrant – *SUCCESS* Extension Program. Website: http://seagrant.gso.uri.edu/ecosystems/index.html. Contact: Virginia Lee. (401) 874-6842
  - Massachusetts. CZM Office. Website: http://www.mass.gov/czm/smartgrowth/lid/index.htm. Contact: Andrea Cooper (617) 626-1222 or andrea.cooper@state.ma.us.
  - Vermont. Vermont Sea Grant. Website: http://www.uvm.edu/%7Eseagrant/extension/nemo.html. Contact: Emma Melvin (802) 656-9110 or emma-lynn.melvin@uvm.edu.
  - New Hampshire. UNH Stormwater Center. Website: http://www.unh.edu/erg/cstev/. Contact: Robert Roseen. (603) 862.4024 or robert.roseen@unh.edu.

- Maine. Maine NEMO. Website: http://www.mainenemo.org/. Contact: LaMarr Cannon, at (207) 771-9020, or lcannon@maine.rr.com.

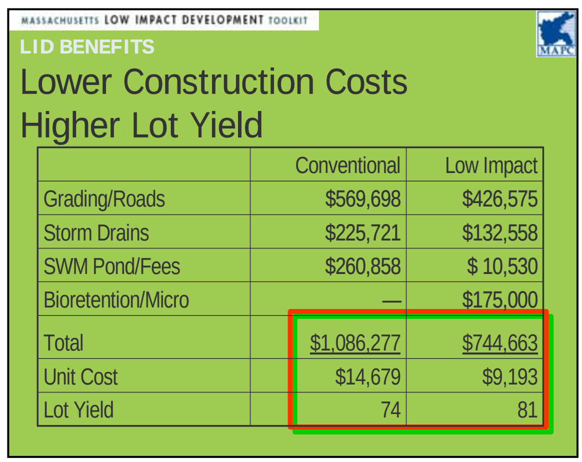
- Make your own presentation: Several good introductory PowerPoint presentations are available online, which you can adapt for your own use. Try the following:
  ☑ From Buzzards Bay Estuary Project: http://www.buzzardsbay.org/download/2-11-04lidshow.pdf
  ☑ From Mass Low Impact Development Toolkit:
  http://www.mapc.org/regional_planning/LID/LID_Toolkit_Slide_Show.ppt
- Hold ongoing discussions: Once people and groups are familiar with the approach, it is important to discuss details how the approach can best be applied and promoted in the community.

As the citizens of your community will have a strong bearing on whether LID takes hold in your community – both as they weigh in on possible new regulations to promote the practice or as neighbors to proposed projects – conducting outreach efforts to the general public is an excellent idea. There are three groups within your municipal government, however, that deserve particular attention as you spread the word:

- Planning Board members: By acquainting board members with LID principles and techniques, they will be more likely to respond positively to the approach when it is proposed, and even become strong advocates for its use in applicable situations.
- Public Works and Public Safety Departments: LID techniques are sometimes viewed skeptically by public works or safety departments because they represent a departure from long-established practices governing stormwater control, or roads, access and parking. Holding up-front meetings to discuss such concerns often is helpful.
- Selectmen/Councilors/Managers/Commissioners: It is also a good idea to familiarize elected officials and municipal administrators with LID as they will be involved in the process of revising regulations or need to respond to citizen inquiries regarding the approach.

3. *Reach Out to Developers*

Many communities are recognizing the benefits of establishing stronger working relationships with developers in fostering more sustainable development practices. Low Impact Development represents an excellent opportunity for such cooperation. Both in one-on-one interactions and as part of organized group gatherings, developers can be acquainted with the approach and its benefits, and encouraged to integrate LID features into proposed projects.


MASSACHUSETTS LOW IMPACT DEVELOPMENT TOOLKIT
LID BENEFITS
Lower Construction Costs
Higher Lot Yield

	Conventional	Low Impact
Grading/Roads	$569,698	$426,575
Storm Drains	$225,721	$132,558
SWM Pond/Fees	$260,858	$ 10,530
Bioretention/Micro	—	$175,000
Total	$1,086,277	$744,663
Unit Cost	$14,679	$9,193
Lot Yield	74	81

Example of Construction Cost Analysis of Conventional versus LID Development

In talking with developers and organizing outreach efforts, two issues deserve particular attention. The first is the cost of implementing LID approaches. Although LID often is touted for its cost-saving benefits, developers may need assurances that the approach makes economic sense. Several websites provide useful information in this regard:

- ***Builders' Guide to Low Impact Development***
  http://www.toolbase.org/PDF/DesignGuides/Builder_LID.pdf#search=%22a%20builder's%20guide%20to%20low%20impact%20development%22
- ***LID Strategies and Tools for Local Governments: Building a Business Case***
  http://lowimpactdevelopment.org/lidphase2/econ_assess.htm

The second issue has to do with the receptiveness of town boards and of the community at large. Before proposing an LID project, developers may want see positive indications of support for the approach among town officials and citizens. Such support may be evident as a result of your successful efforts in spreading the word about LID or by revising local land use regulations to better accommodate the approach. Developers themselves can build understanding and support for LID though neighborhood meetings and pre-development workshops.

4. <u>*Get Projects on the Ground*</u>

A completed project that employs LID principles and techniques is a powerful public relations tool for promoting the approach. There's nothing like having a successful project to help to convert skeptics and galvanize supporters. If a project is constructed in your community or region, work to publicize it and use it as a learning experience that can be built upon.

Rain Garden Demonstration Project
Salem, New Hampshire

If private LID projects are slow in coming to your community, consider integrating LID features into municipal projects. New school facilities or improvements may be a particular good opportunity, as they are high visibility, and can incorporate an educational component.

Opportunities may also exist for the formation of partnerships in which multiple organizations propose or finance LID-oriented projects. One example would be a non-profit housing organization, which is able to partner with an environmental funder to help cover the cost of LID features.

Porous Asphalt Parking Lot
University of Rhode Island, Kingston

A variety of LID projects have been constructed or are underway in New England. The following sites describe LID projects in the region and in other states:

- ***NEMO LID Stormwater Treatment Practice Database***. Excellent listing of LID projects in Connecticut. http://www.clear.uconn.edu/tools/lid/index.htm
- ***Mass Smart Growth Toolkit***. Three case studies in the Bay State. http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-CS-lid.html
- ***National LID Clearinghouse***. A listing of projects nationwide with additional links. http://www.lid-stormwater.net/clearinghouse/effectiveness.htm
- ***Greenroofs.com***. A listing of green roof projects. http://www.greenroofs.com/projects/plist.php

5. <u>*Make Sure Your Local Regulations are "LID-Friendly"*</u>

If the land use regulations of your city or town currently prohibit or discourage certain LID practices, it is doubtful that your community will get many proposals for developments incorporating them. On the other hand, if your ordinances or bylaws contain provisions that not only allow, but also promote the approach, LID projects are much more likely to be proposed and built. Because of the importance of this consideration, a separate "Top Five" fact sheet follows this one.

5 ☑ Things You Can Do Promote LID in Your Local Regulations

Local regulations are often identified as a significant impediment to LID. In some cases, these regulations prohibit or discourage certain LID techniques. Perhaps more commonly, ordinances or bylaws are silent on the approach, leaving planning boards and developers to rely on the "conventional" approaches to stormwater or site design. A fairly comprehensive checklist for evaluating local regulations can be found in the Massachusetts LID Toolkit at **http://www.mapc.org/regional_planning/LID/LID_codes.html.** ***The following Top 5 list offers more concise guidance.***

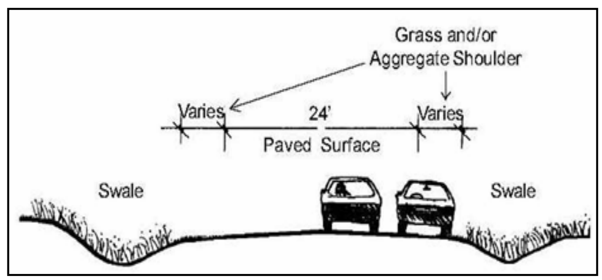
1. *Make Sure They Don't Prohibit/Discourage LID Measures*

A first step is ensuring that LID techniques aren't prohibited or discouraged in your regulations– either explicitly or implicitly. Try reviewing the seven LID techniques described on page 2 (or other ones described in LID literature), and evaluate how your regulations would treat proposals using each technique. Although you may discover outright prohibitions on certain measures (for example, not allowing pervious pavement treatments in commercial parking areas), be attuned to provisions that may act to discourage LID features – such as treating them as structures that must meet setback requirements or not allowing them to be accounted for in determining required areas for landscaping or open space.

2. *Revise Street and Parking Standards to Reduce Impervious Surfaces*

LID's focus on reducing impervious surfaces often runs afoul of local regulations. Ordinances and bylaws typically set minimum standards, that, while intended to ensure adequate traffic circulation, parking and access for public safety vehicles, can result in excessive paving, at least for certain types of projects or improvements.

Consider reevaluating your standards that dictate the size of roads, drives and parking areas. The goal should not be to look solely at pavement reduction, but on ways that circulation, safety and parking needs can be approached in a balanced fashion. Areas that deserve particular attention include:



Example of Reduced Pavement Width for low volume streets

- Required pavement widths on residential streets. Consider allowing widths of 24 feet or less for these streets (18-22 feet may be a reasonable standard for low-volume streets). For a good discussion of both street width and design, see http://www.metrocouncil.org/Environment/Watershed/BMP/CH3_RPPImpStreet.pdf
- The turning radius for cul-de-sacs. Reducing the radius of a cul-de-sac from 40 feet to 30 feet, for example, yields a 45% reduction in paved surface. Emergency vehicle access should be a consideration, but should be balanced with other objectives. See excellent discussion at http://www.metrocouncil.org/environment/Watershed/BMP/CH3_RPPImpCuldeSac.pdf
- Standards governing number of parking spaces. If your regulations require more than 3 spaces per 1,000 square feet of gross floor areas for offices, and 4.5 spaces per 1,000 square feet of gross floor area of retail, consider reducing these standards.
- Other Opportunities for More Efficient Parking Areas. In evaluating parking standards and making changes, take into account the availability of on-street-parking and excess parking capacity in the vicinity, as well opportunities for allowing smaller spaces for compact cars and shared parking among businesses with different peak use profiles.

3. ***Pay attention to Street and Parking Lot Layout and Design***

Besides allowing for the reduction of paved areas, your local regulations can promote design of roads and parking areas that incorporate a decentralized approach to stormwater management consistent with LID principles. Three good examples of this are:

LID parking lot design

- Using of vegetated swales as an alternative to curbs and gutters. Typical standards either mandate or strongly promote curb and gutter profiles for streets, which serves to concentrate stormwater and increase its velocity. Consider adopting provisions that allow or encourage "open section" roadways that utilized vegetated swales, especially for more rural projects.
- Incorporating LID measures into parking lot design and landscaping. Ordinance language can also be revised to promote breaking up large paved expanses into multiple parking areas punctuated with natural vegetation and bio-retention areas. If your regulations now require parking areas to be paved, consider allowing use of permeable paving treatments as well. To build familiarity with the approach, your regulations might be revised to require porous paving for overflow parking areas.
- Installing rain gardens into cul-de-sac design**.** Cul-de-sac islands, in conjunction with open curb treatments, can serve as infiltration areas for the paved areas that surround them.

4. ***Incorporate LID Site Planning/Design Principles* (including promotion of conservation subdivisions)**

Some of the best opportunities for creating LID projects occur at the site planning and design stage. By careful attention to natural features, drainage patterns and the placement of buildings and improvements, projects can be made to work with, rather than against, the site's existing hydrology. Your local regulations can help promote this approach to site planning and design.

Project incorporating LID site plan principles (left – site plan, right – as built) The Pinehills, Plymouth, Massachusetts.

Conservation subdivisions are an approach to site planning and design that can facilitate LID objectives as well as provide other benefits. At the very least, your regulations should allow for the somewhat modified review process needed to facilitate these projects, and the flexibility to allow clustering of buildings or lots to create open space. Ideally, your regulations should require or strongly encourage conservation subdivisions. A wealth of online resources exists on the approach. A particularly good reference to give those who are unfamiliar with or skeptical of conservation subdivisions is a resource developed by *Land Choices* at http://www.landchoices.org/ConservationSubdivisions.htm.

Even projects that don't involve lot size reductions or clustering can be designed to better meet LID objectives. Your regulations may already contain standards such as minimizing site disturbances and retaining natural features. Such provisions can be given more teeth by requiring mapping of significant natural features or submission of tree preservation plans. Preapplication conferences or "sketch plan" meetings represent an excellent opportunity to discuss project planning and design issues – consider adding more guidance in your regulations regarding expectations and submittals for this stage of the process.

5. ***Add Additional LID-promoting Provisions to Your Regulations***

Steps 1-4 above are geared to making relatively modest changes to your local regulations to better accommodate LID development. If your community wants to not only allow, but to more strongly encourage LID techniques, you should consider the adoption of additional language that promotes or provides more guidance on the approach.

A cautionary note: this step should be taken with careful deliberation. When it comes to adding language on LID to your regulations, you are generally better off selectively incorporating standards of performance that are likely to be well understood and applied – as opposed to the bulk adoption of pages of detailed design specifications of various LID techniques and practices.

If adopting a new ordinance or bylaw is the route you want to take, it's generally preferable to adopt a comprehensive integrated stormwater management model that includes LID principles and standards and which applies to all projects covered by other ordinances or bylaws (e.g. zoning, subdivision, site plan and shoreland). Another option is to integrate LID provisions into existing stormwater regulations that are likely to be located in your town's land use regulations. If you want to provide additional design specifications, consider adopting a technical appendix to your regulations. Your planning department or board can also maintain links to LID manuals to assist developers and others who want detailed guidance.

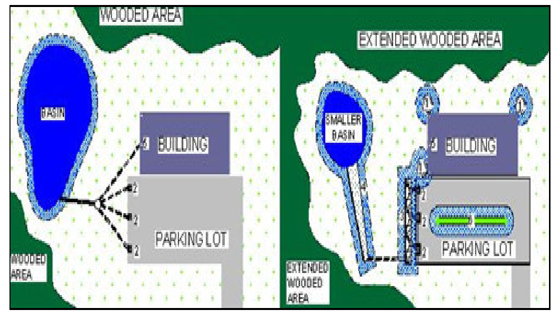


Illustration from Maine DEP Stormwater BMP Manual showing LID alternative to typical commercial development

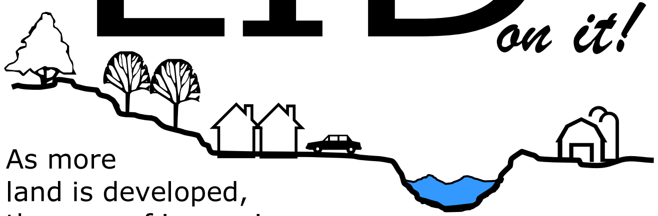
The following resources may be helpful as you consider incorporating additional LID language or conducting a more global evaluation of your local regulations prior to beefing them up to better address stormwater management and water quality protection as a whole:

- ***Massachusetts Model LID Bylaw***. May not be appropriate for wholesale adoption in other states, but could be easily adapted. Its approach to awarding credits for use of LID approaches, as laid out in a technical appendix, may be particularly worthy of consideration. http://www.mass.gov/envir/smart_growth_toolkit/bylaws/LID-Bylaw.pdf.
- ***Maine Stormwater Best Management Practices Manual***. The chapters on LID as a stormwater management approach are a source of both excellent information and principles/standards that might be integrated into local regulations. Chapters on LID technical practices may be more appropriate as an ordinance appendix or reference. http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm
- ***Codes and Ordinance Worksheet*** (from handbook. "Better Site Design: A Handbook for Changing Development Rules in Your Community" published by Center for Watershed Protection). Useful in conducting an overall assessment of your regulations, with a focus on how well they protect water quality. http://www.cwp.org/COW_worksheet.htm.
- ***Municipal Regulation Checklist*** (from NJ Stormwater BMP Manual). Another evaluative tool, with a focus on integrating LID provisions into regulations. http://www.njstormwater.org/tier_A/pdf/NJ_SWBMP_B.pdf

Finally, keep an eye out for new resources focused on promoting LID in your local regulations, either developed by your state environmental agency or by non-profit groups. Your regional planning agencies or councils of government may also be a good resource, especially on what communities in your region are active in promoting LID and other stormwater approaches.

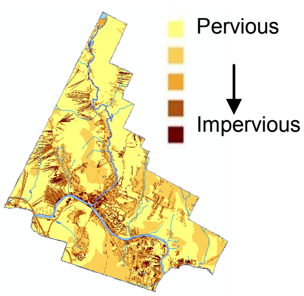
Photo/Graphic Credits: Maine NEMO, Center for Watershed Protection; Metropolitan Area Planning Council, Stephen Blatt Architects, CT NEMO, University of Rhode Island, CEI Engineers, Maine DEP

Put a LID on it!



As more land is developed, the area of impervious surfaces and amount stormwater runoff increases. Rapid, unplanned urbanization can have negative impacts on water resources which can increase flooding events. The volume and intensity of stormwater runoff can over burden existing drainage infrastructure such as in Barre City in the summer of 2007.

Photo by Jeb Wallace Brodeur, Times Argus



Runoff calculations by CVRPC

During an average rain event, the volume of runoff from impervious surfaces in Barre Town, Barre City, Berlin & Montpelier totals approx. 409 acre feet of water. To put this into perspective, the amount of runoff would fill 76 chain-size drugstores! Imagine the effects of multiple rain storms within one season. Future development will only compound the problem.

Overall, LID infiltration and filtration practices can reduce the likelihood of flooding downstream thereby decreasing damages to property and infrastructure.

Low Impact Development

Central Vermont Regional Planning Commission
29 Main Street • Suite 4 • Montpelier • Vermont 05602
802.229.0389 • www.centralvtplanning.org

For more information check out:

Vermont Manuals

- VT Small Sites Guide for Stormwater Management www.anr.state.vt.us/dec//waterq/stormwater.htm
- South Burlington LID Manual www.sburlstormwater.com
- VT Rain Garden Manual Absorbing the Storm www.vacd.org/~winooski/winooski_raingarden.shtml

New England based web resources

- UNH Stormwater Center (Research and resources) www.unh.edu/erg/cstev/index.htm
- LID Manual for Maine Communities www.maine.gov/dep/blwq/docwatershed/materials/LID_guidance/index.htm
- Jordan Cove Urban Watershed Project (case study illustrating the benefits of LID in a New England residential subdivision.) www.jordancover.uconn.edu

Vermont Organizations

- VT DEC Stormwater Section (State office tasked with technical assistance and regulatory oversight) www.anr.state.vt.us/dec//waterq/stormwater.htm
- NEMO Network & Lake Champlain Sea Grant (research-based educational outreach programs that emphasize natural resource-based land use planning and better site design) nemonet.uconn.edu/index.htm & www.uvm.edu/~seagrant/
- VLCT Stormwater Program (model and sample regulations, stormwater compliance and planning tools) www.vlct.org/municipalassistancecenter/waterqualityplanning/
- Friends of the Winooski River (Winooski Watershed organization) www.winooskiriver.org
- Winooski Natural Resources Conservation District (Conservation assistance and public awareness) www.vacd.org/~winooski/

Low Impact Development

- Bioretention
- Vegetated Buffer
- Infiltration basin or trench
- Porous Pavement
- Rain Garden
- Tree wells
- Vegetated Swale
- Green Roof
- Rain Barrel or Cistern
- Underground Storage