MEMORANDUM – DRAFT

Date: June 12, 2013

To: Mary Dolan and Valdis Lazdins, Montgomery County Planning Department

From: Biohabitats and Brown and Caldwell, a Joint Venture

RE: Ten Mile Creek Watershed Environmental Analysis
in Support of the Clarksburg Master Plan Limited Amendment
SUBJ: Summary of the Master Plan Scenario Analysis

Objectives

The Ten Mile Creek watershed in northwestern Montgomery County is the focus of an environmental analysis study in support of the Limited Amendment to the Clarksburg Master Plan, being undertaken by the Maryland-National Capital Park and Planning Commission (M-NCPPC) Montgomery County Planning Department. This environmental analysis is being conducted for the Planning Department by Biohabitats and Brown and Caldwell, a Joint Venture, with support from the Center for Watershed Protection. It is being done in collaboration with Montgomery County Department of Environmental Protection (DEP) and Montgomery County Department of Permitting Services (DPS).

The purpose of this study is to document existing conditions and to evaluate potential watershed response to development within the Ten Mile Creek watershed. As such, analyses focus only on subwatersheds upstream of the existing USGS gage station and those that have the potential to be directly affected by development. These subwatersheds are referred to as the Ten Mile Creek "study area." The Ten Mile Creek study area drains approximately 4.8 square miles of primarily rural and forested lands in Montgomery County, flowing from its headwaters just north of Frederick Road to Little Seneca Lake.

The Planning Department crafted four scenarios for future development within the watershed. Five watershed scenarios were analyzed, including:

Scenario 1: Existing Conditions – The baseline for these analyses is existing conditions within the watershed. This includes current land use, land cover and watershed infrastructure.

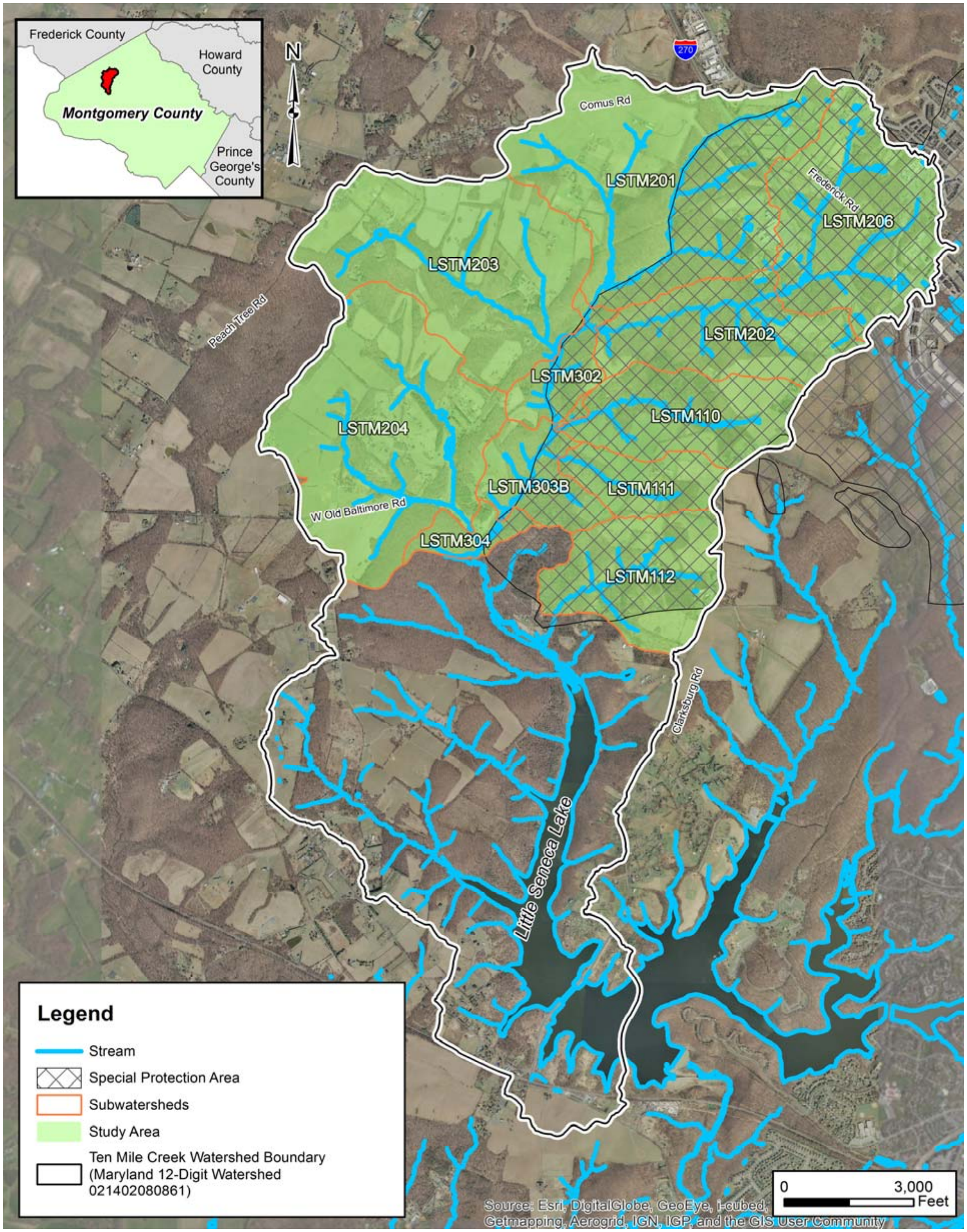
Scenario 2: 1994 Plan – The 1994 Clarksburg Master Plan recommendations for density and land use in Stage 4, assuming full Environmental Site Design for the developable and redevelopable properties.

Scenario 3: Reduced Footprint, Same Yield – The same as Scenario 2 with a reduced footprint for the Pulte properties. Assumes a different unit mix that would allow approximately the same number of units permitted by the 1994 Plan.

Scenario 4: Reduced Footprint Lower Yield – The same as Scenario 3 with the same unit mix as recommended in the 1994 Plan for the Pulte property, resulting in fewer potential units on Pulte.

Scenario 5: 7% Watershed Imperviousness – The same as Scenario 3 with reduced yield on Miles/Coppola, Egan, and the County properties.

This document sets forth the findings of this analysis and recommendations for the Planning Department to consider in formulating the Limited Amendment. Summaries of analysis results for subwatersheds are provided at the end of this memorandum. More detail on analysis methods and results is provided in the technical memorandums produced during this effort, submitted separately.



Ten Mile Creek Watershed and Subwatersheds

Approach to Analyses

The effects of development and land use change on watershed health and stream quality cannot be measured by any single factor. Five factors are generally considered when evaluating watersheds:

- Geomorphology, or stream channel form and stability
- Water quality
- Hydrology, or stream flow
- Habitat, both within the stream and its contributing upland drainage area
- Biology

Development and land use change have the potential to both directly and indirectly impact any of these five watershed factors. In addition, these factors are interdependent whereby impacts to one will influence the other four. For instance, increasing development within a watershed will increase the volume of stormwater runoff to a stream. This change in ***hydrology*** will result in higher and faster stream flows, which will increase channel erosion and change the stream's form, or ***geomorphology***. Sediment from eroded stream channels will be transported downstream, decreasing ***water quality***. In addition, the change in channel form will adversely affect ***habitat*** needed by fish and other aquatic organisms that live in the stream, resulting in an impact on stream ***biology***. The health of a watershed is also influenced by upland ecologies and overall biodiversity. Attributes such as interior forest and ecological hubs and corridors contribute to enhanced biodiversity and as a result system resiliency, providing degrees of protection against watershed adjustments, such as land use change.

Due to the complexity of natural systems, no single model or analytical tool can reliably predict the impacts of development on watershed conditions or the resulting changes in the biological communities which provide indicators of overall stream conditions. Therefore, several analytical methods were used evaluate potential watershed response to different development scenarios, as illustrated below. A Spatial Watershed Analysis identified potential direct impacts to areas of high natural value that provide habitat and support stream quality and watershed health. Pollutant load modeling assessed changes in pollutant loads as a result of development. Hydrologic modeling predicted potential change in stormwater runoff volumes and stream flows. All analyses used existing conditions as the baseline for comparison. These analyses were supplemented by a detailed review of existing watershed conditions and a literature review of the most recent research related to the impacts of development on watersheds and the effectiveness of sediment and stormwater control practices. The findings from these analyses are described in the following section.

Analysis Tool	Watershed Health Indicator				
	Hydrology	Geomorphology	Water Quality	Habitat	Biology
Natural Resource Impacts	O	X	O	X	O
Spatial Watershed Analysis				X	O
Pollutant Load Modeling			X	O	O
Hydrologic Modeling	X	O		O	O

X = Analysis tool projects potential impacts
O = Analysis results allow us to infer potential impacts

Findings

Existing Conditions within the Ten Mile Creek Study Area

The Ten Mile Creek watershed is located in the Clarksburg area of northwestern Montgomery County. Ten Mile Creek originates just north of MD 335 (Frederick Road) and flows into Little Seneca Lake, which flows into the Potomac River. Little Seneca Lake serves as a reservoir providing additional flow to the Potomac River, a public raw water supply, during drought periods (Montgomery County Department of Park and Planning, 1994). Ten Mile Creek and its tributaries are designated as a Use I-P stream – protection of water contact recreation, aquatic life and drinking water supply (Montgomery County Department of Park and Planning, 1994).

A portion of the study area, east of Ten Mile Creek mainstem and north of West Old Baltimore Road, is located within the Clarksburg Master Plan Special Protection Area (SPA). The area west of Ten Mile Creek is within the county-wide Agricultural Reserve. A basic profile of the study area is provided in the table below. The study area within Ten Mile Creek includes 11 subwatersheds.

Existing conditions in the Ten Mile Creek were evaluated through review of GIS data and numerous reports and studies of the watershed, as documented in the report *Existing Conditions in the Ten Mile Creek Study Area* (Biohabitats and Brown & Caldwell, 2013). Key watershed characteristics, summarized below, provide context for the development scenario analyses described later in this section.

- Ten Mile Creek is a reference stream in Montgomery County. Long-term monitoring indicates overall biological condition is healthy and diverse. Sensitive 'indicator' organisms that occur in few other areas within the County are found here. It is part of a small group of high quality watersheds still remaining within the County (e.g., many Patuxent River tributaries, Bennett Creek, and Little Bennett Creek).
- The majority of the streams within the watershed are small and spring fed with cool, clean groundwater. The mainstem is characterized by high concentrations of interior forest and wetlands.
- There is no evidence of widespread, long-term channel instability and flood flows still access the floodplain. In addition, the stream bed material is ideal to support a benthic macroinvertebrate community.
- The dominant land use/land cover is forest, followed by agriculture, with approximately 4% imperviousness.
- Slopes are steep and soils are generally rocky, with shallow to moderate depth to bedrock.

Profile of the Current Ten Mile Creek Study Area

Area in Montgomery County	• 3,046 acres (4.8 square miles)
Stream Length	• Approximately 22 miles (including Ten Mile Creek and its tributaries)
Land Use	• 46% Forest, 38% Rural, 7% Low Density Residential
Land Cover	• 4% Impervious Cover, 46% Forest Cover • Remaining land cover predominantly a mix of non-forested pervious area, including pasture, cropland, and turf
Water Quality	• Use I-P Stream
Major Transportation Routes	• Dwight D. Eisenhower Memorial Highway (I-270), Frederick Road (MD 355)
Significant Natural and Historical Features	• Rustic roads, Old Baltimore Road stream ford, Cemeteries • (Clarksburg School, Moneysworth Farm, and Cephas Summers House • Clarksburg Historical District

Natural Resources and Spatial Analysis

A Spatial Watershed Analysis of existing conditions within the Ten Mile Creek watershed was conducted with the intent of identifying areas with high resource value that support stream quality and watershed health. Natural resource attributes evaluated include steep slopes, erodible soils; hydric soils, forest, interior forest, 100-year floodplain, perennial & intermittent streams, ephemeral channels, wetlands, and springs, seeps & seasonal ponds.

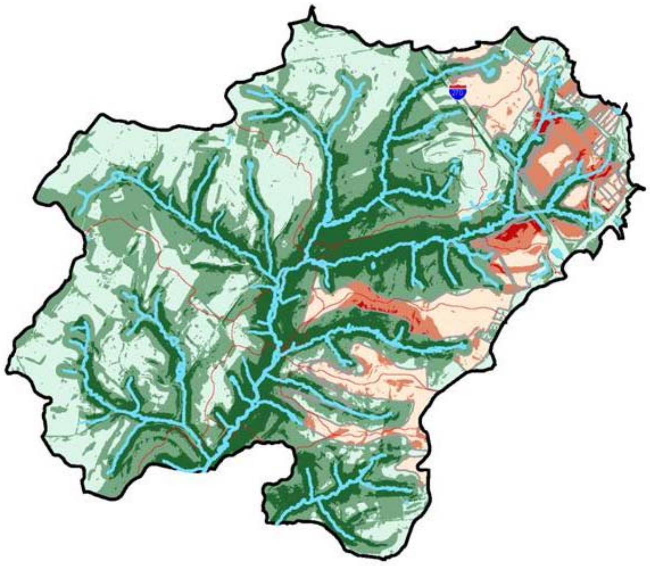
Areas of high resource value within the watershed are generally concentrated near the streams, particularly the mainstem, where wetlands, floodplains, forest, springs, seeps and the streams themselves provide critical watershed functions such as rainfall capture and runoff reduction, pollutant filtering, nutrient cycling, overbank flow attenuation and reduction, and aquatic and upland habitat.

Areas of high resource value are also associated with forest interior, largely concentrated along and east of the mainstem, west of I270, extending onto the County and Pulte properties. In response to a request for information related to rare, threatened and endangered species within the study area, the Maryland Department of Natural Resources stated that "analysis of the information provided suggests that the forested area on the project site contains Forest Interior Dwelling Bird habitat. Populations of many Forest Interior Dwelling Bird species (FIDS) are declining in Maryland and throughout the eastern United States. The conservation of FIDS habitat is strongly encouraged by the Department of Natural Resources." (MD DNR, 2013).

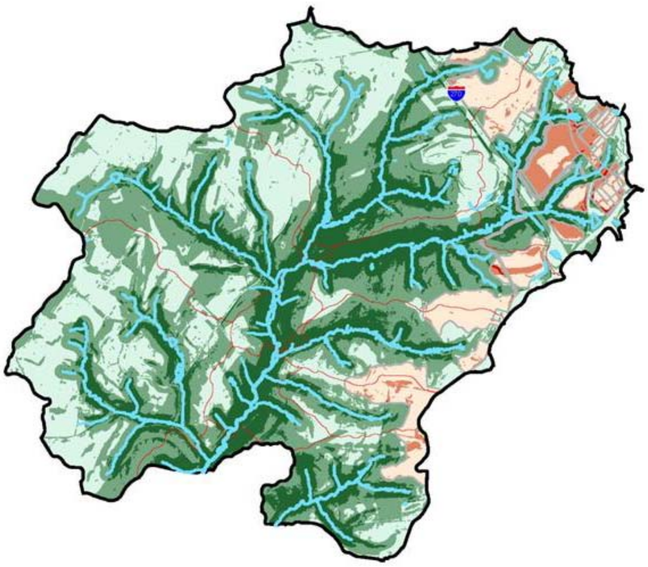
The projected limits of disturbance for Scenario 2 and Scenarios 3&4 were overlaid on the existing conditions Spatial Watershed Analysis to identify the extent of potential impacts to natural resources. Scenarios 3&4 have the same projected limits of disturbance, so this analysis applies to both. The limits of disturbance for Scenario 5 are very similar to Scenario 3, so a separate analysis was not conducted as similar results can be expected. Natural resources throughout the study area will be directly impacted by build-out of the 1994 Master Plan (Scenario 2). A significant decrease in impacts is seen in Scenarios 3&4.

- Of the 22 miles of streams in the area of the watershed studied, about a half of a mile has the potential to be impacted by build-out of the 1994 Master Plan (Scenario 2). The majority of these impacts would be to small headwater tributaries east of I270, as a result of construction of the MD355 Bypass. Construction of the 355 Bypass may also impact an acre of wetlands and nine of the watershed's 149 springs, seeps and seasonal pools (as identified by Montgomery County Department of Environmental Protection).
- Build-out of the 1994 Master Plan has the potential to impact up to 9% of the watershed's forest – about 120 acres out of 1,389 acres. The largest impacts are associated with the Pulte property, followed by the Miles Coppola; the MD355 Bypass; and the County property.
- Build-out of the 1994 Master Plan would also result in the loss of over 60 acres of interior forest, 16% of interior forest within the study area. About 18 of these acres may be directly impacted by development, namely on the County and Pulte properties. The remaining loss would be attributed to overall reduction in forest cover, reducing the size and buffer of contiguous forest.
- Approximately 57 acres on lands with a slope greater than 15% would be developed under the 1994 Master Plan, with 6 of these acres on lands with a slope greater than 25%. These include the Pulte, County, and Miles Coppola properties, as well as the MD355 Bypass.
- Scenarios 3&4 show a significant decrease in impacts areas with high natural resource value. Forest impacts are reduced from 120 acres to approximately 60 acres, and forest interior impacts are reduced from over 60 acres to approximately 14 acres. Direct stream and wetland impacts are reduced by half, largely due to the proposed realignment of the MD355 Bypass.

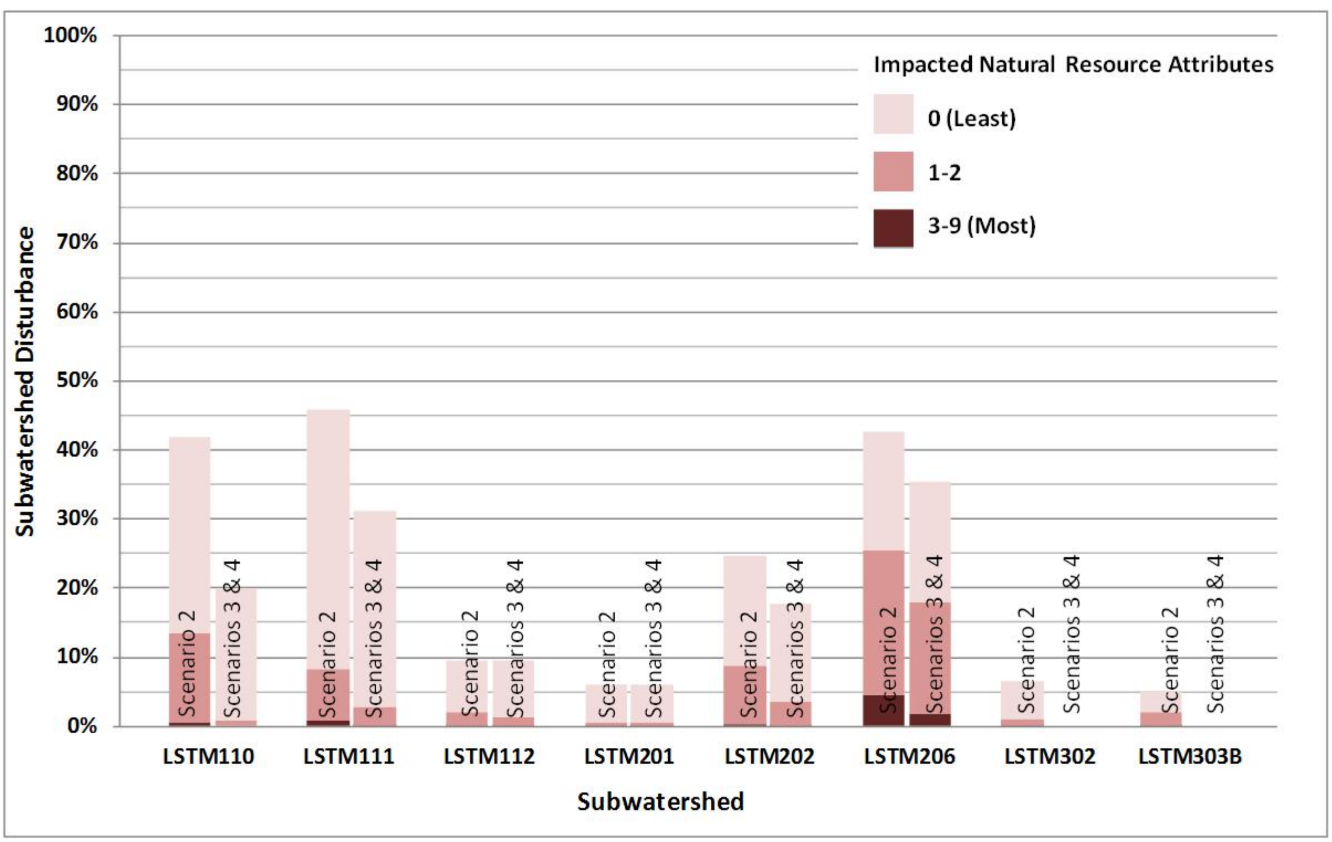
Natural resource attributes overlain with development scenarios within the Ten Mile Creek study area.
Dark green indicates areas with the highest natural resource value, and are generally associated with the presence of the stream system and its buffer areas, forested areas, and wetlands. Medium green indicates areas with fewer, but still valuable, natural resource attributes, such as interior forest and steep. Dark red indicates areas with high ecological value that fall within proposed limits of disturbance and will be directly impacted by development.



Scenario 2



Scenarios 3&4

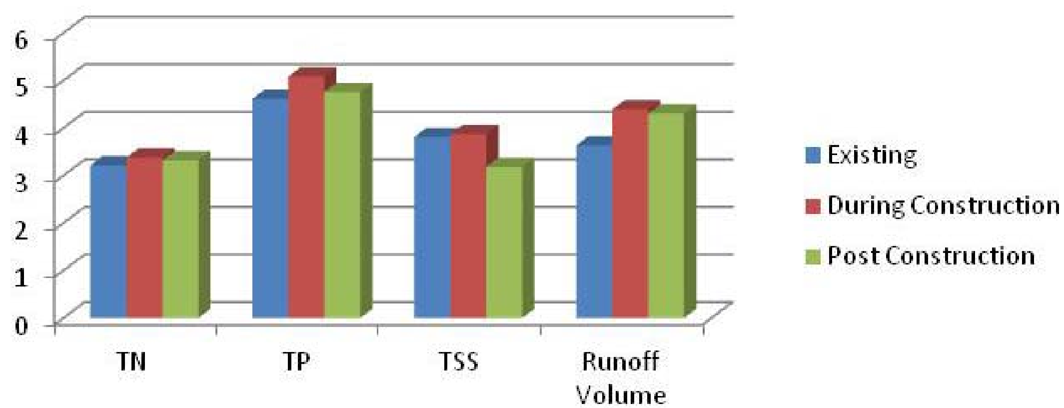


Pollutant Loading

Annual pollutant loading was assessed using the Watershed Treatment Model (CWP, 2010), a spreadsheet model that calculates annual runoff volume as well as pollutant loads for Nitrogen (TN), Phosphorus (TP) and Sediment (TSS). Three scenarios were analyzed: existing conditions; the 1994 Master Plan (Scenario 2); and the construction phase (with state of the practices BMPs). The construction phase is similar to Scenario 2, but assumes that construction occurs over ten construction seasons, so that 10% of the developable land is in active construction, and additional fertilizer is applied to establish new lawns. The pollutant load modeling also reflects conversion of 36 septic systems to sewer. Scenarios 3, 4 and 5 were not modeled as it may be assumed that pollutant loads will be reduced from what is seen for Scenario 2, given reduced limits of disturbance and impervious cover.

Major findings include:

- Sediment loads decrease uniformly after construction, except in undisturbed watersheds. This is because sediment loads from urban land are much lower than those from most pre-developed land uses, with the exception of forest. However, modeled sediment loads do not include channel erosion. Therefore, this modeling under estimates anticipated sediment loads in streams. Sediment loads are higher during construction.
- Some subwatersheds experience an increase in sediment loads during construction, and at the same time have a decrease after construction. For example, subwatershed LSTM 206 has a 76% increase during construction, but a 35% decrease after construction. This result occurs because sediment loads from construction are much higher than any rural land, while loads from developed land are much lower. Consequently, subwatersheds with a large area of disturbance will experience an increase during construction, followed by a much lower post-construction load.
- Annual runoff volume increases during and after construction. This result may seem counterintuitive, since the goal of ESD is to generate hydrology equivalent to “woods in good condition,” which should result in less annual runoff volume than the rural land currently present in much of the land to be developed. However, the WTM assumes that practices that qualify as “ESD Practices” do not actually achieve 100% runoff reduction, due to the likelihood that there will be impacts from soil compaction during construction and that some practices may be undersized due to sizing methodology and site constraints during construction.
- Watershed-wide, pollutant loads for nutrients (Nitrogen and Phosphorus) increase during construction, and decrease to slightly above Existing Condition rates in the Scenario 2 condition.



Comparative Annual Pollutant Loads (as a multiple of loads from forest) throughout the Development Process

Hydrology

Hydrologic analysis was conducted using XP-SWMM 2012, with the following modeling assumptions developed in conjunction with the Planning Department, DEP, and DPS:

- Compaction of soils will occur as a result of development, and the County's topsoiling requirements will be implemented.
- With the exception of the proposed I-270 widening, developed areas will be treated with micro-bioretention, which was modeled with 9 inches of ponding depth, 3.5 feet of media depth, a decaying infiltration rate from 2" per hour to 0.25" per hour, a constant infiltration rate of 0.05" per hour into underlying soils, and underdrains above stone reservoirs with overflow to surface water.
- New impervious surfaces related to I-270 widening will be treated with conventional stormwater management.
- Redevelopment areas will be treated to ESD volume requirements for 100% of impervious surfaces

The model provided estimates of relative changes in total streamflow volume, peak streamflow, and streamflow velocity predicted to occur as a result of the differences between existing land cover compared to each development scenario. Major findings include:

- For all development scenarios, the modeling results indicate that the development proposed for the Ten Mile Creek study area will impact hydrology in all of the modeled subwatersheds to a varying degree, with the exception of LSTM204, which was not predicted to be impacted. Streamflow changes shown in the modeling results will occur in some tributaries directly as a result of land cover changes within the subwatershed, or in some downstream locations indirectly as a result of flow changes from upstream development.
- The subwatersheds predicted to be most impacted from the 1994 Master Plan development modeled in Scenario 2 include LSTM110, LSTM111 and LSTM206, with increased streamflow volumes and peak flows also noted at downstream points LSTM202, LSTM302, LSTM303B and the study outlet point at LSTM304.
- The subwatersheds which showed most improvement from the reduced footprints modeled in Scenario 3 (compared to Scenario 2) were LSTM110 and LSTM111. Improvements were also seen at downstream points LSTM303B and the study area outlet at LSTM304.
- In most subwatersheds, the differences between the development proposed under Scenario 3 versus Scenario 4 were too small to result in any significant model response. However, additional improvements were seen as a result of the reduced imperviousness modeled in Scenario 5, with the greatest benefits predicted in LSTM110, LSTM111 and LSTM206. Improvements were also seen in LSTM201 and at the downstream modeling points at LSTM202, LSTM203, LSTM302, LSTM303B and the study outlet point at LSTM304.

Conclusions and Recommendations

Ten Mile Creek is a reference stream in Montgomery County, whose biological condition is healthy and diverse. Sensitive 'indicator' organisms that occur in few other areas within the County are found here. It is part of a small group of high quality watersheds still remaining within the County.

Of the four development scenarios evaluated, Scenario 2 (1994 Master Plan) has the greatest development footpring and consequently the greatest direct impact to the Ten Mile Creek watershed. These impacts include loss of forest, forest interior, streams and wetlands. Development will disturb approximately 420 acres of land. Four subwatersheds will see the greatest disturbance – approximately 46% of LSTM 111, 42% of LSTM 110, 43% of LSTM 206 and 25% of LSTM 202. Of these, LSTM 206 is currently the most developed subwatershed, with 16% impervious cover and fair stream conditions. In contrast, LSTM 110 and LSTM 111 are small, high quality headwater tributaries dominated by forest cover and rural land uses.

Build-out of the 1994 Master Plan would also result in the loss of over 60 acres of interior forest. About 18 of these acres may be directly impacted by development, namely on the County and Pulte properties. The remaining loss would be attributed to fragmentation and overall reduction in forest cover, reducing the size and buffer of contiguous forest. Approximately 57 acres on lands with a slope greater than 15% would be developed under the 1994 Master Plan, with 6 of these acres on lands with a slope greater than 25%. These include the Pulte, County, and Miles Coppola properties, as well as the MD355 Bypass.

An appreciable difference in potential stream and watershed impacts associated with Scenarios 3, 4 and 5 is not uniformly noted by these analyses. The similarity in limits of disturbance results in similar impacts to natural resources. The exception is the in Scenario 5, where a revised MD355 Bypass realignment reduced stream impacts from approximately 1,100 feet in Scenarios 3 and 4 to 700 feet in Scenario 5, and eliminates wetland impacts.

The results of the hydrologic model indicate that ESD will not fully mitigate the impacts of development on hydrology in the watershed. Scenario 2 results in the largest increases in volume of runoff and stream flow. In most subwatersheds, the differences between the development proposed under Scenario 3 versus Scenario 4 were too small to result in any significant model response. Of the four development scenarios, Scenario 5 showed the lowest increase over existing conditions as a result of the reduced imperviousness, with the greatest benefits predicted in LSTM110, LSTM111 and LSTM206. Improvements were also seen in LSTM201 and at the downstream modeling points at LSTM202, LSTM203, LSTM302, LSTM303B and the study outlet point at LSTM304.

Impacts from potential channel erosion resulting from altered hydrology was not explicitly analyzed as part of this study, due to uncertainty of future stream response. However, research does indicate that channel erosion can be a significant sediment source.

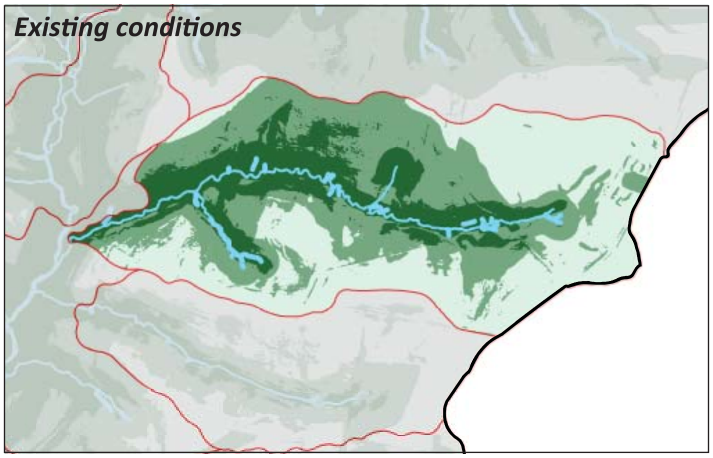
Given the level of development proposed, increases in stormwater runoff volume and peak flow can be expected in all development scenarios despite the application of ESD practices (Center for Watershed Protection, 2013). Literature review of case studies and monitoring to document the effectiveness of ESD and similar low impact development (LID) strategies are limited and don't appear to exist at a watershed scale of analysis. Where case studies do exist at a subdivision scale, there is no conclusive evidence that ESD fully protects stream health.

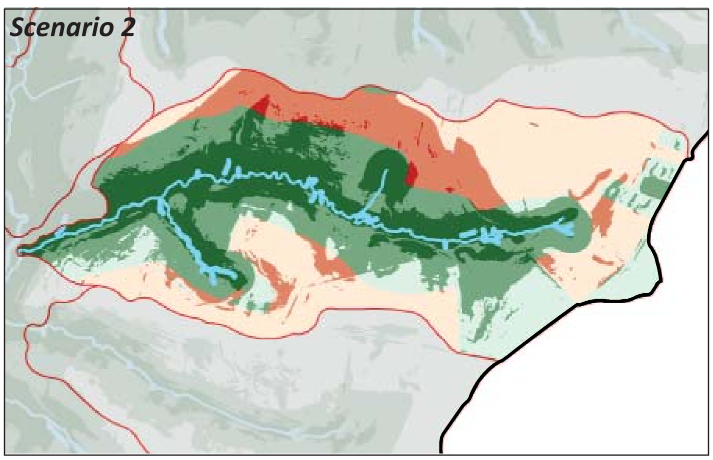
ESD represents the state of the practice for site planning and post-construction stormwater runoff management. However, rigorous and comprehensive implementation across or within watersheds has not occurred nor been monitored to establish a base of literature where we can conclude that watershed impacts won't be observed. While gaining watershed-based knowledge on the efficacy of ESD will be valuable, it may not be prudent to have initial experience and studies conducted in high quality watersheds.

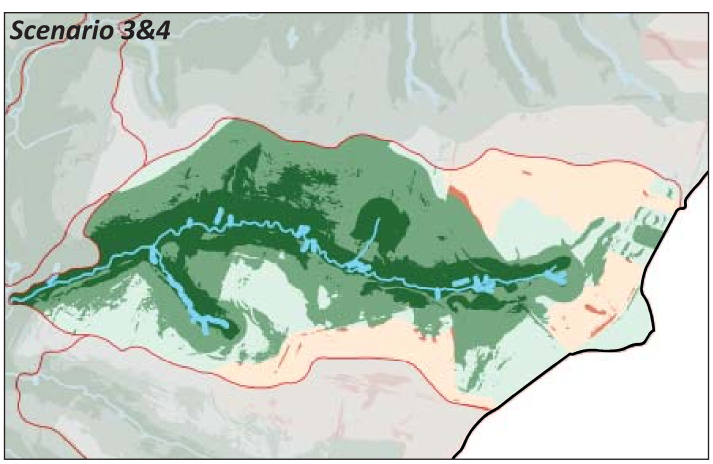
Additional development within the Ten Mile Creek watershed will have a negative impact on watershed health and stream quality. Minimizing impact to Ten Mile Creek will require the following measures:

- Minimize disturbance of natural resources throughout the Ten Mile Creek study area, especially forest cover in the headwater areas.
- Reduce development west of I270, with an emphasis on reducing impacts to upland forested areas and steep slopes. In particular, preserve existing conditions in the high quality headwater subwatersheds LSTM 110 (King Spring) and LSTM 111. In LSTM 202, reduce the extent of development on County-owned property (per Scenarios 3, 4 and 5) so that existing forest is not disturbed.
- Focus and prioritize development east of I270 in LSTM 206.
- If development occurs in subwatersheds LSTM 110 and LSTM 111, the limits of disturbance set forth in Scenarios 3, 4 and 5 should be applied.
- Minimize direct impacts to natural resources associated with new infrastructure, namely the MD355 Bypass and the sanitary sewer extension.
- Strictly enforce erosion and sediment control regulations, with special emphasis on proposed clearing and grading limits.
- Preserve riparian corridors and establish buffers around "zero order" or ephemeral streams not currently regulated.
- Reduce the 1994 Master Plan impervious levels in the headwater areas of LSTM206, LSTM201 and LSTM202 to protect those headwater tributaries and the mainstem of Ten Mile Creek.
- Within any proposed developed areas, employ site planning techniques as the first measure of Environmental Site Design. Prioritize preservation and protection of natural resources; conservation of natural drainage patterns; minimization of impervious areas; clustering of development; and limiting soil disturbance, mass grading and compaction. Achieve control of required volumes or enhanced volumes with the ESD treatment practices selected to achieve the most watershed benefits based on evaluation of site-specific and subwatershed-specific considerations.
- Design stream outfalls to reduce impacts associated with large flows (e.g., implement step pool conveyances at all outfalls).

TEN MILE CREEK
Contributing Subwatersheds: LSTM110



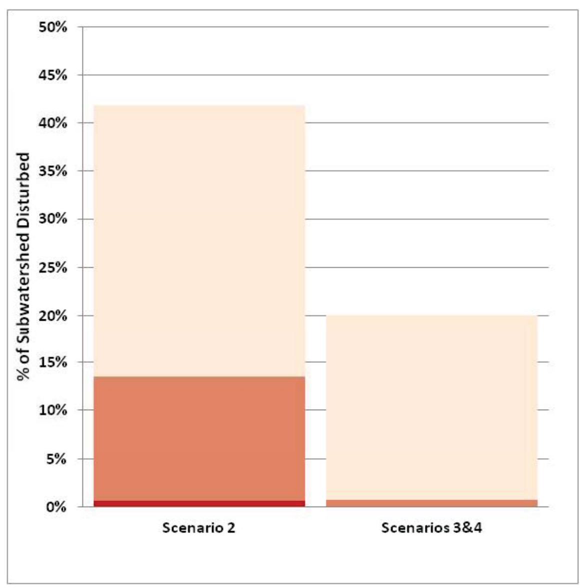




EXISTING CONDITIONS

Drainage Area (acres) – 211
% Impervious – 2%
% Forested – 45%
Stream Length (feet) – 8,535
IBI (average 1994-2012) – 35/good

LSTM101
Subwatershed Disturbance

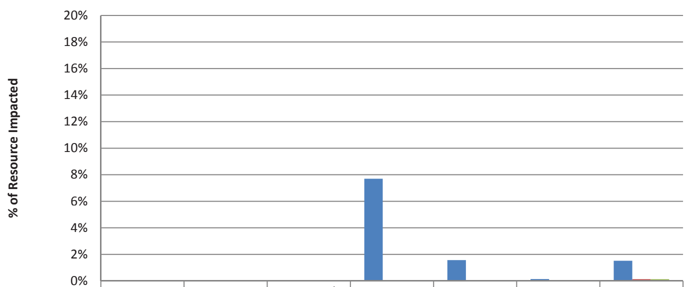


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

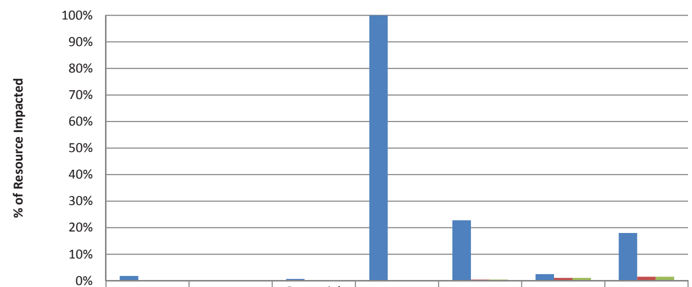
IMPACTS ON RESOURCES

LSTM110
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.0%	0.0%	7.7%	1.6%	0.1%	1.5%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Scenario 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%

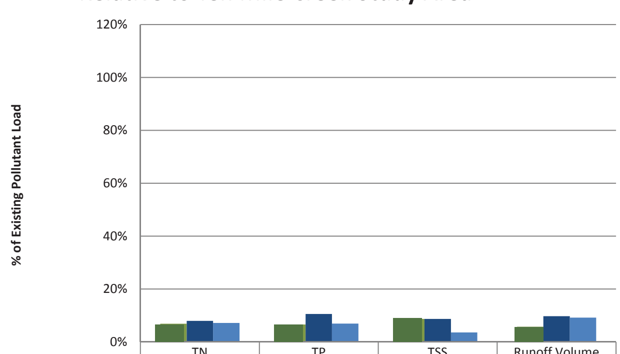
LSTM110
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.8%	0.0%	0.7%	100.0%	22.8%	2.5%	18.0%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	0.5%	1.1%	1.5%
Scenario 5	0.0%	0.0%	0.0%	0.0%	0.5%	1.1%	1.5%

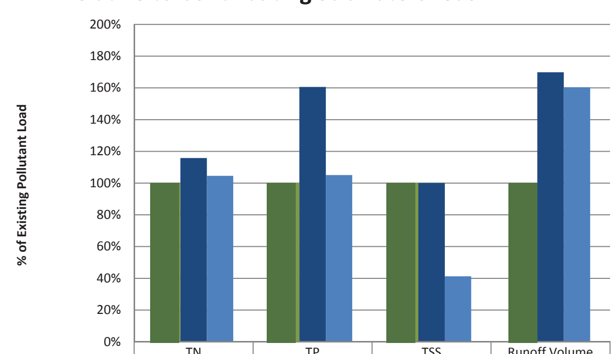
POLLUTANT LOAD ANALYSIS

LSTM110
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	6.9%	6.6%	8.7%	5.7%
Scenario 2 During Construction	7.9%	10.6%	8.7%	9.7%
Scenario 2 Post Construction	7.2%	6.9%	3.6%	9.2%

LSTM110
Relative to Contributing Subwatersheds

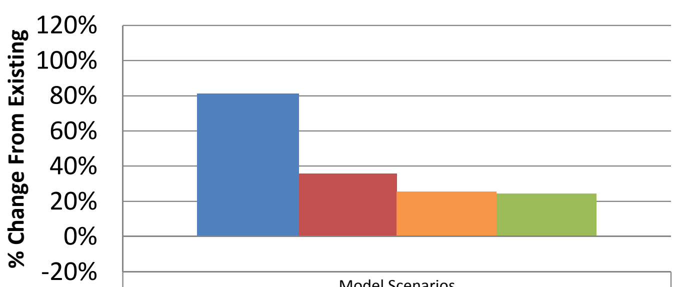


	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	115.8%	160.6%	100.1%	169.8%
Scenario 2 Post Construction	104.6%	105.1%	41.3%	160.3%

HYDROLOGY (1-YEAR, 24-HOUR STORM)

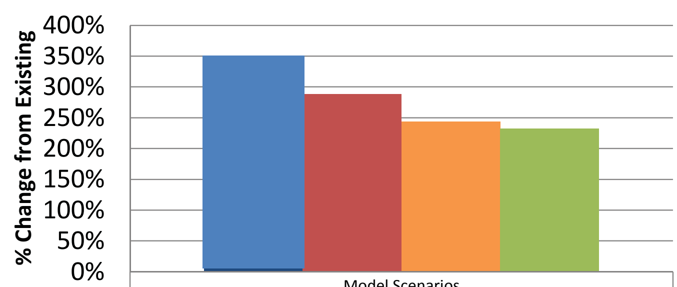
Note: Scale of Peak Stream flow is 0%-400%

LSTM110
Total Stream Flow Volume (ac-ft)



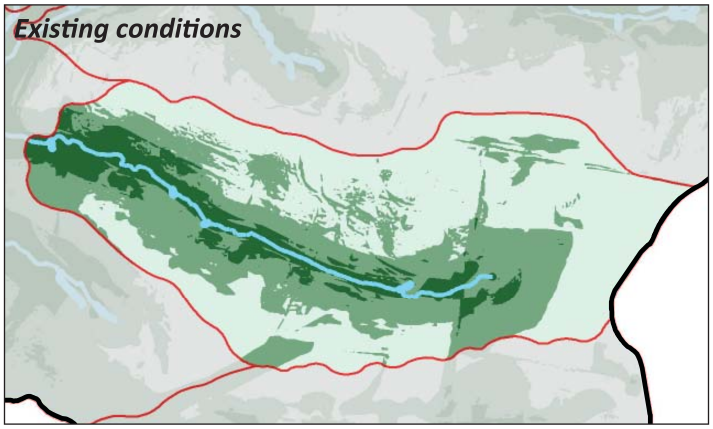
	Model Scenarios
Scenario 2	80%
Scenario 3	36%
Scenario 4	25%
Scenario 5	24%

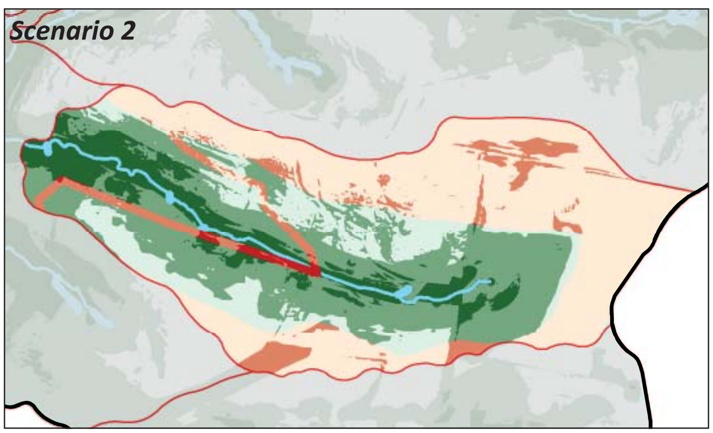
LSTM110
Peak Stream Flow (cfs)

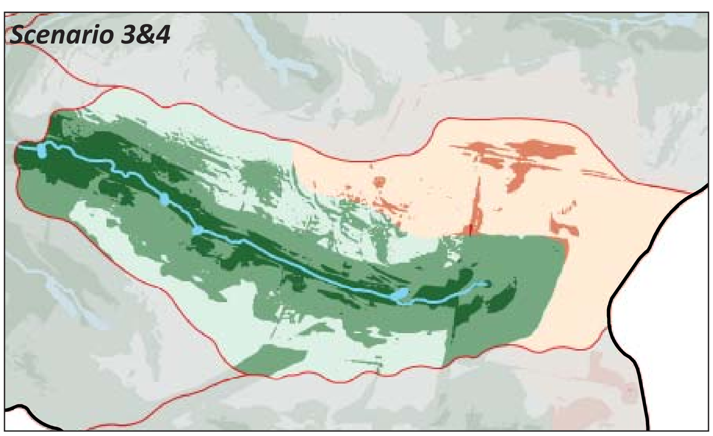


	Model Scenarios
Scenario 2	350%
Scenario 3	289%
Scenario 4	244%
Scenario 5	232%

TEN MILE CREEK
Contributing Subwatersheds: LSTM111



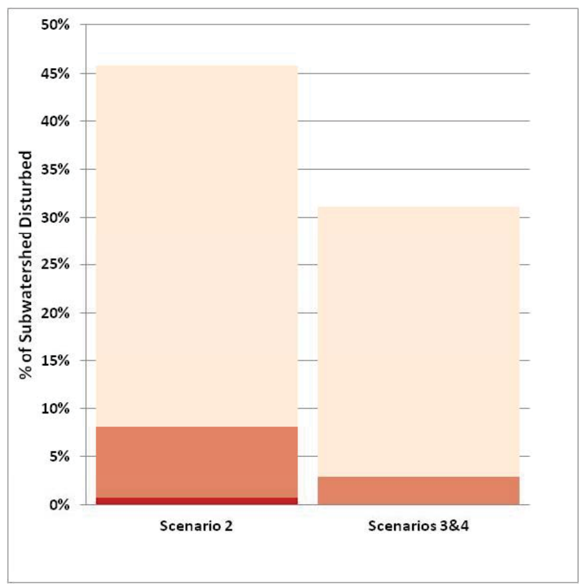




EXISTING CONDITIONS

Drainage Area (acres) – 104
% Impervious – 1%
% Forested – 19%
Stream Length (feet) – 3,273
IBI (average 1994-2012) – 30/good

LSTM111
Subwatershed Disturbance

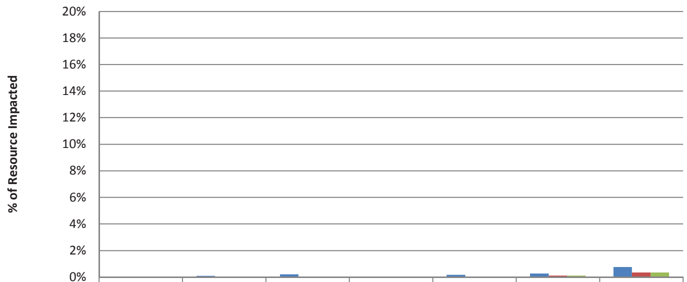


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

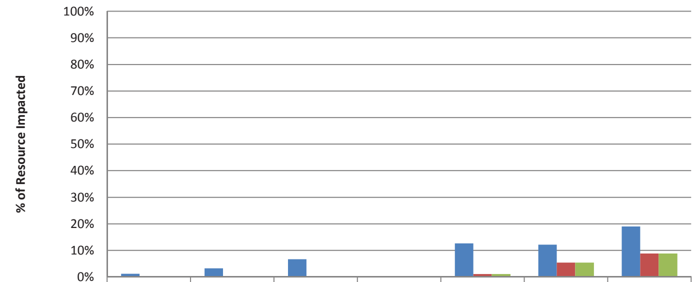
IMPACTS ON RESOURCES

LSTM111
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.1%	0.2%	0.0%	0.2%	0.3%	0.8%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Scenario 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%

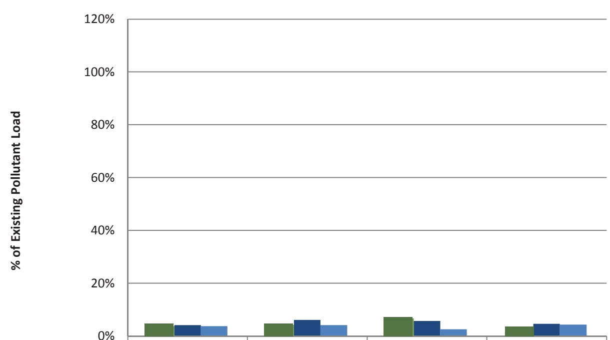
LSTM111
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.2%	3.2%	6.7%	0.0%	12.6%	12.1%	19.0%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	1.1%	5.5%	8.8%
Scenario 5	0.0%	0.0%	0.0%	0.0%	1.1%	5.5%	8.8%

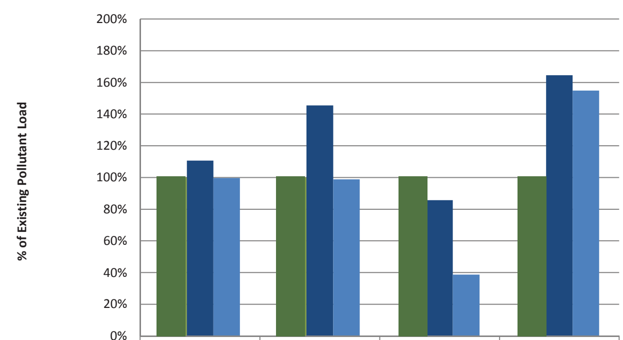
POLLUTANT LOAD ANALYSIS

LSTM111
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	3.8%	4.2%	6.7%	2.8%
Scenario 2 During Construction	4.2%	6.1%	5.7%	4.6%
Scenario 2 Post Construction	3.8%	4.2%	2.6%	4.4%

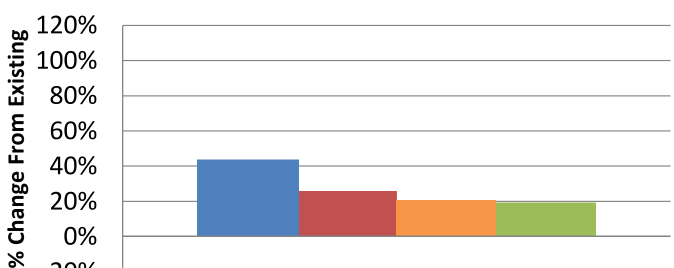
LSTM111
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	110.7%	145.5%	85.8%	164.5%
Scenario 2 Post Construction	99.6%	98.9%	38.7%	154.8%

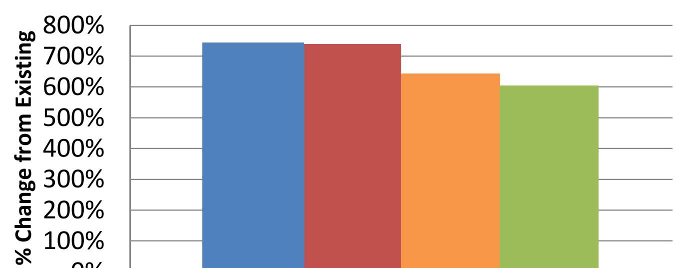
HYDROLOGY (1-YEAR, 24-HOUR STORM) Note: Scale of Peak Stream flow is 0%-800%

LSTM111
Total Stream Flow Volume (ac-ft)



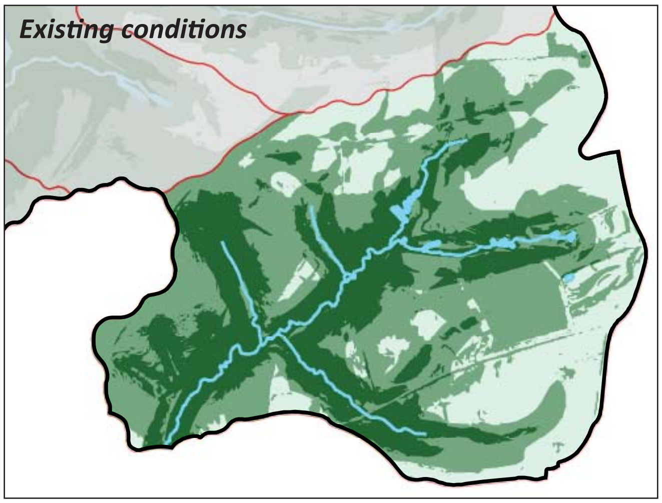
	Model Scenarios
Scenario 2	43%
Scenario 3	26%
Scenario 4	21%
Scenario 5	19%

LSTM111
Peak Stream Flow (cfs)



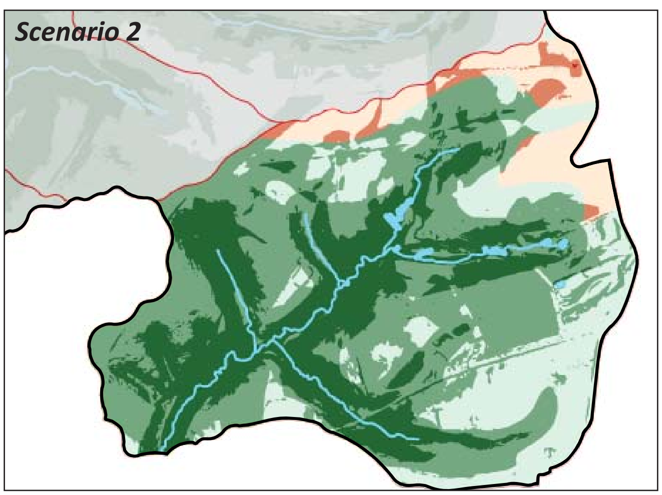
	Model Scenarios
Scenario 2	741%
Scenario 3	739%
Scenario 4	644%
Scenario 5	605%

TEN MILE CREEK
Contributing Subwatersheds: LSTM112

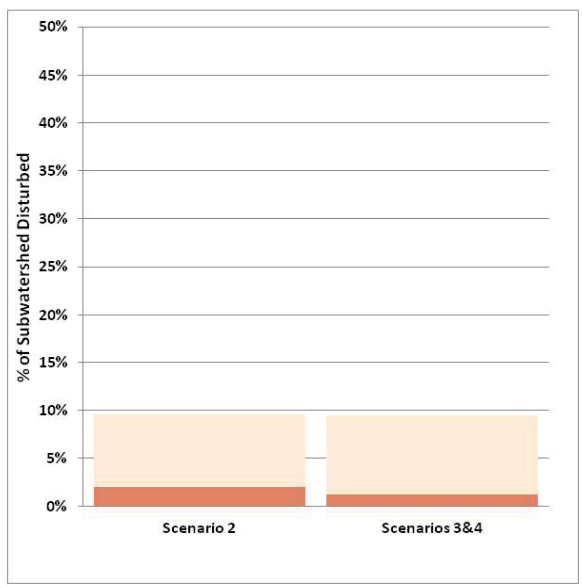


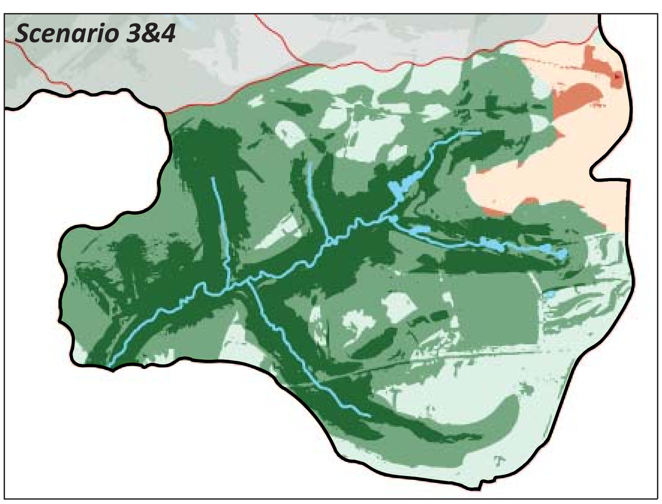
EXISTING CONDITIONS

Drainage Area (acres) – 228
% Impervious – 3%
% Forested – 49%
Stream Length (feet) – 8,841
IBI (average 1994-2012) – 30/good



LSTM112 Subwatershed Disturbance



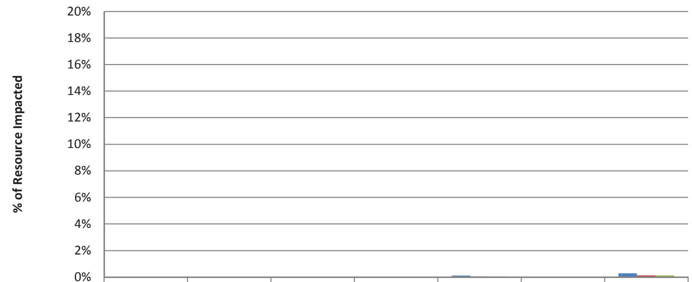


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

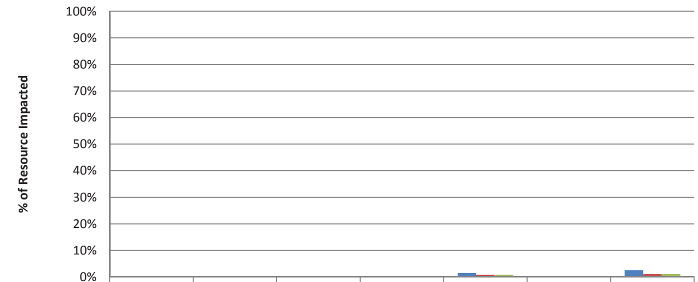
IMPACTS ON RESOURCES

LSTM112
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.3%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
Scenario 5	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%

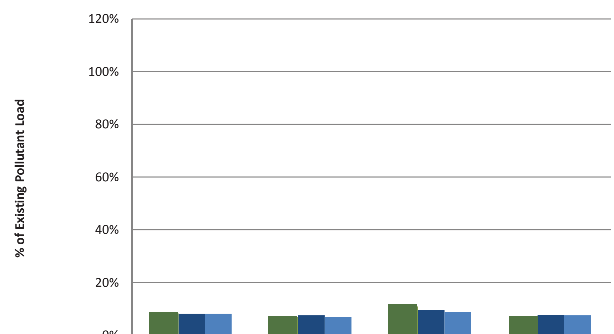
LSTM112
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.0%	0.0%	0.0%	1.5%	0.2%	2.5%
Scenario 3-4	0.0%	0.0%	0.0%	0.0%	0.8%	0.1%	1.1%
Scenario 5	0.0%	0.0%	0.0%	0.0%	0.8%	0.1%	1.1%

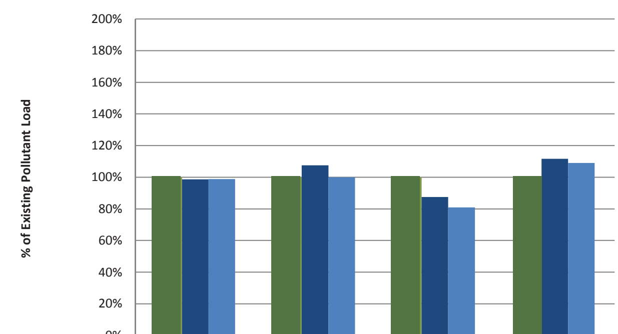
POLLUTANT LOAD ANALYSIS

LSTM112
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	8.3%	7.1%	11.0%	7.0%
Scenario 2 During Construction	8.2%	7.6%	9.6%	7.8%
Scenario 2 Post Construction	8.2%	7.1%	8.9%	7.6%

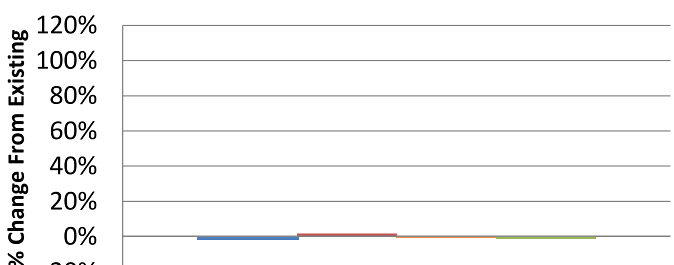
LSTM112
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	98.6%	107.5%	87.4%	111.7%
Scenario 2 Post Construction	98.8%	100.0%	80.9%	109.1%

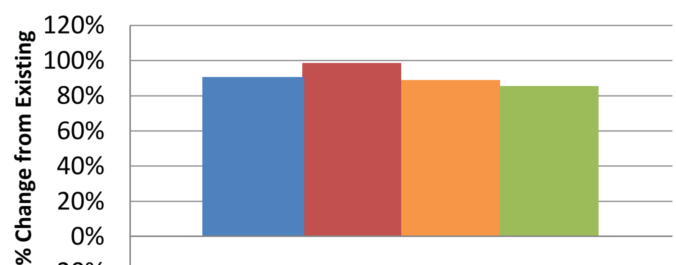
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM112
Total Stream Flow Volume (ac-ft)



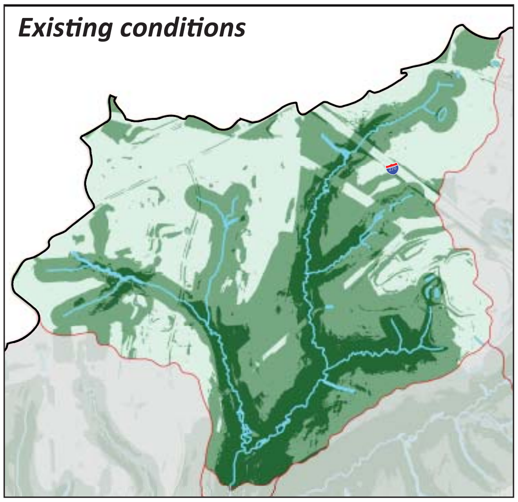
	Model Scenarios
Scenario 2	-1%
Scenario 3	2%
Scenario 4	-1%
Scenario 5	-1%

LSTM112
Peak Stream Flow (cfs)



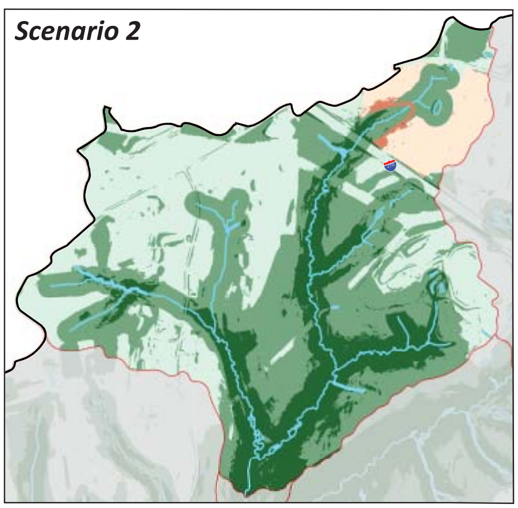
	Model Scenarios
Scenario 2	90%
Scenario 3	98%
Scenario 4	89%
Scenario 5	85%

TEN MILE CREEK
Contributing Subwatersheds: LSTM201

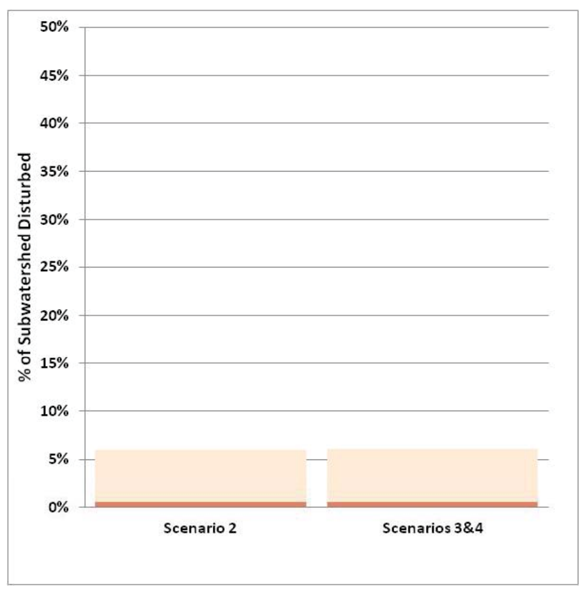

Existing conditions

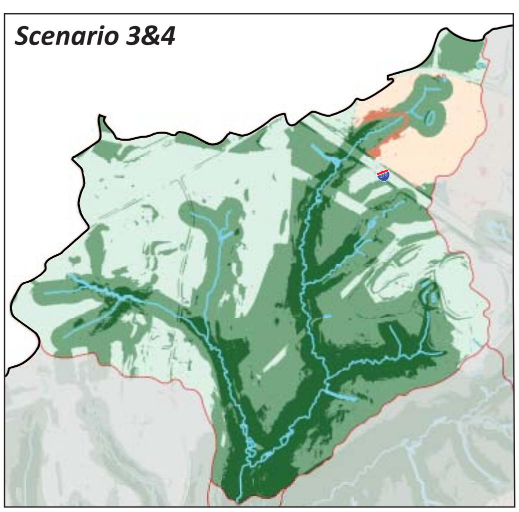
EXISTING CONDITIONS

Drainage Area (acres) – 611
% Impervious – 4%
% Forested – 44%
Stream Length (feet) – 25,396
IBI (average 1994-2012) – 31/good


Scenario 2

LSTM201
Subwatershed Disturbance



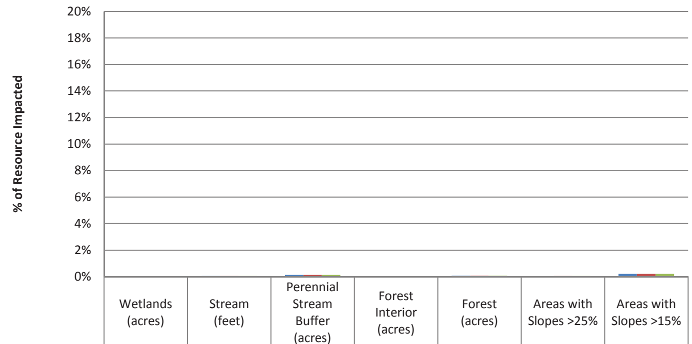

Scenario 3&4

LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

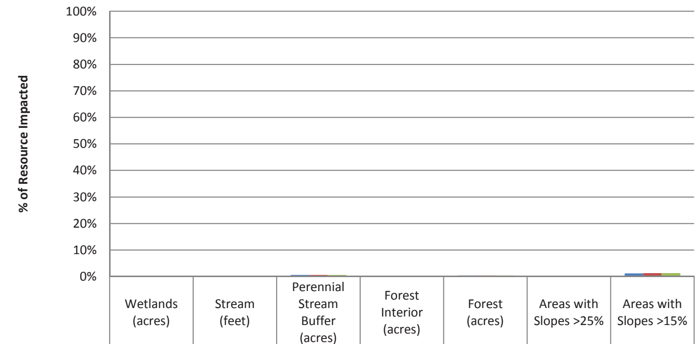
IMPACTS ON RESOURCES

LSTM201
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.2%
Scenario 3-4	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.2%
Scenario 5	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.2%

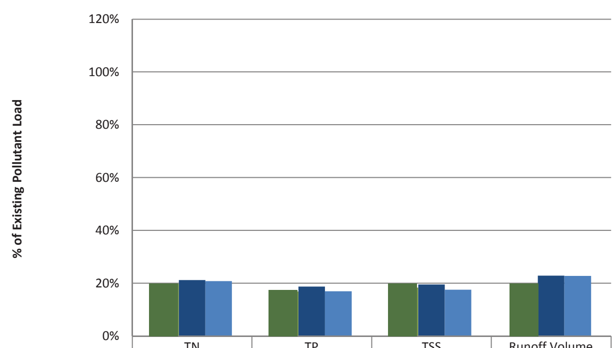
LSTM201
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	0.0%	0.2%	0.7%	0.0%	0.4%	0.2%	1.2%
Scenario 3-4	0.0%	0.2%	0.7%	0.0%	0.4%	0.3%	1.3%
Scenario 5	0.0%	0.2%	0.7%	0.0%	0.4%	0.3%	1.3%

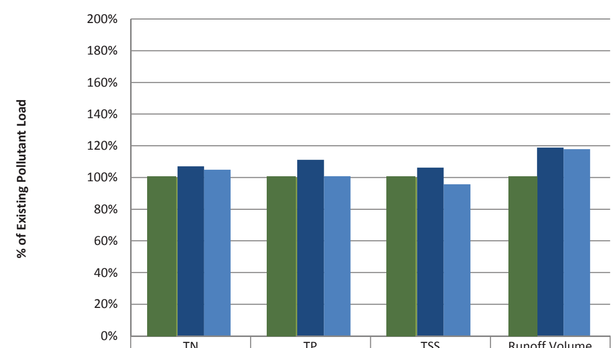
POLLUTANT LOAD ANALYSIS

LSTM201
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	19.8%	16.8%	18.3%	19.3%
Scenario 2 During Construction	21.2%	18.7%	19.5%	22.9%
Scenario 2 Post Construction	20.8%	17.0%	17.5%	22.7%

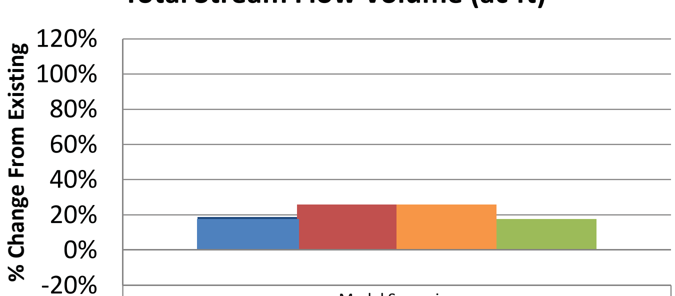
LSTM201
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	107.0%	111.1%	106.3%	118.9%
Scenario 2 Post Construction	105.0%	100.9%	95.7%	117.9%

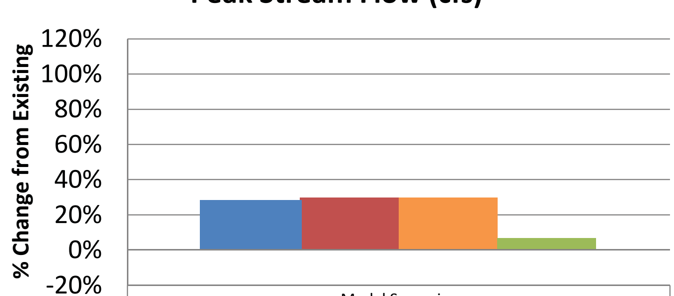
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM201
Total Stream Flow Volume (ac-ft)



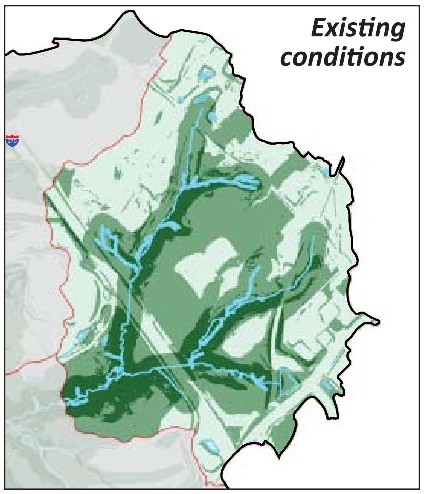
	Model Scenarios
Scenario 2	19%
Scenario 3	26%
Scenario 4	26%
Scenario 5	18%

LSTM201
Peak Stream Flow (cfs)



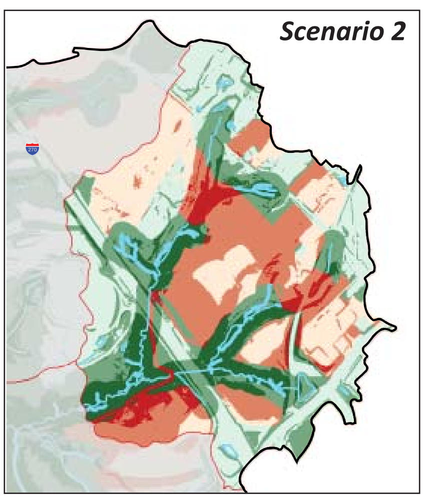
	Model Scenarios
Scenario 2	28%
Scenario 3	30%
Scenario 4	30%
Scenario 5	7%

TEN MILE CREEK
Contributing Subwatersheds: LSTM206

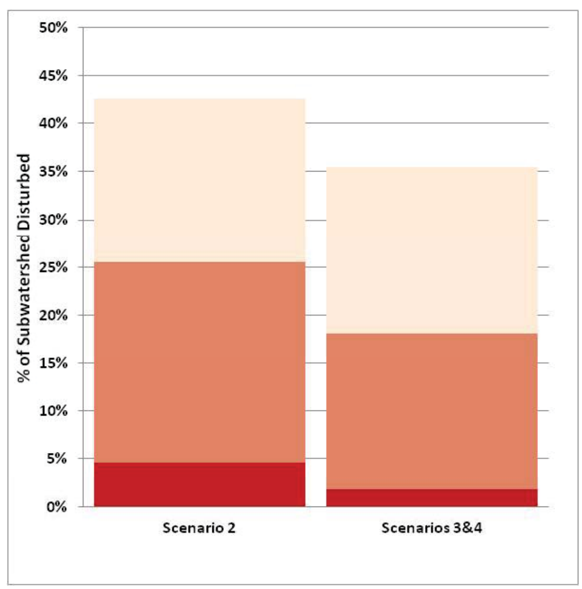


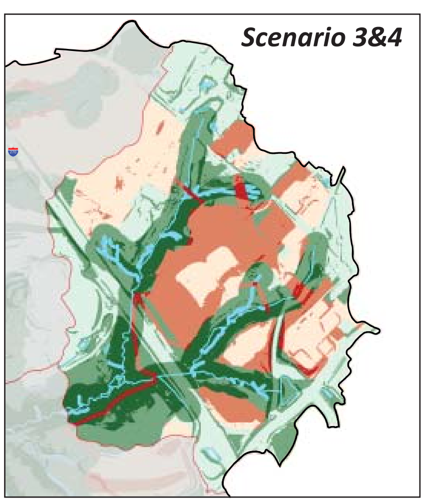
EXISTING CONDITIONS

Drainage Area (acres) – 370
% Impervious – 16%
% Forested – 41%
Stream Length (feet) – 13,202
IBI (average 1994-2012) – 21/fair



LSTM206 Subwatershed Disturbance



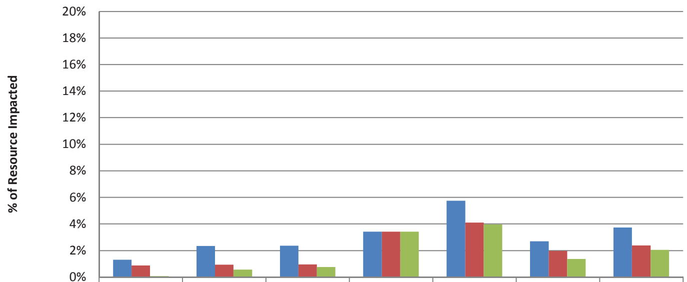


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

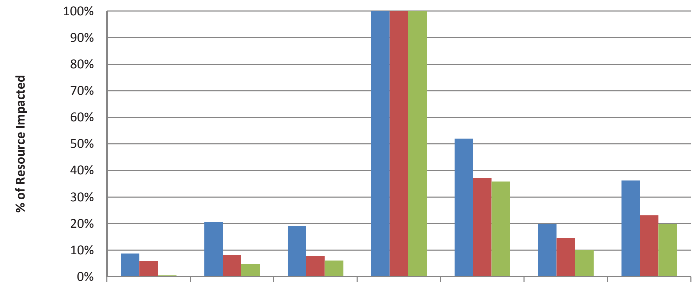
IMPACTS ON RESOURCES

LSTM206
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.3%	2.3%	2.4%	3.4%	5.7%	2.7%	3.7%
Scenario 3-4	0.9%	0.9%	1.0%	3.4%	4.1%	2.0%	2.4%
Scenario 5	0.1%	0.6%	0.7%	3.4%	4.0%	1.4%	2.0%

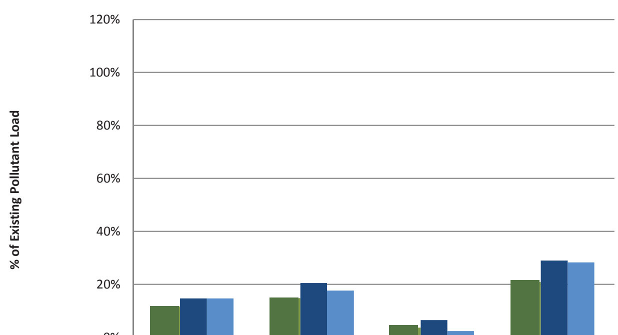
LSTM206
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	8.7%	20.7%	19.1%	100.0%	52.0%	19.9%	36.2%
Scenario 3-4	5.9%	8.2%	7.8%	100.0%	37.2%	14.6%	23.1%
Scenario 5	0.5%	4.9%	6.1%	100.0%	35.8%	10.1%	19.8%

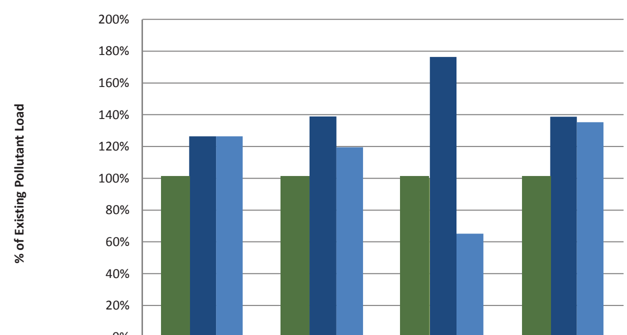
POLLUTANT LOAD ANALYSIS

LSTM206
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	11.6%	14.8%	3.7%	20.9%
Scenario 2 During Construction	14.7%	20.5%	6.5%	29.0%
Scenario 2 Post Construction	14.7%	17.6%	2.4%	28.3%

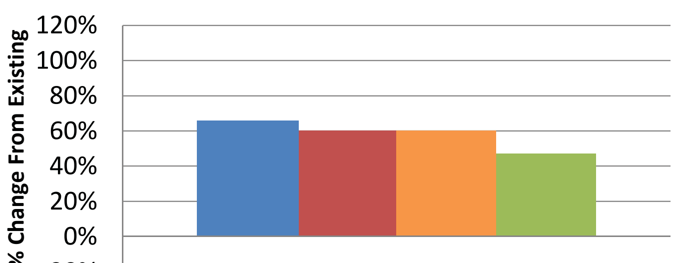
LSTM206
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	126.5%	139.0%	176.4%	138.7%
Scenario 2 Post Construction	126.5%	119.5%	65.1%	135.2%

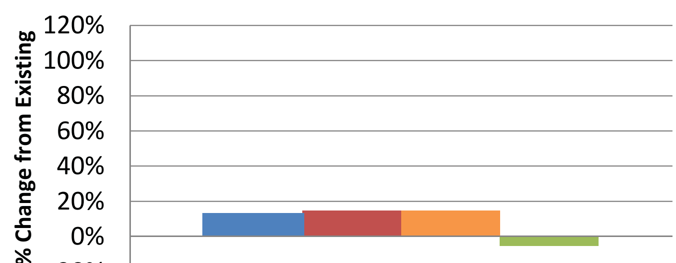
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM206
Total Stream Flow Volume (ac-ft)



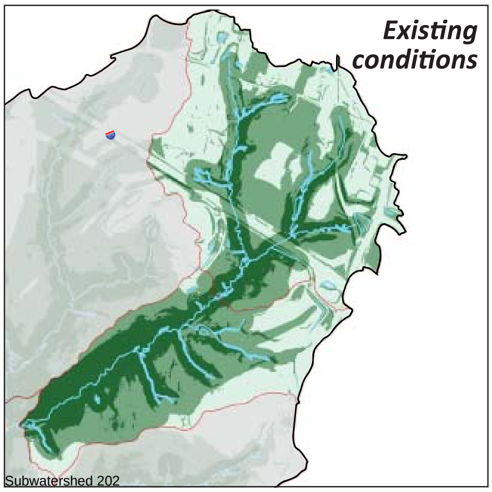
	Model Scenarios
Scenario 2	66%
Scenario 3	60%
Scenario 4	60%
Scenario 5	47%

LSTM206
Peak Stream Flow (cfs)



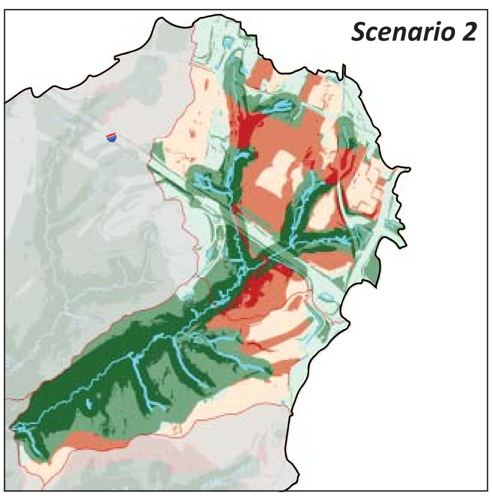
	Model Scenarios
Scenario 2	13%
Scenario 3	15%
Scenario 4	15%
Scenario 5	-5%

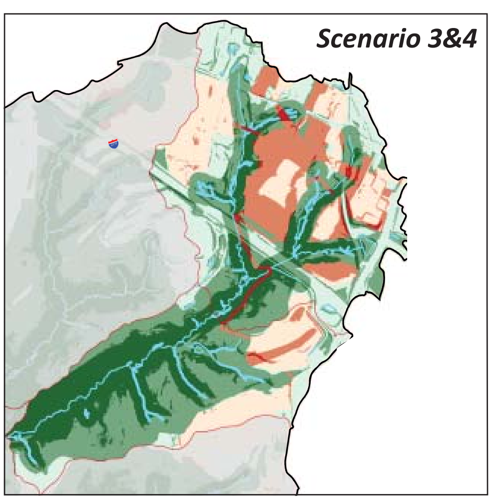
TEN MILE CREEK
Contributing Subwatersheds: LSTM206 & LSTM202



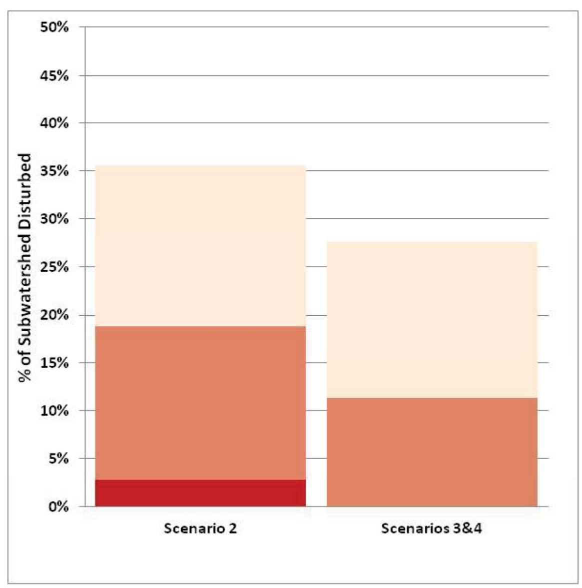
EXISTING CONDITIONS

Drainage Area (acres) – 613
% Impervious – 11%
% Forested – 52%
Stream Length (feet) – 20,707
IBI (average 1994-2012) – 30/good





LSTM206 & LSTM202 Subwatershed Disturbance

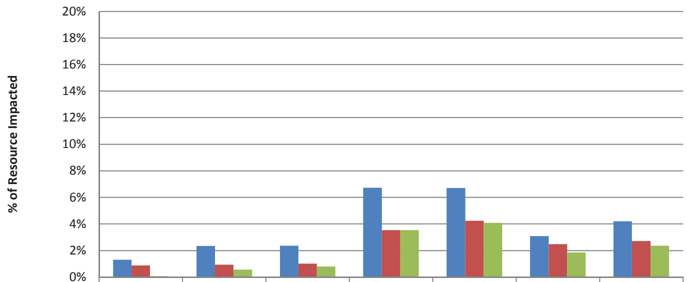


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

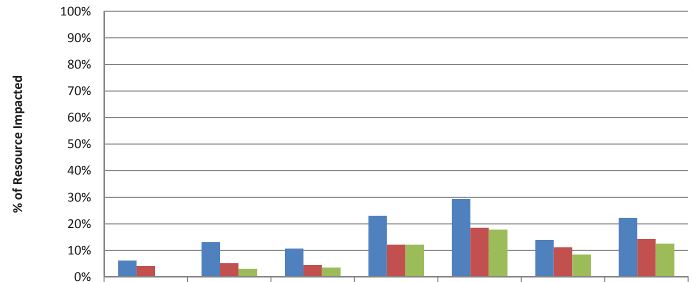
IMPACTS ON RESOURCES

LSTM206 & LSTM202
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.3%	2.3%	2.4%	6.7%	6.7%	3.1%	4.2%
Scenario 3-4	0.9%	0.9%	1.0%	3.5%	4.2%	2.5%	2.7%
Scenario 5	0.1%	0.6%	0.8%	3.5%	4.1%	1.9%	2.4%

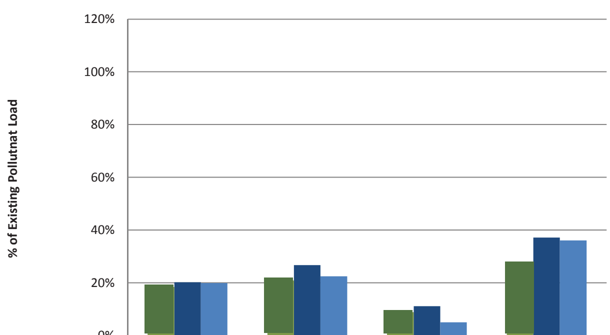
LSTM206 & LSTM202
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	6.2%	13.2%	10.7%	23.0%	29.4%	14.0%	22.2%
Scenario 3-4	4.2%	5.3%	4.6%	12.1%	18.5%	11.2%	14.4%
Scenario 5	0.4%	3.1%	3.6%	12.1%	17.9%	8.4%	12.5%

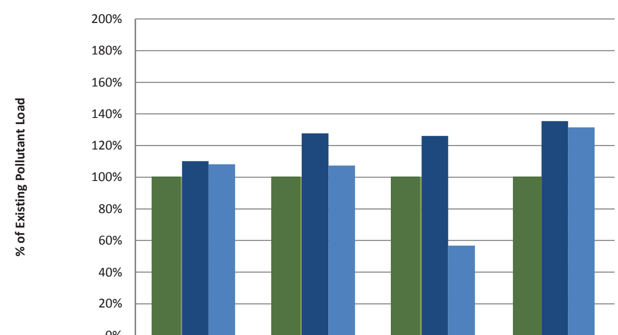
POLLUTANT LOAD ANALYSIS

LSTM206 & LSTM202
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	18.4%	20.9%	8.9%	27.5%
Scenario 2 During Construction	20.3%	26.7%	11.2%	37.2%
Scenario 2 Post Construction	19.9%	22.4%	5.0%	36.1%

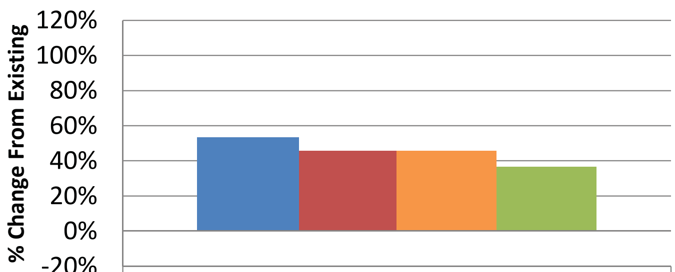
LSTM206 & LSTM202
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	110.1%	127.8%	126.0%	135.4%
Scenario 2 Post Construction	108.2%	107.3%	56.7%	131.5%

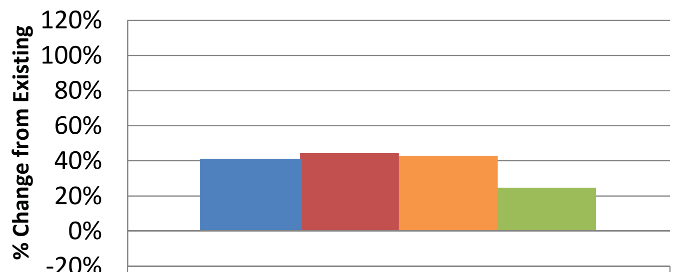
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM206 & LSTM202
Total Stream Flow Volume (ac-ft)



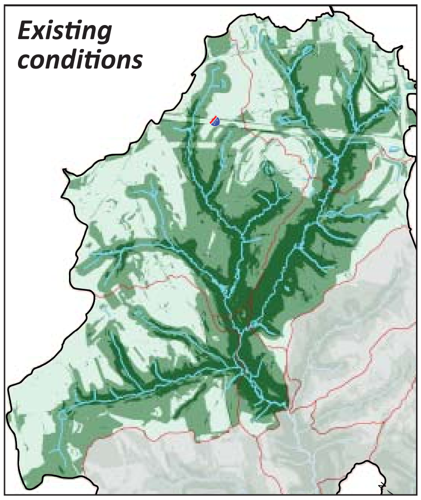
	Model Scenarios
Scenario 2	53%
Scenario 3	46%
Scenario 4	46%
Scenario 5	37%

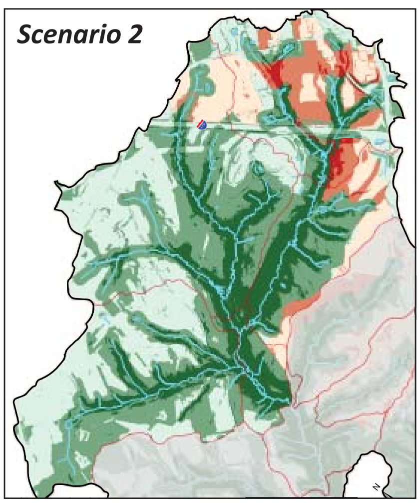
LSTM206 & LSTM202
Peak Stream Flow (cfs)

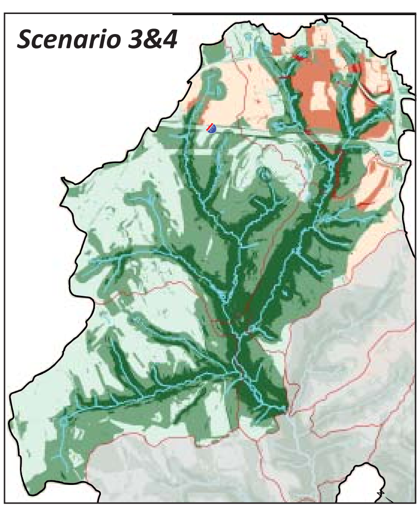


	Model Scenarios
Scenario 2	40%
Scenario 3	44%
Scenario 4	43%
Scenario 5	25%

TEN MILE CREEK
Contributing Subwatersheds: LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302


Existing conditions

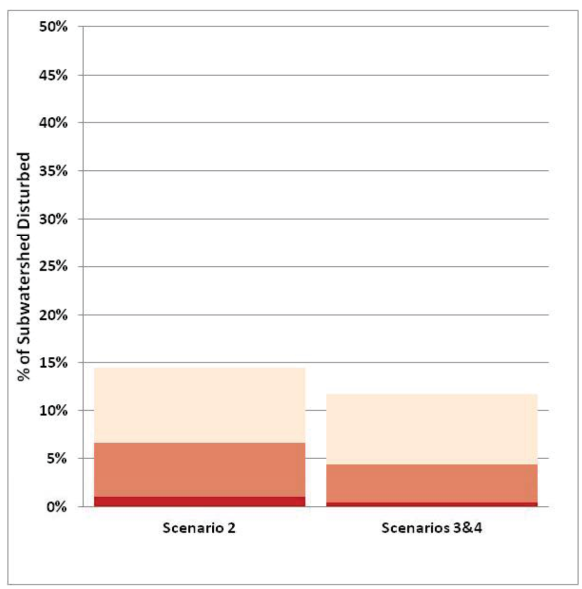

Scenario 2


Scenario 3&4

EXISTING CONDITIONS

Drainage Area (acres) – 1,794
% Impervious – 5%
% Forested – 47%
Stream Length (feet) – 68,412
IBI (average 1994-2012) – 35/good

LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302 Subwatershed Disturbance



LEGEND

Natural Resource Attributes Undisturbed
- 0 Least
- 1 - 2
- 3 - 9 Most

Natural Resource Attributes Disturbed
- 0
- 1 - 2
- 3 - 9

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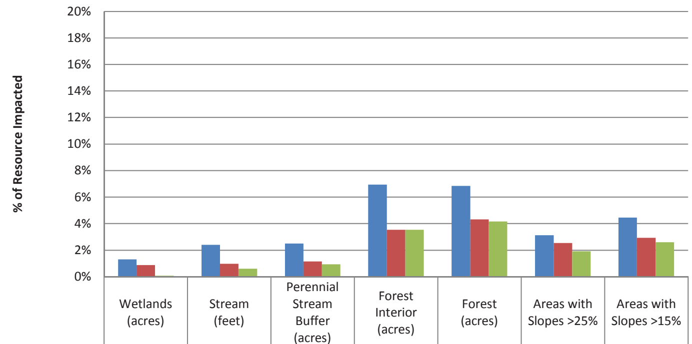
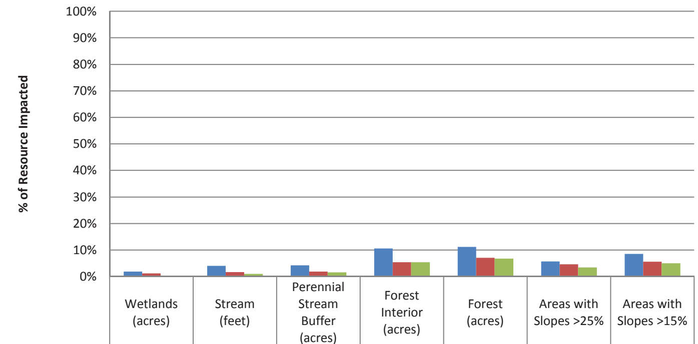
IMPACTS ON RESOURCES

LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.3%	2.4%	2.5%	7.0%	6.8%	3.1%	4.5%
Scenario 3-4	0.9%	1.0%	1.1%	3.5%	4.3%	2.5%	2.9%
Scenario 5	0.1%	0.6%	0.9%	3.5%	4.2%	1.9%	2.6%

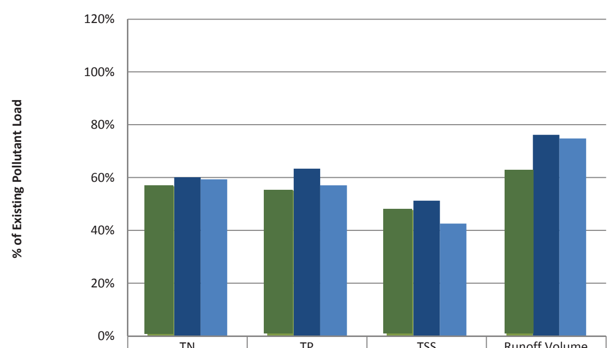
LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.8%	4.1%	4.2%	10.6%	11.2%	5.7%	8.6%
Scenario 3-4	1.2%	1.7%	1.9%	5.4%	7.1%	4.6%	5.7%
Scenario 5	0.1%	1.0%	1.6%	5.4%	6.8%	3.5%	5.0%

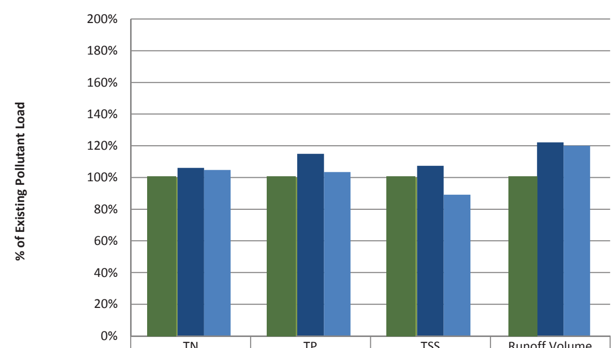
POLLUTANT LOAD ANALYSIS

LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	56.6%	55.1%	47.7%	62.4%
Scenario 2 During Construction	60.1%	63.4%	51.3%	76.2%
Scenario 2 Post Construction	59.3%	57.0%	42.6%	74.8%

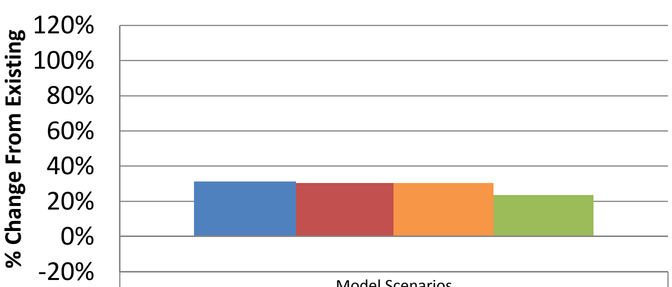
LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	106.1%	115.0%	107.4%	122.2%
Scenario 2 Post Construction	104.7%	103.5%	89.2%	120.0%

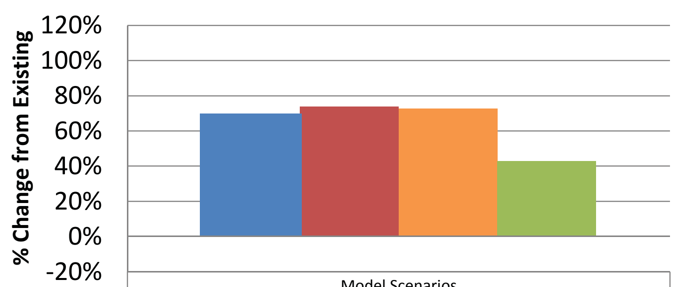
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Total Stream Flow Volume (ac-ft)



	Model Scenarios
Scenario 2	30%
Scenario 3	30%
Scenario 4	30%
Scenario 5	24%

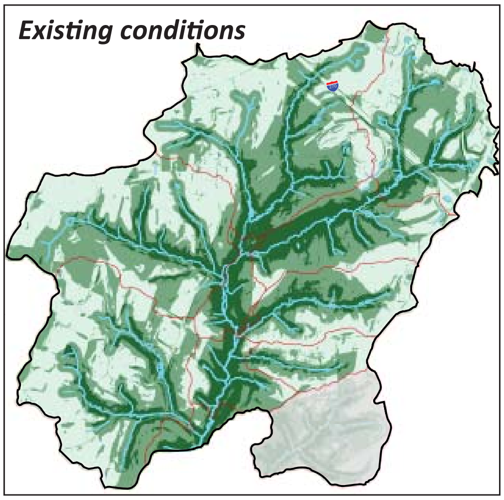
LSTM206, LSTM202, LSTM201, LSTM203, & LSTM302
Peak Stream Flow (cfs)



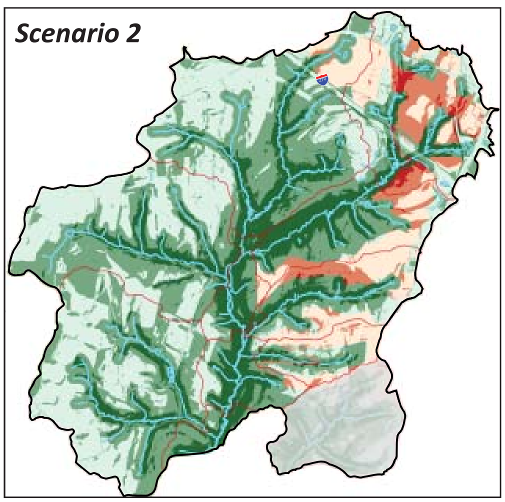
	Model Scenarios
Scenario 2	69%
Scenario 3	74%
Scenario 4	73%
Scenario 5	43%

TEN MILE CREEK

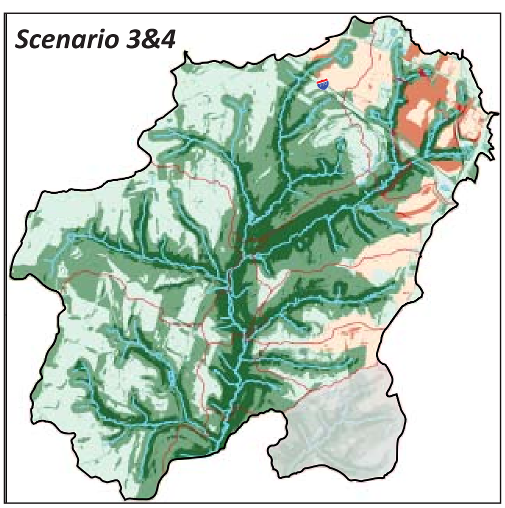
Contributing Subwatersheds: LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304



Existing conditions



Scenario 2

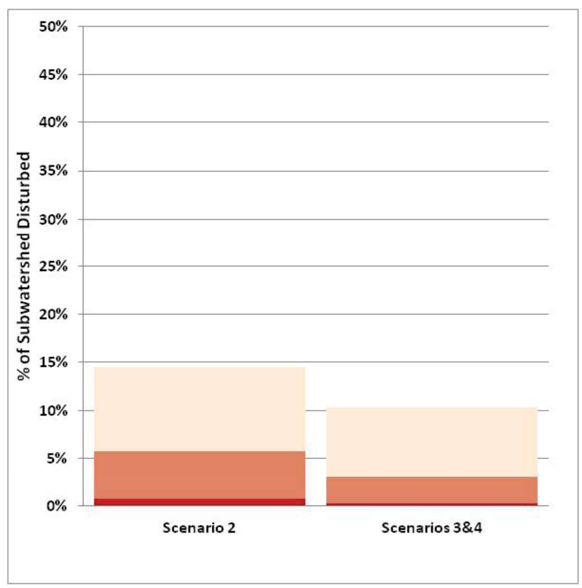


Scenario 3&4

EXISTING CONDITIONS

Drainage Area (acres) – 2,818
% Impervious – 4%
% Forested – 45%
Stream Length (feet) – 107,252
IBI (average 1994-2012) – 35/good

LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304 Subwatershed Disturbance

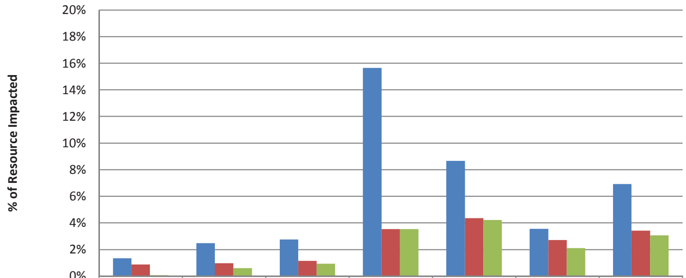


LEGEND

Natural Resource Attributes Undisturbed	Natural Resource Attributes Disturbed
0 Least	0
1 - 2	1 - 2
3 - 9 Most	3 - 9

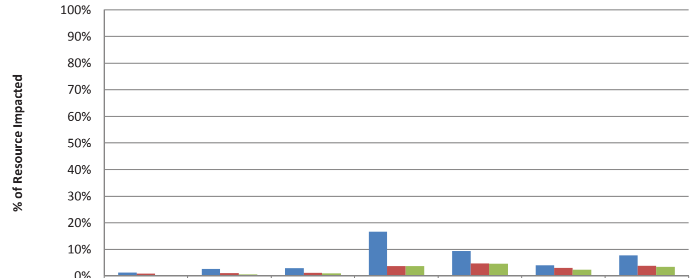
IMPACTS ON RESOURCES

LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Relative to Ten Mile Creek Study Area



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.3%	2.5%	2.8%	15.6%	8.7%	3.6%	6.9%
Scenario 3-4	0.9%	1.0%	1.1%	3.5%	4.4%	2.7%	3.4%
Scenario 5	0.1%	0.6%	0.9%	3.5%	4.2%	2.1%	3.1%

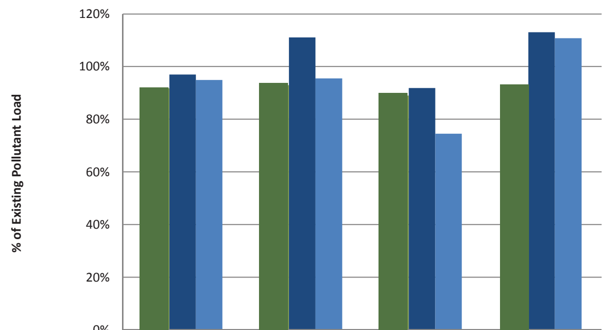
LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Relative to Contributing Subwatersheds



	Wetlands (acres)	Stream (feet)	Perennial Stream Buffer (acres)	Forest Interior (acres)	Forest (acres)	Areas with Slopes >25%	Areas with Slopes >15%
Scenario 2	1.3%	2.7%	3.0%	16.7%	9.4%	4.0%	7.8%
Scenario 3-4	0.9%	1.1%	1.2%	3.8%	4.8%	3.1%	3.8%
Scenario 5	0.1%	0.7%	1.0%	3.8%	4.6%	2.4%	3.5%

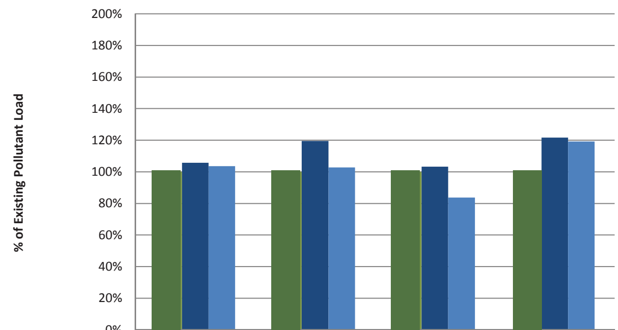
POLLUTANT LOAD ANALYSIS

LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Relative to Ten Mile Creek Study Area



	TN	TP	TSS	Runoff Volume
Existing	91.7%	92.9%	89.0%	93.0%
Scenario 2 During Construction	96.9%	111.1%	91.9%	113.1%
Scenario 2 Post Construction	94.9%	95.5%	74.5%	110.8%

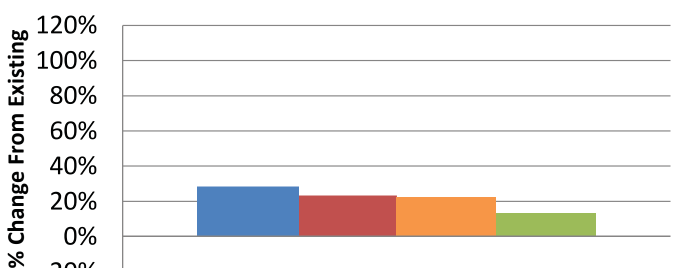
LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Relative to Contributing Subwatersheds



	TN	TP	TSS	Runoff Volume
Existing	100.0%	100.0%	100.0%	100.0%
Scenario 2 During Construction	105.7%	119.5%	103.3%	121.6%
Scenario 2 Post Construction	103.5%	102.7%	83.7%	119.2%

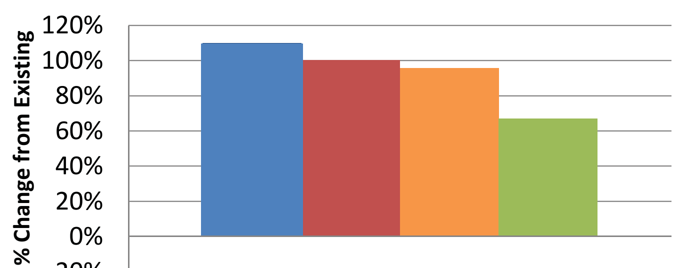
HYDROLOGY (1-YEAR, 24-HOUR STORM)

LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Total Stream Flow Volume (ac-ft)



	Model Scenarios
Scenario 2	28%
Scenario 3	23%
Scenario 4	22%
Scenario 5	13%

LSTM206, LSTM202, LSTM201, LSTM203, LSTM204, LSTM110, LSTM111, LSTM302, LSTM303B, & LSTM304
Peak Stream Flow (cfs)



	Model Scenarios
Scenario 2	110%
Scenario 3	100%
Scenario 4	96%
Scenario 5	67%