Calculating Load Reductions

Although each of the improvement measures identified in the plan will offer some benefit to the watershed, the actual benefit for each measure should be calculated, where possible, to determine the effectiveness of the measure. This information is useful to identify successful measures that should be duplicated elsewhere in the watershed, as well as unsuccessful measures that should be replaced with an alternate measure. This section will identify load reduction calculations for each of the identified measures using measures including the Indiana Department of Environmental Management (IDEM) Region V Load Reduction Model.

Stream Maintenance – The Steuben County Surveyor's Office currently maintains waterways in the county. The watershed management plan calls for continued maintenance; therefore, this item is not directly measurable for load reductions against current conditions.

Development Code Enforcement – Local development codes are currently in place and enforced by Steuben County and the City of Angola. The watershed management plan calls for continued enforcement; therefore, this item is not directly measurable for load reductions against current conditions.

Removal of Illicit Connections – The Steuben County Health Department currently inspects illicit connections to local waterways. The watershed management plan calls for continued inspection, as well as a "Voluntary Inspection Program" for houses adjacent to waterways. Through continued discovery and remediation of illicit connections, bacteria loading in the waterways should decrease and can be tracked by periodic *E. Coli* testing along Pigeon Creek.

Public Education – The watershed management plan calls for public outreach programs to inform the public how their actions affect water quality within the watershed. Program results will largely depend on public acceptance and participation in the program, which may vary throughout the watershed. Therefore, this item is not directly measurable for load reductions against current conditions.

Obtain IDNR Hydrologic and Hydraulic Models – Over the years, many projects have been proposed to improve flood control within the watershed. Although each project that provides additional storage will measure to an improvement, the exact effect of the project on flood control within the watershed is difficult to determine without a hydrologic planning model. The watershed management plan calls for obtaining IDNR's hydrologic and hydraulic models to aid in the local determination of the benefits of proposed improvements. This item alone is not directly measurable for load reductions against current conditions without connection to a resulting project.

Voluntary Buyout and Structure Elevation – Although many flood control projects are listed in the watershed management plan, some homes are overly-prone to flood damage and will still flood during extreme rainfall events. For these structures, a Voluntary

Buyout and Structure Elevation Plan is included in the watershed management plan to remove the structures from the floodplain. The effects of this plan can be measured by the number of plan volunteers and the reduction in flood damages reported.

Wetland / Habitat Restoration – The watershed management plan calls for the development and restoration of wetlands and other habitats throughout the watershed, which will offer runoff treatment, sediment removal, and some runoff retention. Each of these improvements can be measured through water quality testing, observations of sediment held in the wetland / reductions in sediment aggradation at downstream locations, and reductions in stream / flood flow, respectively.

Site BMP Restoration / Retrofitting – Similar to Wetland / Habitat Restoration, Stream and Site BMP Restoration / Retrofitting will offer runoff treatment and some runoff retention, as well as additional erosion control. Results can be measured through water quality testing, reductions in stream / flood flow, and reductions in stream/site erosion verified either visually or by field survey methods.

Flood Access Plan – Many local roads flood during heavy periods of rain throughout the county. The watershed management plan calls for development of a Flood Access Plan to ensure emergency vehicles can access all properties during floods. The Flood Access Plan will result in the potential for reduced emergency response times during periods of heavy rain.

Kankamp Property – The project located on the Kankamp Property provides for a stormwater detention facility on Wood Ditch between the Angola Wastewater Treatment Plant and Pigeon Creek. In addition to stormwater detention, the facility will also provide additional treatment for the tributary flow, as well as sediment removal. Effectiveness can be measured through downstream reductions in stream / flood flow, *E. Coli*, and turbidity, as well as the amount of observed sediment held in the facility / reductions in sediment load downstream of the facility.

Bill Deller Road – The Bill Deller Road project involves construction of a large stormwater detention facility for the runoff capture upstream of the lake chain. In addition to stormwater detention, the facility will also provide a level of treatment / pollutant removal for the runoff, as well as sediment removal. Results can be measured through downstream reductions in stream / flood flow, water quality testing, and observed sediment held in the facility / reductions in sediment load downstream of the facility.

Sediment Basins – The watershed management plan calls for the installation of sediment basins at several locations in the watershed. The effectiveness of a sediment basin can be observed visually by the volume of sediment collected by the basin and the slower accumulation of sediment at downstream deposits.

Rock Vortex Weirs and Cross Vanes – Rock vortex weirs and cross vanes direct flow toward the center of the channel and away from the stream banks reducing the potential

for bank erosion at the installation site. The effectiveness of these measures can be measured by the visual or measured progress of bank erosion at the installation site.

Filter Strips – Filter strips provide a vegetated buffer for pollutant and sediment removal between adjoining lands and waterways. The efficiency of filter strips can be measured through downstream water quality testing for pollutant loads and visual or measured sediment removal.

Monitoring CR 150W Culvert Replacement – This project is currently under development and is included in the watershed management plan to ensure existing flood storage volume is not lost. As no load reductions are expected from the monitoring activities alone, this item cannot be directly measured for load reductions.

Shoreline Stabilization – Shoreline stabilization consists of the reinforcement of shorelines to reduce erosion through either vegetative or engineered methods. The efficiency of shoreline stabilization can be calculated through visual or measured shoreline erosion (lake expansion) over time.

West Otter Lake Pump Station – The West Otter Lake Pump Station project is proposed by the Steuben County Surveyor's Office to increase discharge from West Otter Lake during heavy rainfall events. The effectiveness of this project can be measured by the decrease in flood elevations on the lake during periods of heavy rainfall.

Gravel Pits – The watershed management plan proposes to divert flow from Pigeon Creek through adjacent gravel pits for runoff treatment, sediment removal, and runoff detention (if possible). The effectiveness of these projects can be measured by water quality testing, downstream reductions in stream / flood flow, and observed sediment held in the facility / reductions in sediment load downstream of the facility.

Hammond Ditch Culvert Modifications – The watershed management plan proposes to modify select culverts in the watershed to increase flood storage upstream of the crossing. The effectiveness of these projects can be measured through downstream reductions in stream / flood flow. Also, upstream impacts due to the culvert restrictions would be considered a negative result.

Arrowhead Lake Outlet – The outlet to Arrowhead Lake has been identified as a possible project in the watershed management plan. Restricting the outlet to store additional runoff in the lake, without impacting upstream or adjacent homes, will lessen the burden on downstream waterways during heavy periods of rain. The effectiveness of this project can be measured through downstream reductions in stream / flood flow. Also, upstream impacts due to the outlet modification would be considered a negative result.

Calculating the load reductions to Pigeon Creek for implementation projects with estimates of anticipated load reductions is shown in Table 26. Table 27 summarizes load reduction calculations suitable for each improvement measure. Table 28 presents anticipated load reduction estimates for each improvement measure. Table 29 lists achievable monitoring objectives for measurable improvement measures.

Measure	Anticipated Load Reduction
Public Education	Reductions Dependent on Public Participation
Voluntary Buyout and Structure Elevation	Reductions Dependent on Public Participation
Wetland / Habitat Restoration	BOD Reduction = 2 lb/yr/acre tributary (67% Reduction)
	TSS Reduction = 119 lb/yr/acre tributary (80%)
	Bacteria Reduction = 78%
Site BMP Restoration / Retrofitting	TSS Reduction Dependent on Scope of Restoration Activity
Kankamp Property	BOD Reduction = 2 lb/yr/acre tributary (67%)
	TSS Reduction = 119 lb/yr/acre tributary (80%)
	Reduced Flooding on Wood Ditch
Bill Deller Road	Reduced Flooding at Lake Chain
	TSS Reduction = 92 lb/yr/acre tributary (60%)
Sediment Basins	BOD Reduction = 2 lb/yr/acre tributary (67%)
	TSS Reduction = 125 lb/yr/acre tributary (82%)
Rock Vortex Weirs and Cross Vanes[c]	Sediment Load Reduction = 15.8 tons/yr
	Phosphorus Load Reduction = 13.4 lb/yr
	Nitrogen Load Reduction = 26.8 lb/yr
Filter Strips	BOD Reduction = 2 lb/yr/acre tributary (67%)
	Sediment Load Reduction = 37 tons/yr
	Phosphorus Load Reduction = 48 lb/yr
	Nitrogen Load Reduction = 90 lb/yr
	TSS Reduction = 112 lb/yr/acre tributary (73%)
Shoreline Stabilization[e]	Sediment Load Reduction = 6.3 tons/yr/100 feet
	Phosphorus Load Reduction = 5.4 lb/yr/100 feet
	Nitrogen Load Reduction = 10.7 lb/yr/100 feet
West Otter Lake Pump Station	Reduced Flooding at West Otter Lake Outlet
Gravel Pits	TSS Reduction = 92 lb/yr/acre tributary (60%)
Hammond Ditch Culvert Modifications	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification
Arrowhead Lake Outlet	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification

Table 26: Estimates of Anticipated Load Reductions.

Measure	Target	Calculation Method
Stream Maintenance	Flow obstructions	N/A
Development Code Enforcement	Minimizing water quality and quantity impact from development	N/A
Removal of Illicit Connections	Untreated wastewater, bacteria removal	*E. Coli* testing along Pigeon Creek
Public Education	Minimizing human water quality impacts	N/A
Obtain IDNR Hydrologic and Hydraulic Models	Improving flood control planning	N/A
Voluntary Buyout and Structure Elevation	Reducing flood related damage	Compare flood damage reports Number of volunteers
Wetland / Habitat Restoration	Runoff treatment	Water quality measurements along Pigeon Creek for *E. Coli*, phosphate, nitrate loading
	Sediment removal	Observed sediment removal
	Runoff detention	Compare downstream flows and flood elevations
Site BMP Restoration / Retrofitting	Runoff treatment	Water quality measurements along Pigeon Creek for *E. Coli*, phosphate, nitrate loading
	Runoff detention	Compare downstream flows and flood elevations
	Erosion control	Observed erosion reduction
Flood Access Plan	Access during flood events	Compare emergency responsive times during periods of heavy rainfall
Kankamp Property	Bacteria removal	*E. Coli* testing along Pigeon Creek
	Runoff detention	Compare downstream flows and flood elevations
	Sediment removal	Observed sediment removal
Bill Deller Road	Bacteria removal	*E. Coli* testing along Pigeon Creek
	Runoff detention	Compare downstream flows and flood elevations
	Sediment removal	Observed sediment removal
Sediment Basins	Sediment removal	Observed sediment removal
Rock Vortex Weirs	Streambank erosion control	Observed erosion reduction
Rock Cross Vanes	Streambank erosion control	Observed erosion reduction
Filter Strips	Pollutant removal (filter)	Downstream water quality testing for *E. Coli* and nitrate
	Sediment removal	Observed sediment removal
Monitoring CR 150W Culvert Replacement	Prevent loss of existing flood storage	N/A
Shoreline Stabilization	Shoreline erosion control	Observed erosion reduction
West Otter Lake Pump Station	Reducing flood related damage	Compare flood damage reports on West Otter Lake
Gravel Pits	Runoff treatment	Water quality measurements along Pigeon Creek for *E. Coli*, phosphate, nitrate loading
	Sediment removal	Observed sediment removal
Hammond Ditch Culvert Modifications	Reducing flood related damage	Compare downstream flows and flood elevations Compare upstream flood elevations
Arrowhead Lake Outlet	Reducing flood related damage	Compare downstream flows and flood elevations Compare upstream flood elevations

Table 27: Summary of Load Reduction Calculations.

Measure	Anticipated Load Reduction	Source
Stream Maintenance	Current Practice - No Direct Additional Reduction	N/A
Development Code Enforcement	Current Practice - No Direct Additional Reduction	N/A
Removal of Illicit Connections	Current Practice - No Direct Additional Reduction	N/A
Public Education	Reductions Dependent on Public Participation	N/A
Obtain IDNR Hydrologic and Hydraulic Models	No Direct Reduction	N/A
Voluntary Buyout and Structure Elevation	Reductions Dependent on Public Participation	N/A
Wetland / Habitat Restoration[a]	BOD Reduction = 2 lb/yr/acre tributary (67% Reduction)	IDEM Region 5 Load Reduction Workbook
	TSS Reduction = 119 lb/yr/acre tributary (80%)	
	Bacteria Reduction = 78%	EPA 1999 Study
Site BMP Restoration / Retrofitting	TSS Reduction Dependent on Scope of Restoration Activity	N/A
Flood Access Plan	No Direct Reduction – Stream Crossing Improvements Resulting From Plan Will Reduce Road Flooding	N/A
Kankamp Property[a]	BOD Reduction = 2 lb/yr/acre tributary (67%)	IDEM Region 5 Load Reduction Workbook
	TSS Reduction = 119 lb/yr/acre tributary (80%)	
	Reduced Flooding on Wood Ditch	Tri-State Study
Bill Deller Road[f]	Detain Up to 10,700 Acre-Feet Flood Volume	NRCS 1967 Study
	Reduced Flooding at Lake Chain	NRCS 1967 Study
	TSS Reduction = 92 lb/yr/acre tributary (60%)	IDEM Region 5 Load Reduction Workbook
Sediment Basins[b]	BOD Reduction = 2 lb/yr/acre tributary (67%)	IDEM Region 5 Load Reduction Workbook
	TSS Reduction = 125 lb/yr/acre tributary (82%)	
Rock Vortex Weirs and Cross Vanes[c]	Sediment Load Reduction = 15.8 tons/yr	IDEM Region 5 Load Reduction Workbook
	Phosphorus Load Reduction = 13.4 lb/yr	
	Nitrogen Load Reduction = 26.8 lb/yr	
Filter Strips[d]	BOD Reduction = 2 lb/yr/acre tributary (67%)	IDEM Region 5 Load Reduction Workbook
	Sediment Load Reduction = 37 tons/yr	
	Phosphorus Load Reduction = 48 lb/yr	
	Nitrogen Load Reduction = 90 lb/yr	
	TSS Reduction = 112 lb/yr/acre tributary (73%)	
Monitoring CR 150W Culvert Replacement	No Direct Reduction	N/A
Shoreline Stabilization[e]	Sediment Load Reduction = 6.3 tons/yr/100 feet	IDEM Region 5 Load Reduction Workbook
	Phosphorus Load Reduction = 5.4 lb/yr/100 feet	
	Nitrogen Load Reduction = 10.7 lb/yr/100 feet	
West Otter Lake Pump Station	Reduced Flooding at West Otter Lake Outlet	Steuben County Surveyor's Office
Gravel Pits[f]	TSS Reduction = 92 lb/yr/acre tributary (60%)	IDEM Region 5 Load Reduction Workbook
Hammond Ditch Culvert Modifications	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification	N/A
Arrowhead Lake Outlet	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification	N/A

Table 28: Summary of Anticipated Load Reductions by Measure.

Load Reduction Assumptions:

a – Wetland Detention with Agricultural Non-Sewered Runoff. Permanent pool volume should be at least the volume of the 2-year tributary runoff, preferably three times the volume of the 2-year tributary runoff.
b – Settling Basin with Agricultural Non-Sewered Runoff.
c – Grade Stabilization Structure (Top Width = 20', Bottom Width = 10', Length = 25', Time = 5 Years), 4ft Deep with Agricultural Non-Sewered Runoff.
d – Filter Strips with Agricultural Non-Sewered Runoff. Treats sheet flow at low velocity. Not for use with point discharge. Assumes 10 acre tributary area.
e – Bank Stabilization (100' long, 6' high) with Sandy Soils and Moderate Erosion Rate.
f – Wet Pond with Agricultural Non-Sewered Runoff. Permanent pool volume should be at least the volume of the 2-year tributary runoff, preferably three times the volume of the 2-year tributary runoff.

The BMPs that are intended to be implemented within the Pigeon Creek watershed, including improvements to stream corridors, streambanks, wetlands, lakes, shorelines, sediment basins, rock vortex weirs, filter strips, and additional storage combine to provide purification of surface water flowing in and through the system. Contributions through removing pollutants and excess nutrients by means of physical filtration and biological uptake of plant material, or the physical reduction of velocity and volumes within the flowing waters all combine to provide quantifiable reductions in total suspended solids, biological oxygen demand, bacteria, sediment loads, nitrogen, phosphorus, and flooding that can be measured.

Measure	Anticipated Load Reduction	Achievable Monitoring Objective
Public Education	Reductions Dependent on Public Participation	One informative public meeting per year.
Voluntary Buyout and Structure Elevation	Reductions Dependent on Public Participation	Average of one volunteer every five years.
Wetland / Habitat Restoration	BOD Reduction = 2 lb/yr/acre tributary (67% Reduction)	Demonstrate a 67% reduction in BOD from baseline data to post-implementation data
	TSS Reduction = 119 lb/yr/acre tributary (80%)	Demonstrate an 80% reduction in TSS from baseline data to post-implementation data
	Bacteria Reduction = 78%	Demonstrate a 78% reduction in cfu's of bacteria from baseline data to post-implementation data
Site BMP Restoration / Retrofitting	TSS Reduction Dependent on Scope of Restoration Activity	Demonstrate a 25% reduction in TSS from baseline data to post-implementation data
Kankamp Property	BOD Reduction = 2 lb/yr/acre tributary (67%)	Demonstrate a 67% reduction in BOD from baseline data to post-implementation data
	TSS Reduction = 119 lb/yr/acre tributary (80%)	Demonstrate an 80% reduction in TSS from baseline data to post-implementation data
	Reduced Flooding on Wood Ditch	Demonstrate that floods are less frequent or less severe post-implementation
Bill Deller Road	Reduced Flooding at Lake Chain	Demonstrate that floods are less frequent or less severe post-implementation
	TSS Reduction = 92 lb/yr/acre tributary (60%)	Demonstrate a 60% reduction in TSS from baseline data to post-implementation data
Sediment Basins	BOD Reduction = 2 lb/yr/acre tributary (67%)	Demonstrate a 67% reduction in BOD from baseline data to post-implementation data
	TSS Reduction = 125 lb/yr/acre tributary (82%)	Demonstrate an 82% reduction in TSS from baseline data to post-implementation data
Rock Vortex Weirs and Cross Vanes[c]	Sediment Load Reduction = 15.8 tons/yr	Demonstrate an 25% reduction in TSS, Total P, NO2+NO3 from baseline data to post-implementation data
	Phosphorus Load Reduction = 13.4 lb/yr	
	Nitrogen Load Reduction = 26.8 lb/yr	
Filter Strips	BOD Reduction = 2 lb/yr/acre tributary (67%)	Demonstrate an 67% reduction in BOD, Total P, NO2+NO3, TSS from baseline data to post-implementation data
	Sediment Load Reduction = 37 tons/yr	
	Phosphorus Load Reduction = 48 lb/yr	
	Nitrogen Load Reduction = 90 lb/yr	
	TSS Reduction = 112 lb/yr/acre tributary (73%)	
Shoreline Stabilization[e]	Sediment Load Reduction = 6.3 tons/yr/100 feet	Demonstrate an 25% reduction in TSS, Total P, NO2+NO3 from baseline data to post-implementation data
	Phosphorus Load Reduction = 5.4 lb/yr/100 feet	
	Nitrogen Load Reduction = 10.7 lb/yr/100 feet	
West Otter Lake Pump Station	Reduced Flooding at West Otter Lake Outlet	Demonstrate that floods are less frequent or less severe post-implementation
Gravel Pits	TSS Reduction = 92 lb/yr/acre tributary (60%)	Demonstrate a 60% reduction in TSS from baseline data to post-implementation data
Hammond Ditch Culvert Modifications	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification	Demonstrate that floods are less frequent or less severe post-implementation
Arrowhead Lake Outlet	Reduced Flooding at West Otter Lake – Reduction Dependent on Modification	Demonstrate that floods are less frequent or less severe post-implementation

Table 29: Projected Load Reduction Measures of Success.