Private property, public utilities and roads have been damaged due to floodwaters. The average annual flood damage to approximately 400 buildings (including 295 homes and 40 commercial-public buildings) throughout the watershed is estimated at $770,000. This is anticipated to remain unchanged in the future with the limited land development forecasted and the expectation that proper stormwater management activities will be pursued to minimize and control any increase in storm runoff.

The flooding frequency has been aggravated by the partial reduction to complete elimination of channel capacity in some locations due to the deposition of water deposited stream "gravel" and by large (greater than 14 inch diameter) trees washed from the streambank.

A review of the existing conditions flood elevations based on the predictive hydrology and hydraulics analysis shows that flood damage (basement and/or first floor) for homes and commercial-public buildings occurs for the following flood frequencies:

Flood Frequency (years)	No. of Flood Damaged Homes and Commercial-Public Buildings	Maximum Flood Depth (feet) Homes / Commercial-Public
10-year	150	5.0 / 3.1
25-year	200	6.0 / 6.1
100-year	335	7.0 / 6.6

A review of the existing conditions flood elevations shows that first floor damage occurs for the following flood frequencies:

Flood Frequency (years)	1st Floor Damage
10-year	40 Homes / 25 Commercial-Public
25-year	70 Homes / 30 Commercial-Public
100-year	150 Homes / 35 Commercial-Public

Tributary flood damages were also evaluated, especially for Justice Run, Buck Creek and Trout/Fall Creeks. Flood damage in the tributaries was determined to be insufficient to warrant further evaluation.

Streambank Erosion

The erosion of the streambanks and scouring of the flood plain adjacent to Bentley Creek and in some key tributaries is identified as a major concern to residents and the local and state government. Streambank erosion is resulting in the loss of large areas of property, such as lawns and agricultural land, and has the potential to threaten homes and businesses located near the stream channel. The severe erosion also degrades riparian and aquatic habitat.

In the 1965 Preliminary Investigation Report, streambank erosion was recognized as existing, but being relatively minor. To quote from that report, "A small amount of land on the flood plain is lost each year due to channel erosion". This relatively minor level of bank erosion is confirmed by 1959 and 1960 aerial photography. Although there is evidence in the 1959/1960 aerial photography of manmade manipulation of the steam channel and banks in a few locations and along Bentley Creek, the streambank appears stable with woody riparian vegetation adjacent to the streambank.

The flood of 1972, Hurricane Agnes, is identified as the destabilizing event for the streambanks. This information was obtained from discussions with residents and local, state and federal government officials familiar with the watershed. In flood evaluation documents gathered by the Soil Conservation Service in August 1972, reference is made to flood damaged buildings and infrastructure and "tremendous deposition-bedload movement".

As a result of the 1972 flood, extensive flood recovery efforts were undertaken by all levels of government (local, state, and federal) as well as by private individuals. These efforts were primarily focused at removing floatable debris deposited in channels and to removing the "gravel" eroded from the streambanks and deposited in various sections of the stream channel. The efforts were performed by bulldozers and loaders pushing the gravel out of and onto the top of streambanks. There were no attempts to perform this work in

accordance with accepted engineering techniques. The effort resulted in unstable streambanks, extensive sections of the stream channel in poor hydrologic condition and a stream vulnerable to accelerated erosion.

Since 1972, but not including the Hurricane Agnes storm restoration work, in excess of $1 million has been spent in the Bentley Creek watershed for stabilizing accelerated eroding streambanks. In spite of these efforts, 78 percent of the main stem of Bentley Creek has unstable streambanks based on a 1997 reconnaissance survey. The local Sponsors and others are continuing efforts to address this problem along Bentley Creek. In addition, a tributary reconnaissance study has identified an immediate need to stabilize critically eroding streambanks in four tributaries that are aggravating main stem bank instability.

Sediment Damages

Accelerated streambank erosion is causing heavy loading of sediments and "gravel" into surface water (see Photo 4). Some of this sediment impacts downstream areas, including the Chesapeake Bay. These sediments are also transporting nutrients which are identified as a major cause of degradation of the Chesapeake Bay aquatic environment. Sediments are damaging or destroying aquatic habitat, reducing bridge and channel capacity, aggravating flooding in Bentley Creek, and are contributing to sediment removal costs locally and downstream. The Pennsylvania Fish and Boat Commission (PFBC, 2000) observed that the fisheries of the watershed is among the poorest they ever surveyed. One of the major contributors to impaired quality is poor instream habitat, largely the result of excessive and shifting sediments.

Photo 4. – Gravel Deposits, Bentley Creek

A case study of the impact of sediment downstream of the watershed can be seen in the content of a paper presented to the 1995 Spring Meeting of the American Geophysical Union, Geochemical Society, and Mineralogical Society of America by Lloyd A. Reed of the U.S. Geological Survey. Mr. Reed observed that sediments from the soils typical of the Bentley Creek Watershed remain in suspension at much longer time periods than anticipated. In fact, as much as 25% of the sediment from the watershed may remain in suspension until captured by one of the downstream dams on the Susquehanna River or by the Chesapeake Bay. Much of the nutrient load coming out of Bentley Creek is associated with these fine sediments and contributes to eutrophication of the Bay. The cost of removal of this sediment from behind the dams on the Susquehanna River is conservatively estimated at 12 dollars per ton. Consequently, the cost of removing sediment downstream of the watershed confluence with the Chemung River and impacts to the Bay are likely to be high, but were not quantified as part of this plan.

Quantifying sediment yields and transport in flashy, gravel-cobble streams such as Bentley Creek is extremely difficult (Schmidt, L.J. and Potyondy, J. P., 2004) because they are influenced by numerous factors, e.g. localized variations in tractive power, sporadic sediment input from side channels and local bank erosion, turbulent velocity fluctuations and other sediment imbalances over short spatial and temporal scales. Subsequently, estimates of costs to maintain or rehabilitate such streams can, at best, be rather subjective. However, in this watershed, there was some recorded history of cleanout events from which to document existing conditions, as well as base planning for future alternatives.

Although most of the land in the watershed is currently wooded or grassed, heavy timbering and cropping in the early part of the last century initiated severe gullying in several of the major tributaries. The glaciated character of these upland tributaries has subsequently been contributing large amounts of gravel and cobbles to Bentley Creek in sporadic doses as the gully banks erode; i.e., when the nearly vertical banks are undercut sufficiently, the entire bank falls (see Photo 5). These episodic slugs of coarse sediment cause short-term deposits as the excessive bedloads "pause" until the next threshold event moves them. However, smaller runoff events cause localized overbank flooding where these deposits exist and reduce the channel capacity. Several "natural stream design" structures that the U.S. Fish and Wildlife Service installed on Bentley Creek in the recent decade have either washed out or been buried due, in part, to the excessive bedload. Bedload that does eventually move through the entire length of Bentley Creek is subsequently deposited at its confluence with the much larger Chemung River. Unfortunately, this aggrading reach is within the Village of Wellsburg. The sediment load raises flood levels in Wellsburg, requiring periodic cleanout. Cleanout of this aggrading reach over recent decades averages about $20,000 per year. Of course, these cleanouts occur primarily after major events which simultaneously aggrade the reach and produce overbank discharges.

Photo 5. – Tributary Erosion, Bentley Creek Watershed

Since the land uses in the watershed already provide a fairly good cover, it is not expected that runoff can be reduced in the future. Therefore, the unstable banks of tributaries will continue to produce more sediment than Bentley Creek can move through to the Chemung. Although the majority of the sediment comes from the eroding banks of the tributaries, as they incise further upstream, this load can be expected to increase, from both degrading beds and additionally exposed banks.

The Bradford County Conservation District has performed an extensive assessment of the stability of all 2nd, 3rd, and 4th order tributaries in the watershed, and found that 13.6% of those streambanks were eroding. The conservation district, at a cost of over $350,000, has implemented projects to stabilize about 3,800 feet of eroded streambanks in 3 of the 4 tributaries identified as the largest contributors of bedload material. Based on monitored stream sites, this was estimated to have prevented 200-300 tons of sediment from entering the system in the first two years after their installation. Approximately 21,800 feet of eroding streambanks are estimated to remain, with plans in place to address an additional 3,000 feet.

Based on the tributary assessment, the Conservation District found that the majority of the bedload material is coming from Cowell Hill Creek, Justice Run, Terwiliger Creek, and Wesleyan Church Creek. Stabilization of these four tributaries could reduce the total watershed sediment yield (i.e., from tributaries) by 80%.

Watershed Opportunities

The following is a general list of opportunities that can be realized with project action to address the identified problems related to flooding, unstable streambanks and sedimentation.

- Substantially reduce flood and sediment damages
- Substantially reduce threats to life and property from flooding and sedimentation
- Reduce sediment loads
- Stabilize land along streams
- Improve aquatic and riparian habitat

Quantification of these opportunities is provided later in the report under **Effects of Alternatives**.

SCOPE OF ENVIRONMENTAL ASSESSMENT

A scoping process was used to identify issues of economic, environmental, cultural, and social concerns in the watershed. Watershed concerns of Sponsors, agencies, organizations and local citizens were expressed at planning and public meetings. Factors that would affect soil, water, air, plant, and animal resources were identified by multidisciplinary teams composed of engineers, biologists, economists, resource conservationists, water quality specialists, and others. The following table shows the concerns, degree of concern and degree of importance to decision making.

Table A. Identified Concerns

Economic, Environmental, Cultural and Social Concerns	Degree of Concern	Importance to Decision Making	Comment
Public Safety	High	High	Primary concern of Sponsors
Floodwater Damages	High	High	Primary concern of Sponsors
Streambank Erosion	High	High	Primary concern of Sponsors
Sedimentation	High	High	Primary concern of Sponsors
Flood Plain Urbanization/Use	Medium	Medium	Minor new development expected
Land Use Changes	Medium	Medium	Minor change expected
Important Farmland	Medium	Low	Little new agriculture expected
Soil Resources	Medium	Medium	Large land losses during flood events
Riparian Areas	Medium	Medium	Unstable land along many streams
Forest Resources	Low	Low	Minimal effect for all alternatives
Aquatic Life Resources	High	Medium	Unstable streams provide little habitat
Wildlife Resources	Low	Low	Minimal effect for all alternatives
Threatened/Endangered Species	High	Low	None identified in project areas
Wetlands	Medium	Low	Minimal effect for all alternatives
Water Quality	Medium	Low	Minimal effect for all alternatives
Cultural Resources	High	Medium	Historic building to be removed & mitigated
Visual/Aesthetic Resources	Medium	Medium	Could be affected by some alternatives
Social Issues	Medium	Medium	Compare differences between alternatives
Civil Rights/Environmental Justice	Medium	Medium	No differences between alternatives
Public Utilities/Services	High	Medium	Loss of services during floods

FORMULATION AND COMPARISON OF ALTERNATIVES

Formulation Process

The Bentley Creek Watershed project is formulated to address the identified watershed problems and opportunities with full consideration of the effects of various alternative solutions on other watershed resource concerns. Formulation was developed around the following guidelines

- Address the identified watershed problems and meet the Sponsors objectives to the maximum extent practicable
- Develop cost effective solutions
- Maximize positive effects and minimize negative effects for all Identified Concerns which have a high or medium Importance to Decision Making (see SCOPE OF ENVIRONMENTAL ASSESSMENT).

The action alternatives must for the most part be formulated in consideration of the following four general criteria as outlined in Economic and Environmental Principles and Guidelines for Water and Related Land Resource Problems (P&G) (U.S. Water Resources Council, 1983):

- Completeness – alternatives should address the purpose and need and the Sponsors' objectives for meeting the purpose and need.
- Effectiveness – alternatives should reasonably alleviate identified watershed problems and help to achieve watershed opportunities.
- Efficiency – alternatives should be cost-effective and if possible provide positive net economic benefits while protecting the environment.
- Acceptability – alternatives should not have insurmountable adverse effects on the human environment that cannot be reasonably mitigated and should also have the *potential* to: a) be supported by the public; b) receive needed financial assistance or otherwise be able to be affordable to the Sponsors; c) comply with and receive all needed permits required by local, state and federal agencies.

In addition, formulation of alternative plans followed procedures outlined in the NRCS-National Watershed Manual; NRCS-National Planning Procedures Handbook, and other NRCS watershed planning policy.

The process involved considerable input from meetings of the public, agencies, organizations, project Sponsors and interdisciplinary team. Many ideas were put forth to address the watershed problems. The following ideas were evaluated individually and in various combinations:

> Flood warning system, tributary stabilization, dikes, stream rehabilitation, bridge/culvert modification, flood bypass channel, flood control dams, flood plain property acquisition, individual property acquisition, building elevation, building floodproofing, protection of floodprone building utilities, and comparing flood damage reduction for all buildings (including sheds, barns and outbuildings) versus focusing primarily on homes, businesses and public buildings.

Alternatives Eliminated from Detailed Study

Dikes - 5 locations

Dikes were evaluated in 7 locations where there are concentrations of flood prone buildings. Five of the dike locations were not developed in detail. Costs were 2 to 3 times the benefits for four of the dikes. One dike was thoroughly evaluated from a cost and layout standpoint because of high benefits relative to costs. However, the primary beneficiary, a local business, determined that it was unacceptable to the operation of the business and was very adamant that it no longer be considered. The local Sponsors determined that this dike should be eliminated from further study. No other cost effective alternative was identified for non-residential buildings in that area of the flood plain. The dike locations not developed in detail are the New York mobile home park, residential area 1,200-3,300 feet south of the State line, commercial area about

one mile south of the State line and adjacent mobile home park, residential area just south of Centerville, and an area in the village of Bentley Creek.

Stream rehabilitation in most locations

Stream rehabilitation was evaluated for all flood prone areas as a means to increase stream stability, restore aquatic habitat and increase flood plain capacity. The effectiveness of this technique for flood damage remediation in most of Bentley Creek is highly variable, very costly, high in maintenance costs and very unpredictable. However, it was determined that this alternative may be more predictable and cost-effective in Wellsburg due to the following factors: 1) it is feasible to control some major upstream sediment sources; 2) the downstream bridges and Chemung River backwater result in localized sediment deposition which creates an ongoing cost for gravel/sediment removal; 3) rehabilitation has the potential to provide large benefits for reducing flood and sediment damages. Due to the extreme instability of Bentley Creek and ongoing attempts to stabilize the creek, it was determined that stream rehabilitation for the purpose of flood damage reduction, including aquatic habitat restoration, is not a reasonable alternative, except in the area of Wellsburg.

Bridge/culvert modification and a flood bypass channel

Bridge/culvert modification and a flood bypass channel were evaluated in Wellsburg. These measures would provide only localized benefits, would have high costs relative to benefits, and would need to be combined with other alternatives to be effective. The cost to modify the state highway bridge to provide for improved flood flow characteristics would be in excess of the flood damage reduction benefits provided. Only the northern portion of Wellsburg would benefit requiring additional measures to address the Sponsor's objectives for the southern portion of the community and the rest of the watershed. Alone or in combination with other measures, it was determined that this alternative is not cost effective.

Flood control dams

Five potential dam locations were evaluated. The sites were located on Bentley Creek (above Middletown), Fall Creek, Miller Run, Buck Creek, and Terwiliger Run. The sites are well upstream of the damage areas and/or control too little of the watershed to be effective relative to implementation costs. The dams were evaluated individually and in various combinations. If all five were implemented, they would control about 38 percent of the watershed and reduce flood damages to buildings by about 30 percent. Estimated costs to implement the dams vary from $1.5 to $4.5 million each and were determined to provide inadequate benefits relative to costs.

Flood plain acquisition

Complete flood plain acquisition, would involve purchasing and removing all structures in the 100-year flood plain. It would not be cost effective along Bentley Creek and would result in the near elimination of the major communities located in the watershed, including about 2/3 of the Village of Wellsburg. Implementation costs alone for this alternative are in excess of $20 million, which is more than the total potential flood damage reduction benefits. Socioeconomic impacts to the communities would be dramatic and unacceptable. Total acquisition was also evaluated in two areas where dikes were cost-effective. Acquisition in the dike areas was not cost effective relative to flood damage reduction benefits. Total acquisition was evaluated for two mobile home parks. Acquiring the mobile home parks and relocating all residents into safe and sanitary housing was not cost effective relative to benefits and would cost 2 to 3 times the cost of elevating the mobile homes.

Building elevation

Building elevation is extremely costly due to the complications of dealing with old foundations, relocating utilities and utility connections, constructing new access into the elevated structure, temporary housing for the occupants, building the elevated support structure and restoring the building for occupancy. It can be cost effective is areas with high real estate values since the cost to elevate may be more cost effective than acquisition. However, based on the real estate values in the project area, the cost to elevate buildings exceeds the flood damage reduction benefits achieved. It would cost considerably less to acquire the same property and restore the sites to flood plain use.

Dry "floodproofing" buildings with basements

Dry "floodproofing" of buildings with basements cannot be effectively achieved, especially in areas such as Bentley Creek where soils are permeable. Some of the problems that make these measures impractical for

most buildings with basements include, the need for pumps maintained and operated by the homeowner to prevent excessive hydrostatic pressure on basement walls and the need for auxiliary power if electricity fails during a flood, difficulties in handling water inside the floodproofing walls/seals, difficulties sealing off garage walls, uncertainties of using homeowner installed stop logs and similar devices and the inability to assure the features will function properly during flood events. This approach was determined to be ineffective and cost prohibitive unless the building was on a slab or over a crawl space where water entry would not be damage the structure.

Nonstructural measures for non-residential buildings
Non-residential buildings were evaluated for potential nonstructural flood damage reduction treatments. The most cost-effective treatment for each building was determined. Treatments included individual flood walls or dikes, dry "floodproofing", acquisition and protection of basement utilities. Although some individual buildings may be able to be treated cost effectively, no cost-effective nonstructural treatment plan could be developed for non-residential buildings evaluated as a group.

Nonstructural measures in Wellsburg
Combinations of nonstructural measures were evaluated in two areas where dikes were found to be cost-effective. In Wellsburg, the nonstructural measures would cost two times as much as the dike to implement and would provide fewer benefits. Benefits would be less because of continued flooding of buildings that are impractical to treat and continued flooding of roads and utilities.

Combination of measures for Wellsburg
Various combinations of potentially cost effective measures were evaluated in Wellsburg, including dike plus stream rehabilitation and stream rehabilitation plus nonstructural measures. The dike plus stream rehabilitation cost 1.5 times the cost of either alone and provides about the same level of benefits as the dike. There were no other substantial benefits associated with the combination. The stream rehabilitation plus nonstructural measures cost almost 3 times the dike and provide fewer benefits. Therefore these combinations were eliminated from more detailed study.

Summary of Alternatives Not Evaluated in Detail
The following alternatives were not developed in detail since they were too costly relative to the benefits provided, or other alternatives were much more cost–effective or the effectiveness was limited to a small area or in one case the alternative was completely unacceptable locally:

- Dikes -5 locations
- Stream rehabilitation other than in Wellsburg
- Bridge/culvert modification and flood bypass channel in Wellsburg
- Five flood control dams and combinations of these dams
- Complete flood plain property acquisition, including acquisition in two areas where a dike is cost effective and acquisition of two mobile home parks.
- Building elevation
- Dry "floodproofing" of buildings with basements
- Nonstructural measures for non-residential buildings
- Nonstructural measures in Wellsburg
- Combinations of measures for Wellsburg

Description of Alternatives

No Action
This alternative represents the future condition of the watershed without some type of project action to address the identified natural resource problems. Future conditions are expected to remain much as they exist presently. Development is not expected to increase substantially and any development that does occur will be required to implement improved stormwater management measures and conform to local flood plain ordinances. There are local efforts underway in both states to establish better stormwater management of future developments. As a result, the vulnerability to flood damages is not expected to change significantly. Streambank erosion should continue to decline somewhat due to ongoing stream rehabilitation efforts, but large sediment sources emanating from tributaries is unlikely to be adequately addressed with projected funding availability.

Dikes plus Nonstructural (National Economic Development alternative)
This alternative includes the following components:

- Watershed-wide flood warning system, including rain and stream gages, repeater station and reverse 911 type system
- Tributary stabilization of about 19,000 feet in Cowell Hill tributary, Terwiliger Creek, Justice Run and Wesleyan Church tributary
- Wellsburg dike (PA-681), about 4200 feet long with 2 road closure structures, stormwater basin, stream reconstruction and hillside diversion, 5-6 house acquisitions
- Centerville dike (PA-680), about 2400 feet long with 1 road closure structure, stormwater basin and hillside diversion
- Outside of dikes, voluntary nonstructural measures, including acquisition of homes (with basements) that receive first floor flooding, dry "floodproofing" of homes (without basements) that receive first floor flooding, basement utility protection for homes with basement-only flooding, elevation for mobile homes.

ESTIMATED TOTAL COSTS: $5,600,000 (PL 83-566 - $5,420,000; Other - $180,000)

Average Annual Equivalent: $280,000 (including $45,000 for Operation and Maintenance)

Stream Rehabilitation plus Nonstructural
This alternative is the same as Alternative 1, except for the following differences:

- Substitute 4500 feet of stream rehabilitation for the Wellsburg dike and dike components.
- Substitute voluntary residential nonstructural measures for the Centerville area dike

ESTIMATED TOTAL COSTS: $5,270,000 (Federal - $5,210,000; Local - $60,000)

Average Annual Equivalent: $255,000 (including $32,000 for Operation and Maintenance)

Effects of Alternatives

This section describes anticipated effects on resource concerns identified by the project Sponsors and by the public during public meetings. Effects of alternative plans of action on resource concerns of national importance and other important considerations are also included. Since the No Action Alternative represents projected future conditions in the watershed and no noteworthy changes are anticipated relative to existing conditions, it can be inferred that No Action results in conditions equivalent to the existing watershed conditions, unless noted otherwise. When analyzing effects, temporary, direct, indirect and cumulative effects are all considered and presented.

Public Safety / Hazard Potential

No Action [Future without Project] – Flooding will be an ongoing threat to public safety since most of the watershed population lives in or adjacent to the flood plain. Flood depths and velocities will continue to impact hundreds of residents and dozens of commercial-public buildings, dislodge mobile homes, damage roads, utilities and bridges and generally threaten life and property. An estimated 400 buildings, including 335 residential, commercial and public buildings, will be at risk from the 100-year flood event.

Dikes plus Nonstructural – Flood damages and risk to life and property will be substantially reduced. Residences and commercial-public buildings located behind two dikes will be afforded protection against flood damage from Bentley Creek flows through the 100-yr frequency storm (or 1% chance event), with added freeboard protection. In addition, the Wellsburg dike in combination with the railroad embankment will prohibit Chemung River flows from entering Wellsburg up to the 100-yr flood with no freeboard. Those residences being treated by nonstructural means that remain in the flood plain will show minimal effect from the 100-year flood. All occupants of the flood plain will be alerted in advance, through use of a flood warning system, and be advised to evacuate thereby reducing the threat of loss of life. Nearly 200 residential, commercial and public buildings

along with additional structures will be substantially protected from the 100-year flood. About 135 residences and commercial-public buildings and their occupants will remain at the current level of flood risk. The dike at Wellsburg is planned to terminate at the railroad embankment near the Chemung River. The dike will contain the Bentley Creek 100-year flood plus freeboard to this point. Flood stages of the Chemung River are considered to control flow elevations downstream of this point. The railroad embankment height was found to be slightly above the 100-year Chemung River flood stage in the Wellsburg vicinity but with no freeboard being allocated. Therefore the Bentley Creek dike at Wellsburg is planned to protect the village from 100-year Bentley Creek flows plus design freeboard whereas the railroad embankment does not provide Wellsburg with design freeboard protection above the Chemung River 100-year flows.

Stream Rehabilitation plus Nonstructural – Flood damages and risk to life and property will be substantially reduced. However, without a dike in Wellsburg this area will be more susceptible to 100-year flooding than the "Dikes plus Nonstructural" alternative. The benefit of stream rehabilitation will be primarily in Wellsburg. Flood frequency and stage upstream will continue as it currently exists. Those residences being treated by nonstructural means that stay within the flood plain will show minimal effect from the 100-year flood. All occupants of the flood plain will be alerted in advance, through use of a flood warning system, and be advised to evacuate thereby reducing the threat of loss of life. About 115 residential, commercial and public buildings and additional structures will be substantially protected from the 100-year flood and another 60 buildings in Wellsburg will show reduced flood risk. About 160 residences and commercial-public buildings and their occupants will remain at the current level of flood risk.

Floodwater Damages

No Action [Future without Project] – Flood damages will continue with little change. Damage to buildings, costs of emergency response, lost business and wages, clean-up costs and costs to repair roads, bridges and utilities will continue. The estimated average annual damage to buildings alone will be $770,000.

Dikes plus Nonstructural – Flood damages will be substantially reduced. All categories of flood damage will be nearly eliminated behind the two dikes. Participating residential buildings outside of the diked areas will have little or no flood damages. Emergency response costs will be reduced. Total estimated average annual flood damages to buildings will be reduced to about $210,000.

Stream Rehabilitation plus Nonstructural – Flood damages will be substantially reduced. All categories of flood damage will be substantially reduced in Wellsburg, but not eliminated. Participating residential buildings elsewhere will have little or no flood damages. Emergency response costs will be reduced. Total estimated average annual flood damages to buildings will be reduced to about $285,000.

Streambank Erosion

No Action [Future without Project] – Streambank erosion will continue to be severe. Slight reductions will likely be achieved through ongoing efforts to stabilize the highest priority tributaries. Over 75 percent of the main stem of Bentley Creek will continue to have unstable streambanks. About 3,000 feet of tributary streambanks will be stabilized.

Dikes plus Nonstructural – Streambank erosion will be reduced moderately along Bentley Creek and substantially in the critically eroding high priority tributaries. Less than 75 percent of the main stem of Bentley Creek will continue to have unstable streambanks. An additional 19,000 feet of tributary streambanks will be stabilized.

Stream Rehabilitation plus Nonstructural – Streambank erosion will be reduced moderately along Bentley Creek and substantially in the critically eroding high priority tributaries and in the 4500 foot stream rehabilitation in Wellsburg. Less than 75 percent of the main stem of Bentley Creek will

continue to have unstable streambanks. An additional 19,000 feet of tributary streambanks will be stabilized.

Sedimentation

No Action [Future without Project] – Sediments will continue to damage or destroy aquatic habitat, reduce bridge and channel capacity, aggravate flooding in Bentley Creek, and contribute to sediment removal costs locally and downstream. The sediments will transport nutrients which are identified as a major cause of degradation of the Chesapeake Bay aquatic environment. Bedload that does eventually move through the entire length of Bentley Creek will be deposited at its confluence with the Chemung River within the Village of Wellsburg. Cleanout of this aggrading stream reach will average $20,000 per year.

Dikes plus Nonstructural – Sediments will be reduced an estimated 50 percent in the main stem of Bentley Creek and 80 percent in the critically eroding tributaries, resulting in moderate improvement in aquatic habitat, improved bridge and channel capacity, somewhat reduced flood damages along Bentley Creek, and reduced sediment removal costs locally and downstream, and reduced sediment and nutrient loads to the Chesapeake Bay. Sediment cleanout costs in Wellsburg will be reduced to about $10,000 per year.

Stream Rehabilitation plus Nonstructural – Same as Dikes plus Nonstructural Alternative, except Wellsburg sediment cleanout costs will be reduced an additional $2,000 per year since more of the sediment will move through the system in the rehabilitated stream.

Flood Plain Urbanization / Use

No Action [Future without Project] – Little new development is expected over the next 20-25 years. Development that does occur will be regulated by local flood plain ordinances. Enforcement and improvement of these ordinances will ensure that new development will be at low risk of flood damage.

Dikes plus Nonstructural – May encourage new development in the diked areas, but little room for expansion exists. About 5 acres will be restored to flood plain function as a result of house acquisitions.

Stream Rehabilitation plus Nonstructural – About 12 acres will be restored to flood plain function as a result of stream rehabilitation and house acquisitions.

Land Use Changes

No Action [Future without Project] – Little new development and few changes in current land use is expected over the next 20-25 years.

Dikes plus Nonstructural – About 19 acres of mixed meadow/lawn/trees and one acre of forest will be converted to dike and components. About 5 acres will be restored to flood plain use as a result of house acquisitions for the dike and nonstructural measures.

Stream Rehabilitation plus Nonstructural – About 7 acres of mixed meadow/trees will be converted to vegetated streambank as part of stream rehabilitation. About 6 acres will be restored to flood plain use as a result of voluntary house acquisitions.

Important Farmland

No Action [Future without Project] - All important farmland is located outside of the identified problem areas within the flood plain. Little change is expected in the watershed in terms of agricultural activities or land development. Important farmland will not change appreciably.

Dikes plus Nonstructural – No effect

Stream Rehabilitation plus Nonstructural – No effect

Soil Resources

No Action [Future without Project] – Soil resources will remain relatively healthy in the watershed. Most soil has good to excellent cover year round and sheet and rill erosion rates are generally low. There are exceptions in some cropped fields without adequate soil conservation, but the majority of agricultural producers are following good conservation practices and this is expected to continue. The largest threat to soil resources is a result of the highly unstable streambanks throughout the watershed. During even moderate flood events, large areas of land are lost into the stream system as streambanks fail. Some improvement is expected as an additional 3000 feet of critically eroding streambanks are stabilized.

Dikes plus Nonstructural – An additional 19,000 feet of the most critically eroding streambanks will be stabilized resulting in substantially reduced land loss in the tributaries and reduced threats to downstream land areas.

Stream Rehabilitation plus Nonstructural – Same as Dikes plus Nonstructural Alternative plus an additional 4500 feet of stream will be stabilized and rehabilitated in Wellsburg.

Riparian Areas

No Action [Future without Project] – There are over 33 miles of stream and tributaries in the watershed that run through cultivated land, pasture and urbanized areas. These areas lack adequate forested riparian buffers. No substantial change is expected except for about 3000 feet of tributary stabilization which will substantially improve riparian habitat in the treated area.

Dikes plus Nonstructural – Flood flows in the areas of the dikes will not have access to the original flood plain. No trees or shrubs will be permitted to grow on the dike embankments which are about 4200 feet long in Wellsburg and 2400 feet long in Centerville. Stabilization of an additional 19,000 feet of tributary streams will substantially enhance riparian habitat in those areas. During construction and establishment there will be a temporary decline.

Stream Rehabilitation plus Nonstructural – Rehabilitation of 4500 feet of stream in Wellsburg and stabilization of an additional 19,000 feet of tributary streams will substantially enhance riparian habitat in those areas.

Forest Resources

No Action [Future without Project] – Little change expected, due to minimal land development or agricultural pressure to convert to other land uses. About one-half of the watershed is forested.

Dikes plus Nonstructural – About one acre of forest will be converted to meadow land cover as a result of hillside diversion component of the dikes.

Stream Rehabilitation plus Nonstructural – Some trees along the stream adjacent to residential areas will be removed.

Aquatic Life Resources

No Action [Future without Project] – Surveys by the Pennsylvania Fish and Boat Commission (2000) and Pennsylvania Cooperative Fish and Wildlife Unit (1998) found a somewhat low diversity of fish species in the watershed. The species consisted of 10 cyprinids, 2 sucker species, 3 sunfish species, brown bullhead, madtom, fantail darter, perch and sculpin. Four or five species of cyprinids, white sucker and mottled sculpin are fairly common and to a lesser extent fantail darter and pumpkinseed sunfish. The fish community is typical of an assemblage found in transitional

streams. It was concluded that poor instream habitat along with warm summer temperatures and low summer flows limit the potential for watershed streams to support significant game fish populations. Water quality is generally good. Habitat degradation is due to the excessive streambank erosion, excessive sedimentation, poor riparian habitat in many areas, unstable and shifting bedload and extremes in flow regime. These conditions will only improve slightly as a result of ongoing rehabilitation efforts.

Dikes plus Nonstructural – Moderate habitat improvement in some areas as a result of stabilization of critically eroding tributaries which have poor riparian habitat and are contributing large unstable sediment loads. A previously modified tributary in Wellsburg will be restored to near its original outlet. However, due to the extreme nature of the existing degradation, little to no change in aquatic game species is expected, although other aquatic life is expected to improve moderately.

Stream Rehabilitation plus Nonstructural – Moderate habitat improvement in some areas as a result of stabilization of critically eroding tributaries which have poor riparian habitat and are contributing large unstable sediment loads. In addition, about 4500 feet of Bentley Creek in Wellsburg will be rehabilitated. However, due to the extreme nature of the existing degradation, little to no change in aquatic game species is expected, although other aquatic life is expected to improve moderately.

Wildlife Resources

No Action [Future without Project] – Wildlife resources are typical and include white tail deer, black bear, fox, coyote, turkey, raccoon, squirrel, and other associated species. Waterfowl use and nesting is limited. An active heron rookery exists in the ridge area, beyond the riparian zone. Active streambank erosion and disconnected riparian forest areas disrupts a significant portion of the riparian areas and many potential nesting areas. Little change is expected.

Dikes plus Nonstructural – Moderate improvement of riparian habitat along critically eroding tributaries being stabilized, resulting in less habitat fragmentation. Temporary impacts to meadow/lawn species and woodland species in the areas impacted by dike system construction. Few to no permanent wildlife impacts are expected from dike implementation.

Stream Rehabilitation plus Nonstructural – Moderate improvement of riparian habitat along critically eroding tributaries being stabilized, resulting in less habitat fragmentation. No temporary dike impacts, since none are included with this alternative. Habitat is currently of low value in the area of the Wellsburg stream rehabilitation, so little wildlife habitat improvement is expected in this reach.

Threatened / Endangered Species

No Action [Future without Project] –The New York State Department of Environmental Conservation was contacted along with the U.S. Fish and Wildlife Service to determine the status of species in New York. The Pennsylvania Natural Diversity Inventory (PNDI) was accessed to determine the status of all federal and state species at risk. The Pennsylvania Department of Conservation and Natural Resources-Bureau of Forestry, Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, Pennsylvania Biological Survey and U.S. Fish and Wildlife Service all participate in the PNDI system. Two New York endangered plants and one Pennsylvania plant of concern were identified as having a historic presence. A botanical field survey of the New York area was conducted by Cornell University, Cooperative Extension, Chemung County in June 2007. The survey found no evidence of the plants of concern. The Pennsylvania Department of Conservation and Natural Resources found no impact is likely and no further coordination is needed based on the location and types of measures being considered.

Dikes plus Nonstructural – No effect

Stream Rehabilitation plus Nonstructural – No effect

Wetlands

No Action [Future without Project] – The majority of the wetlands in the watershed occur in conjunction with the creeks and drainage ways. Additional wetlands occur in many upland areas. Due to the presence of fragipans in the upland soils, there exists a perched water table that creates numerous smaller wetlands that are included in non-hydric soil mapping units. Along the stream corridors, the primary wetland types include palustrine, open water, intermittently exposed permanent, excavated wetlands; and riverine, upper perennial wetlands. In the upland areas, the primary wetland types include palustrine, emergent, narrow-leaved, persistent wetlands; as well as palustrine scrub/shrub and palustrine forested and many lacustrine open water wetlands. Few changes are expected in the amount or type of wetland.

Dikes plus Nonstructural – No effect, wetland in the vicinity of the Centerville dike will be avoided.

Stream Rehabilitation plus Nonstructural – No effect

Water Quality

No Action [Future without Project] – Surface waters will continue to be slightly degraded from excessive sediment, iron and aluminum. Generally water quality is good. Ground water quality and quantity remains good and is maintained by enforced stormwater ordinances and other pollution prevention laws.

Dikes plus Nonstructural – There will be a slight improvement in stream water quality and downstream water quality due to a substantial reduction in sedimentation, reduced nutrient loads and improved riparian condition. A short term increase in sedimentation will occur during construction of tributary stabilization measures and possibly some dike components. However, the amount will be minimized by the use of approved erosion and sediment control practices.

Stream Rehabilitation plus Nonstructural – Same as Dikes plus Nonstructural alternative, except additional long term surface water quality improvements will occur in the stream rehabilitation reach in Wellsburg.

Cultural Resources

No Action [Future without Project] – Phase 1 Cultural Resources Surveys were conducted of the project area. The New York State and Pennsylvania State Historic Preservation Offices and the Seneca Nation of Indians were consulted regarding findings. One house in the project area is eligible for the National Register (NR) of Historic Places. This building and associated outbuildings will continue to be subject to flood damage with no protective measures planned. Otherwise, the Phase I surveys located no prehistoric cultural material, no other cultural features and no archaeological sites.

Dikes plus Nonstructural –One property with a house and outbuildings is NR eligible. This alternative will require the house to be removed from the flood plain due to induced flooding from the planned Wellsburg dike. A mitigation plan will be coordinated with the New York State (NYS) Office of Parks, Recreation and Historic Preservation (NYS Historic Preservation Office). In addition, further investigation is required of the Wellsburg dike diversion outlet during project design to ensure no adverse impacts to unmarked graves, if any.

Stream Rehabilitation plus Nonstructural – No effect

Visual / Aesthetic Resources

No Action [Future without Project] – Little change from existing watershed setting. Raw stream banks will continue to be exposed and damages related to flooding will continue to impact the visual and aesthetic qualities of the area.

Dikes plus Nonstructural – Tributary stabilization will substantially reduce the amount of raw stream banks. Substantially reduced flood damages will improve the overall aesthetic character of the area, especially immediately following flood events. Dikes will reduce visibility of Bentley Creek along two dikes totaling about 6600 feet and lines of site near the ends that tie into high ground in four locations. However the Centerville dike is a low dike and the Wellsburg a moderate height dike with similar elevation to existing pushed-up gravel on the existing stream banks. Therefore the overall visual impacts will be slight to moderate.

Stream Rehabilitation plus Nonstructural – Tributary stabilization will substantially reduce the amount of raw stream banks. Substantially reduced flood damages will improve the overall aesthetic character of the area, especially immediately following flood events. Stream rehabilitation should improve the visual quality of about 4500 feet of Bentley Creek and reduce the number of temporary visual impacts from stream clean-outs. Elevated mobile homes and "floodproofed" houses may be less attractive to some observers.

Social Issues

No Action [Future without Project] – Little change from existing watershed conditions relative to the local economy, unemployment, income, and housing vales. Flooding will continue to periodically disrupt community life, causing lost wages, repair and clean-up costs, closed businesses and demand for emergency services.

Dikes plus Nonstructural – Improved economic conditions due to reduced flood hazard. Nearly 200 buildings will have little to no impact from the 100-year flood. Access to and view of creek reduced in areas with dikes. Five or six household displaced by dikes and six additional households may voluntarily abandon the flood plain. Those participating in mobile home elevation and possibly some of the other nonstructural measures will have short term disruptions in living conditions.

Stream Rehabilitation plus Nonstructural – Improved economic conditions due to reduced flood hazard. About 115 buildings will have little to no impact from the 100-year flood and 60 more with reduced flooding. Another 11 households may voluntarily abandon the flood plain. Those participating in mobile home elevation and possibly some of the other nonstructural measures will have short term disruptions in living conditions.

Civil Rights / Environmental Justice

No Action [Future without Project] – No change from existing conditions

Dikes plus Nonstructural – All people in the targeted area, including economically disadvantaged groups, minorities, women and persons with disabilities will be eligible to participate in the program. There will be no disproportionately high or adverse human health or environmental impacts to these groups or individuals as a result of the project action.

Stream Rehabilitation plus Nonstructural – Same as Dikes plus Nonstructural alternative

Public Utilities / Services

No Action [Future without Project] – Little change from existing watershed conditions. During floods, community services are disrupted, access to emergency equipment is restricted, roads and bridges may become impassible. There are 20 bridges and adjacent roads that flood for frequencies less than the 100-year flood. Stream scour during flood events affects adjacent roads, dislodges gas and electric lines. Telephone service is also disrupted during floods.

Dikes plus Nonstructural –Three road closures during significant floods will disrupt traffic flows, but will allow for roads to open more quickly after a flood. Emergency services will be able to continue somewhat normal services within diked areas with advance preparation and there will be a reduced need for emergency services related to flooding. Construction will result in the temporary disruption of natural gas service to relocate lines at one dike.

Stream Rehabilitation plus Nonstructural – Reduced flood levels in Wellsburg will result in fewer disruptions to community services and shorter duration of adverse conditions. Roads and utilities will be subjected to less flooding in Wellsburg. There will be a reduced need for emergency services related to flooding.

Relationship to Other Plans and Policies

No Action [Future without Project] – Flood Plain and Storm Water ordinances will continue to be the primary mechanism for assuring flood damages do not increase in the future. The Federal Emergency Management Agency (FEMA) has commenced work to update flood plain mapping in the New York portion of the watershed and has initiated some inquiries regarding the Pennsylvania portion. NRCS has offered to share with FEMA the hydrology and hydraulic analyses completed for the watershed. Several high hazard dams in the watershed are regulated by the Pennsylvania Department of Environmental Protection, Bureau of Dam Safety.

Dikes plus Nonstructural – The plan would be compatible with existing plans and policies and will increase the importance of strong Flood Plain and Storm Water ordinances. The plan is also compatible with the Susquehanna River Basin Commission Comprehensive Plan which has flood damage reduction as a primary focus area.

Stream Rehabilitation plus Nonstructural – Same as Dikes plus Nonstructural alternative

Irreversible and Irretrievable Commitment of Resources

No Action [Future without Project] – No appreciable change from existing conditions.

Dikes plus Nonstructural – This alternative requires a small commitment of fossil fuel to construct the various project measures. The dikes will be primarily earthfill, some may be borrowed off-site. Therefore up to 78,000 cubic yards of soil resources from off-site borrow areas will be committed to dike construction. The dike and appurtenances could be removed at a future date, so the commitment of resources in those areas is reversible.

Stream Rehabilitation plus Nonstructural – This alternative may require slightly smaller commitment of fossil fuel to construct compared to the "Dikes plus Nonstructural" alternative. Stream rehabilitation will require cutting back stream banks along about 4500 feet of the east side of Bentley Creek to accommodate a larger flood flow cross-section. This will require commitment of the soil resource in that area.

Cumulative Effects

No Action [Future without Project] - No appreciable change from existing conditions other than about 3,000 feet of tributary stabilization.

Dikes plus Nonstructural – Cumulative effects will be primarily the result of the planned action. This alternative would greatly improve public safety due to substantially reduced flood damage and sedimentation, improve riparian and aquatic life resources in treated tributaries and the main stem Bentley Creek, improve water quality as a result of reduced sedimentation, reduce access of flood flows into the flood plain at Wellsburg and Centerville, result in the mitigated removal of one flood prone house that is eligible for the National Register of Historic Places, change the visual quality of the area due to substantially fewer "raw" streambanks, substantially reduced visual impacts after floods and a change in the landscape where the two dikes are located, 20 acres of land converted

to dike and appurtenances, 5 acres restored to flood plain / riparian functions in the case of house acquisitions, and protection of soil resources along 19,000 feet of tributaries.

Stream Rehabilitation plus Nonstructural – Cumulative effects will be primarily the result of the planned action. This alternative would have similar effects as the "Dikes plus Nonstructural" alternative, except for the following: flood flow access into the flood plain at Wellsburg and Centerville would not be reduced, in Wellsburg flood flows would be reduced in the village and accommodated in a sub flood plain in the rehabilitated stream, no change in the landscape where the two dikes would have been located and enhanced stream characteristics in Wellsburg, 12 acres of land restored to flood plain function as a result of stream rehabilitation and house acquisitions.

Comparison of Alternative Plans

Table B provides a Summary and Comparison of each alternative plan.

Risk and Uncertainty

Uncertainty and variability are inherent in many aspects of water resources planning and may result in effects that are different from those anticipated. Complex natural, social and economic trends may result in flawed projections of future watershed conditions. Sound analytical and modeling procedures are employed to reduce these uncertainties. However, model projections only approximate future watershed conditions based on historical data and any anticipated changes. The project decision makers must be cognizant of this variability and factor it into their selection of a recommended plan of action.

Projections of flood damages are rooted in modeling of hydrology, hydraulics and economics. The hydrology model employed, WinTR20 (NRCS, 2004) has been used, calibrated and updated for several decades. It produces dependable results. The Win TR20 model was calibrated in this instance based on results found when using the US Geological Survey hydrologic regression equations for Pennsylvania (Stuckey and Reed, 2000). It must be noted however, that factors used in the model may change over time, particularly land use. In this watershed, the land use changes that have occurred over the last 50 years and projected into the foreseeable future are unlikely to substantially affect model results. Long term changes in precipitation patterns tend to occur very slowly and are likewise unlikely to substantially alter the results.

The flood water surface elevations were predicted using a well seasoned hydraulic model, HEC-RAS (USACE, 2003). The results of predictive hydrology peak discharge by frequency were combined with the predictive hydraulic model to assign estimated dike elevations required throughout their length. Dike elevations were planned to include three feet of freeboard as a safeguard measure. The factors that may affect the results of this model would be modifications to bridges or stream cross-sections or major changes in the vegetation or obstructions placed in the flood plain. Again, in this watershed, these types of changes are unlikely to be significant.

The economic analysis of flood damages to homes, buildings and roads/bridges are based on the output of the HEC-RAS model and are only as good as that model's projections as well as the results of the hydrologic analysis by WinTR20. Factors that will likely affect the certainty of the flood damage analysis are major changes in the future number of buildings in the flood plain or unscheduled modifications to bridges. Standard estimates were used to determine the value of building content and the subsequent flood damages to the contents. Standard damage factors have proven to be reasonably reliable in past work done by the U.S. Army Corps of Engineers and NRCS.

Sediment transport projections through the Bentley Creek drainage system is based largely on the estimation of historical clean out efforts. Major changes in erosion rates for the four unstable tributaries would directly influence overall sediment transport in this system.

Projections of the effects of alternatives on ecological and cultural resources were based on on-site evaluations, consultation with specialists and existing reports. Projected changes in habitat and wetland types are fairly reliable since the area is not ecologically complex.

Engineering needs and cost estimates are also reliable since they are based on well established design and construction practices. The areas of uncertainty primarily revolve around the final design for the dikes and appurtenant structures (diversions and stormwater holding ponds). The costs associated with the nonstructural measures have obvious degrees of uncertainty. This is due in part to the unknown features related to specifics style of treatment as well as participation rate of the residents. A cost contingency was added to cover these areas of uncertainty and the overall affect on costs is not adequate to change the relative comparison of the costs of the various alternatives.

Implementation of certain phases of the structural measures in this plan does entail some risk. Specifically, this relates to the manual placement of hardware at the water closing gates at various points in the dikes where road crossings occur. This will need to be done prior to when Bentley Creek flood elevations reach the road elevation at the crossing. This will entail a flood forecasting method that ties existing watershed hydrologic and climatic conditions with up to date satellite Doppler radar imagery to identify when dike closure operations should be executed. Methods used to offer trigger flow elevations and time of response to close the gates do pose some risk in that they are often empirical in nature. True watershed response in terms of rate of runoff and its timing related to excessive rainfall will be learned through time and experience operating the flood gates in this setting. This experience, through time, will likely lead to a more site specific feel of when to commence placement of the water closing gates. Gate closure operations will be performed by local public works employees based upon hearing from the county emergency management staff.

Each closing should likely take, perhaps 15 minutes or so, with all of the related hardware to be kept near the gate for ready access. This operation should be routinely practiced on a regular basis to provide experience to all parties involved and to minimize risk of implementation. The warning system leading to when to enact the closing of the gates may likely cause their closing at times when no actual flooding will occur. This will likely cause local residents, businesses and emergency vehicles some hardships, especially if road closures are considerably more frequent than actual flood threats. The attempt should be made to keep the warning system as accurate as possible yet still allow for ample time to close the water gates before flood damage and threat to life occurs.

Overall, the risk and uncertainty associated with the evaluation of alternatives in the Bentley Creek watershed are low. Decision makers can be reasonably assured that the comparative data presented should be adequate to make a well informed decision on a recommended plan of action.

Rationale for Plan Selection

The "Dikes plus Nonstructural" alternative is selected as the Recommended Plan. It is developed to accommodate the maximum number of resource concerns identified throughout the scoping process of this project since its inception. When compared against the "No Action" and "Stream Rehabilitation plus Nonstructural" alternative, the "Dikes plus Nonstructural" alternative better meets the Sponsors' objectives reducing the potential for loss of life or injury and property damage resulting from flooding along Bentley Creek. The "Dikes plus Nonstructural" alternative is the National Economic Development plan, which maximizes net economic benefits consistent with protecting the Nation's environment. The plan's economic, social and ecological benefits exceed the costs. One National Register of Historic Places eligible house will be removed from the flood plain. The house removal will be mitigated in consultation with the New York State Historic Preservation Office. There are no significant environmental impacts associated with the Recommended Plan.