Tar-Pamlico River Basin
Flood Risk Management
Feasibility Study

Appendix A. Planning Appendix

US Army Corps
of Engineers

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Table 1. Criteria used to screen the initial list of management measures. Description and associated metrics used to assess each criterion are provided. Management measures were evaluated based on completeness, effectiveness, efficiency, and acceptability, as outlined in the PR&G (USACE, 2013). Additional considerations for screening included environmental effects, environmental justice, and technical feasibility.

Criteria	**Description**	**Metric(s)**
Efficiency	Cost effectiveness. Comparison of economic benefits and costs	Quantitative – Comparison of preliminary costs and expected benefits.
Effectiveness – Damages Reduced	Damages to buildings, related contents, and vehicles	Semi-Quantitative – Expected benefits based on preliminary cost benefits analysis and hydrologic and hydraulic modeling.
Effectiveness – Industry and Commercial	Degree to which flood risk is reduced in commercialized reaches	Qualitative – expected benefits in targeted reaches
Effectiveness – Life Safety	Changes in life safety risk expected with alternative implementation.	Qualitative– population at risk, qualitative assessment of reductions in life loss due to~~, and~~ expected changes in flooding characteristics (e.g., depth, velocity)
Acceptability	The viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies.	Qualitative – narrative description of acceptability.
Environmental Effects	Effects to aquatic (stream, wetland) and terrestrial (riparian, upland, critical) habitats, water quality, and threatened/endangered species.	Qualitative – low, medium, high based on footprint and effect of each alternative
Environmental Justice	Changes in flood risk or consequences within areas identified as traditionally disadvantaged with respect to environmental concerns per the CEQ's Climate and Economic Justice Screening tool and EPA's EJScreen tool were used to characterize potential benefits to socially vulnerable communities.	Qualitative – Qualitative assessment of potential benefits in areas identified as socially vulnerable based on initial hydrologic and hydraulic modeling results.
Engineering Feasibility	As to whether the measure is engineering feasible and constructable.	Best professional judgement based on engineering practices and standards.

Table 2. The table below details each individual flood risk management measure examined, the location where it was considered, the analysis that the measure underwent, notes or explanation on why the measure was screened (S) or retained (R), and the level of analysis completed for the measure. Location maps of measures that underwent Civil or Structural Engineering Design, or Hydrologic and Hydraulic modeling are show in Appendix E or Appendix F, respectively. NA = not applicable. The first iteration of screening (designated as "1º", below) was conducted using existing data for the Tar-Pamlico River basin and existing models while the integrated hydrologic and hydraulic models of the entire Tar River were being developed. The secondary iteration (designated as "2º", below) was based on results of the basin-wide hydrologic and hydraulic model, and the application of those results to analysis of economic and life safety benefits.

				Screening Iteration		
ID #	**Type**	**Measure**	**Description**	**1º**	**2º**	**Screening Justification**
	Structural Measures					
S1	Floodwater Storage	Dry Dam – Stony Creek	Dry dam on Stony Creek upstream of Nashville. Dry dam would store water during periods of high flow, reducing peak flows downstream.	R	R	Initial economic analysis indicated that the Stony Creek Dry Dam would have a benefit cost ratio of 1.6. The dry dam would have significant environmental impacts to critical habitat and associated threatened and endangered species that would require mitigation.
S2	Floodwater Storage	Dry Dam – Upper Tar River	Dry dam on the upper Tar River. Dry dam would store water during periods of high flow, reducing peak flows downstream.	R	R	Initial hydrologic and economic analysis indicated that the Upper Tar River Dry Dam would work together with the Stony Creek Dry Dam to reduce flood risk within Rocky Mount and that additional design work and screening is warranted. The dry dam would have significant environmental impacts to critical habitat and associated threatened and endangered species that would require mitigation.
S3	Floodwater Storage	Dry Dam – Fishing Creek	Dry dam Fishing Creek. Dry dam would store water	R	S	Initial economic analysis indicated that the Fishing Creek Dry Dam would not be economically justified as the costs estimated to be over $875M.

			during periods of high flow, reducing peak flows downstream.			The dry dam would also have significant environmental impacts to critical habitat and associated threatened and endangered species that would require mitigation.
S4	Floodwalls / Earthen Levees	Rocky Mount Levee System	Included five different levee sections totaling approximately 58,100 feet within and downstream of Rocky Mount.	S	NA	Initial hydrologic and economic analysis indicated that the benefit cost ratios of individual levee segments within the Rocky Mount levee system were less than or equal to 0.6, with an overall benefit cost ratio of 0.4. Therefore, this measure was screened due to lack of efficiency.
S5	Floodwalls / Earthen Levees	Tarboro Wastewater Treatment Plant (WWTP)	Floodwall adjacent to the Tarboro Wastewater Treatment Plant to reduce impacts to critical infrastructure.	R	S	Proximity of the wastewater treatment plant to the channel would require an I-wall, which carries significant risk and height limitations. A floodwall would not provide sufficient benefits to justify construction because the wastewater treatment plant is only inundated under the 0.2% annual exceedance probability event. Therefore, this measure was screened from further consideration.
S6	Floodwalls / Earthen Levees	East Tarboro	Included two separate levee segments east of Tarboro along the Tar River totaling 11,400 feet.	R	S	Initial hydrologic and economic analysis indicated that the benefit cost ratio of the East Tarboro levee system is 0.2. Therefore, this measure was screened.
S7	Floodwalls / Earthen Levees	Tarboro-Edgecombe Airport	Levee adjacent to the Tarboro-Edgecombe Airport to reduce damages to infrastructure.	R	S	Conservative estimate of maximum flood reduction benefits was estimated to be significantly less than what would be needed to get a positive benefit cost ratio based on best engineering judgement regarding cost estimates.
S8	Floodwalls / Earthen Levees	Greenville Levee System	Included two separate levee sections totaling 27,700 feet north of the Tar River within	S	NA	Initial hydrologic and economic analysis indicated that the benefit cost ratio of the Greenville levee system is 0.2. Therefore, this measure was screened.

			the City of Greenville.			
S9	Floodwalls / Earthen Levees	Green Mill Run	Included an 800-foot embankment and pump station designed to reduce backwater flooding from the Tar River along Green Mill Run.	R	S	Initial hydrologic and economic analysis indicated that the benefit cost ratio of the Green Mill Run system is 0.04. Therefore, this measure was screened.
S10	Diversion Channel	Nashville Au xiliary Diversion Channel – Stony Creek	Diversion channel that would reroute water upstream Nashville north of Highway 64.	R	S	Initial hydrologic and economic analysis indicated that the benefit cost ratio of the Nashville Auxiliary Diversion Channel is 0.2. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation. Therefore, this measure was screened from further consideration.
S11	Diversion Channel	Logsboro / Hartsboro Auxiliary Diversion Channel	This measure consists of a series of seven stream reaches auxiliary channels that connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Logsboro / Hartsboro Auxiliary Diversion Channel was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S12	Diversion Channel	Tarboro / Princeville Auxiliary Diversion Channel #1	Redirection of Penders Mill Run and creation of an auxiliary channel on the Tar River that would connect	R	S	The Tarboro / Princeville Auxiliary Diversion Channel #1 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant

			meanders, increasing storage capacity and hydraulic conductivity.			impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S13	Diversion Channel	Tarboro / Princeville Auxiliary Diversion Channel #2	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Tarboro / Princeville Auxiliary Diversion Channel #2 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S14	Diversion Channel	Tarboro / Princeville Auxiliary Diversion Channel #3	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Tarboro / Princeville Auxiliary Diversion Channel #3 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S15	Diversion Channel	Tarboro / Princeville Auxiliary Diversion Channel #4	Diversion channel #4 is located south of Tarboro and Princeville, NC and runs roughly parallel to the Tar Pamlico River for approximately 3.6 miles, increasing storage and hydraulic conductivity.	R	S	The Tarboro / Princeville Auxiliary Diversion Channel #4 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.

S16	Diversion Channel	Rocky Mount Auxiliary Diversion Channel #1	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Rocky Mount Auxiliary Diversion Channel #1 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S17	Diversion Channel	Rocky Mount Auxiliary Diversion Channel #2	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Rocky Mount Auxiliary Diversion Channel #2 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S18	Diversion Channel	Rocky Mount Auxiliary Diversion Channel #3	Creation of an auxiliary channel that runs parallel with the Tar River upstream and within Rocky Mount that would increase storage capacity and reduce adjacent flooding.	R	S	Initial hydrologic and economic analysis indicated that the benefit cost ratio of the Rocky Mount Auxiliary Diversion Channel #3 is 0.1. Therefore, this measure was screened. This auxiliary diversion channel was expected to provide the greatest economic benefit based on optimistic benefit estimates and rough order of magnitude cost estimate for the diversion channel. Therefore, this measure was used to screen other similar measures on the Tar River around Rocky Mount and Tarboro/Princeville. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.

S19	Diversion Channel	Rocky Mount Auxiliary Diversion Channel #4	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity, and divert flows around populated areas downstream of Rocky Mount.	R	S	The Rocky Mount Auxiliary Diversion Channel #4 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S20	Diversion Channel	Rocky Mount Auxiliary Diversion Channel #5	Creation of an auxiliary channel on the Tar River that would connect meanders, increasing storage capacity and hydraulic conductivity.	R	S	The Rocky Mount Auxiliary Diversion Channel #5 was screened based on the screening of the Rocky Mount Auxiliary Diversion Channel #3 (benefit cost ratio of 0.1), which was deemed to have a greater likelihood of being economically justified. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S21	Diversion Channel	Diversion channels – Tar River to Cokey Swamp	Divert the Tar River into Cokey Swamp upstream of Rocky Mount.	S	NA	Topographic limitations would necessitate a pump station for the diversion channel to function, which would be expensive to install and operate. Diversion of water into Cokey Swamp would also necessitate significant modification to Cokey Swamp to prevent transferred risk. This measure would also have significant impacts to environmental resources, including critical habitats for threatened and endangered species that would require mitigation.
S22	Diversion Channel	Roseneath / Palmyra Fishing Creek	Divert Fishing Creek into the Roanoke River.	S	NA	The Roseneath / Palmyra Fishing Creek Diversion Channel would discharge into a separate drainage—the study of which is outside the scope of this feasibility effort and study authority. As a result,

		Diversion Channel				this measure was screened due to lack of acceptability with respect to USACE planning policy and guidance.
S23	Channel Improvement	Rocky Mount	Modifying the channel along the Tar River and/or Stony Creek to increase capacity and/or hydraulic conductivity.	S	NA	An initial feasibility assessment determined that channel modification along the Tar River and/or Stony Creek within Rocky Mount would not be viable due to limited real estate and storage capacity, potential downstream impacts due to changes in hydraulics, and significant environmental impacts. Therefore, this measure was screened from further consideration.
S24	Channel Improvement	Green Mill Run	Several locations were investigated for channel improvements along Green Mill Run, including channelization and crossing improvements to increase conveyance.	S	NA	Areas assessed for channel modification along Green Mill Run do not comply with Engineering Regulation 1105-2-100, which states that flood risk management authorities can only address risks downstream from the point where the flood discharge is greater than 800 cubic feet per second for the 10% annual exceedance probability flood. Therefore, this measure is not acceptable per USACE policy and guidance.
S25	Transportation modification	Bridge Modification (n=17)	Increased conveyance through addition of culverts, bridge removal, and/or modification to bridge spans/culverts.	R	S	Structures with the greatest opportunity for improved conveyance were identified through visual inspection of model results and comparison with structure/municipal data. Increased water surface elevations in urbanized, flood prone areas were identified at 17 bridge locations. Bridge removal was simulated at each location to analyze differences in the inundation area. Differences in the inundation area were negligible in all cases. Three bridge locations that showed minor improvement in the inundation area were further analyzed to assess economic viability. All three

						bridge modifications were found to not be cost effective (i.e., cost would need to be less than $1.5M, which was determined to be infeasible) and therefore were screened.
S26	Debris Management	Modification of existing infrastructure (n=24)	Modification of existing bridges to prevent debris buildup and associated water backup and inundation during high flow events.	R	S	Structures with the greatest opportunity for improved conveyance through debris management were identified through visual inspection of model results. Potential for decreased water surface elevations was identified at 24 bridge locations. Complete removal of debris was simulated at each location within the hydraulic model to analyze differences in water surface elevation and inundation area. Differences in the inundation area were negligible in all cases. Debris management was screened from further consideration due to lack of effectiveness.
S27	Existing Water Resource Project Modification	Modify Tar River Reservoir	Modifications to the infrastructure (i.e., dam elevation, spillway modifications) and operations of the dam.	R	S	Topography associated with the lake is not conducive to increasing storage capacity at the reservoir. Hydrologic and hydraulic modeling indicated that raising the dam and modifying the spillway would provide minimal downstream peak flow and risk reduction. Therefore, this measure was screened for lack of efficiency and effectiveness.
S28	Existing Water Resource Project Modification	Rocky Mount Mill Dam Removal	Removal of the Mill Dam at Rocky Mount to increase hydraulic conductivity and reduce adjacent and upstream flood risk.	R	S	Hydraulic modeling results indicate that removal of the Rocky Mount Mill Dam would have minimal impact on water surface elevations (i.e., maximum change of 0.3 feet during the 5% annual exceedance probability event). Therefore, this measure was screened from further consideration due to lack of effectiveness.

	Nonstructural Measures					
NS1	Physical Nonstructural Measure	Acquisition and relocation	Acquisition and relocation, also called buyouts, includes acquisition and demolition of flood prone structures. A structure relocation is the process of moving a structure from one location to another. Residents would be relocated outside of the floodplain. Participation in the relocation would be mandatory. The floodplain would be planted with native vegetation. The local sponsor would retain ownership of the acquired property and must ensure no future development or fill would occur.	R	R	NA
NS2	Physical Nonstructural Measure	Structure Elevation	Structure elevation involves raising structures in place so that the structure sees a reduction in frequency and/or depth of flooding	R	R	NA

			during high-water events. Elevation can be done on fill, foundation walls, piers, piles, posts, or columns, depending on flood characteristics.			
NS3	Physical Nonstructural Measure	Dry Floodproofing	Dry floodproofing involves sealing building walls and openings to prevent the entry of flood waters and is most applicable in areas of shallow, low velocity flooding.	R	R	NA
NS4	Physical Nonstructural Measure	Relocation	Structure relocation is the process of physically moving a structure from one location to another.	R	S	Initial cost estimates and associated research indicated that relocation would be much more expensive than other nonstructural approaches (e.g., floodproofing and elevation) in all areas and technically infeasible for many structures. As a result, this measure was screened from further consideration.
NS5	Non-Physical Nonstructural Measures	Education & communicatio n	This measure includes educating the public about existing and future flood risk within the basin.	S	NA	North Carolina residents have access to the Flood Risk Information System, which provides spatially explicit information on flood risks. In addition, counties and communities along the Tar River and its major tributaries have extensive resources available to residents. As a result, this measure was screened from further consideration.

NS6	Non-Physical Nonstructural Measures	Emergency preparedness / warning	This measure includes flood warning systems and emergency evacuation and planning.	S	NA	Counties along the Tar River and many of its major tributaries already utilize the CodeRed emergency warning system and have existing hazard mitigation plans. In addition, many communities (e.g., Rocky Mount) have their own targeted flood warning systems. As a result, this measure was screened from further consideration.
NS7	Non-Physical Nonstructural Measures	Flood ordinance / floodplain management		S	NA	This measure should be included in each municipalities zoning code. As a result, this measure was screened from further consideration.
	Natural and Nature-Based Measures					
NNB1	Watershed restoration & Conservation	Watershed restoration	Restoring natural watershed processes (e.g., reforestation and increased transpiration) could reduce runoff and downstream flooding.	S	NA	Given the volume of water associated with flooding downstream along the Tar River and its tributaries, this measure was determined to be ineffective and likely not cost efficient for the minimal potential reduction in risk. Therefore, this measure was screened.
NNB2	Dispersed Water Management	Offline detention / water farming (n=5)	Maximizing capacity to store and temporarily detain water in existing floodplains and associated farmlands.	R	S	A total of five potential locations for offline detention were identified along Swift Creek (1), Fishing Creek (1), and the Tar Pamlico River (3) based on potential storage volume and site-specific constraints (e.g., impacts to existing infrastructure) for screening-level analysis. Offline storage resulted in minimal changes in downstream water surface elevation, particularly along the Tar Pamlico River. The greatest reductions in water surface elevations were observed along Swift Creek and Fishing Creek where there was minimal benefit to at-risk structures. As a result, this measure was screened due to lack of effectiveness and efficiency.