Preliminary Hydraulic Analysis for the Proposed Woodfin Wave Project

September 26, 2017

Presented to:

Town of Woodfin
90 Elk Mountain Rd.
Woodfin, NC 28804

Presented by:

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Executive Summary

The Town of Woodfin has engaged S_2O Engineering and Design for two phases of planning/design work for the Woodfin Wave project. The first, completed and delivered in September of 2016, was the Conceptual Design and Feasibility Study. The report presented today provides preliminary results of the second phase, the Hydraulic and Flood Study, which together with the earlier study, can provide guidance for moving the project forward. The current Hydraulic and Flood Study includes a hydraulic analysis using flood modeling software of proposed solutions in order to determine feasibility. It also includes a site visit and public engagement step in Woodfin and pre-permitting meetings with regulatory authorities.

The Conceptual Design and Feasibility Study laid out a preferred alternative for siting and design approach – that a simple rock-drop or "U-structure" located adjacent to Riverside Park would be the most economical and functional approach, assuming that it could meet flood regulation and permitting criteria. This study went on to lay out alternative design and siting approaches should the preferred alternative prove infeasible. These alternative approaches included a design at the same Riverside Park site that would incorporate mechanical gates that could be lowered during flood events in order to meet regulatory and permitting criteria.

The current Hydraulic and Flood Study indicates conclusively that the preferred design alternative – the rock-drop structure at Riverside Park – cannot meet regulatory and permitting criteria. It does, however, indicate that a very high-quality, world-class whitewater park feature is still achievable at or near Riverside Park, and this preliminary report lays out three alternatives that S_2O is confident will meet regulatory and permitting criteria.

Two of the alternatives would be located at the originally preferred site adjacent to Riverside Park. One would provide two channels for navigation and surfing, deploying a moderate number of mechanical gates. The second alternative at the preferred site would provide a single channel for navigation and surfing – perhaps a higher quality recreational experience than the first – and would require more extensive usage of mechanical gates. The third alternative would allow for a simpler rock drop structure as contemplated in the original preferred design alternative, but would be sited at a new location approximately 350 feet upstream of the original site, alongside the property at 1476 Riverside Drive which is currently owned by WastePro of North Carolina, Inc.

The 3.35-acre WastePro site currently holds a very large bench-shaped deposit of fill material, consisting primarily or entirely of construction and demolition debris and soil. Removal of a sufficient portion of the debris and soil from the existing floodplain in conjunction with the construction of the Wave feature would allow for regulatory and permitting compliance by providing adequate conveyance, preventing impacts to the regulatory 100-year flood. From the standpoints of simplicity, of design, and of operation the WastePro site alternative would be preferable. And while the Wave structure and in-stream improvements costs would be lower at the Wastepro site, the Town would face the costs of property acquisition, fill removal, and park development that could make its overall capital costs higher than either of the first two alternatives.

This project included a preliminary pre-permit meeting with the USACE and related state and federal regulatory agencies. The purpose of this meeting was to familiarize these entities with the project and to identify regulatory constraints that might impact the design and the design process.

Introduction

A Conceptual Design and Feasibility Study conducted by S_2O Design and Engineering in September of 2016 identified Riverside Park in Woodfin, North Carolina (Figure 1) as a likely candidate location to create a hydraulic feature in the French Broad River. The potential site identified in this study was a location roughly 4,000 feet upstream of the Craggy Dam in Riverside Park. The wave would create a place to surf, kayak, and float that would attract users from throughout the region and country. Similar features, located in similar places, have been found to be significant attractions that have multi-million dollar economic impacts, host major kayaking events and festivals, attract visitors from afar, and draw and encourage the local community to pursue outdoor recreation.

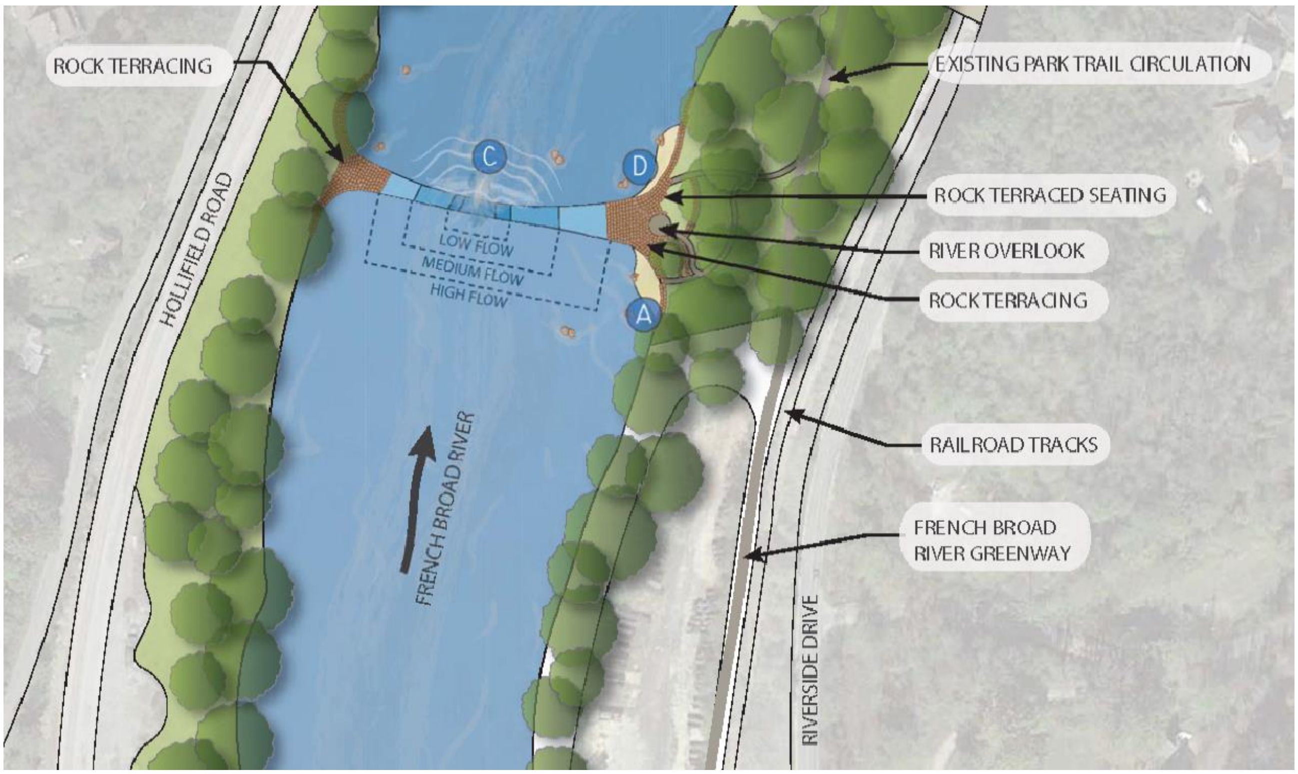

Figure 1. A previous study found that a whitewater park drop structure located in the existing Woodfin Riverside Park would create a surfing attraction that would draw users from throughout the region. Shown above is the site and conceptual design of the preferred alternative identified in that study.

The previous study evaluated the site in terms of access, hosting of paddlers, ownership, hydraulic conditions, in addition to a number of other factors, and concluded that the existing Riverside Park in Woodfin, North Carolina would be an ideal location for the Wave project if the hydraulics proved to be feasible. The site is located at the head of the Craggy Dam Reservoir, which is a safe place to recover from surfing activities. It features existing access, parking, restrooms, trails and viewing points and is near a large community of committed paddlers and supporters. However, while the existing upland area of the park is an ideal site for a Whitewater Park, the river itself presents a challenge from a hydraulic feasibility standpoint. The French Broad River in this location is a low slope and wide aspect ratio river. These characteristics are not ideal for project development as it relates to compliance with flood regulations and permitting, meaning that design and engineering solutions are required that address these issues in order to make a project at this location feasible. This study evaluates these potential solutions.

Study Objective

The objective of this study is to determine the hydraulic feasibility, permitting requirements, and cost implications of creating a whitewater park structure at or near the Riverside Park location. Hydraulic feasibility is established by ensuring that the proposed design will have sufficient drop to create a hydraulic feature, but will not cause an increase to the 100-year regulatory flood levels (no-rise requirement)[1]. A hydraulic study for the proposed Wave feature at this site was conducted and preliminary findings are presented here. Permitting feasibility for this project focused primarily on the United States Army Corps of Engineers (USACE) 404 permit, a requirement of the Clean Water Act. This permit regulates discharges of dredged or fill materials into waters of the United States. An individual permit also evaluates applications under a public interest review. The review includes inputs from related agencies and stakeholders including, for example, United States Fish and Wildlife (USFWS) and the North Carolina Wildlife Resources Commission (WRC), amongst others. This permit also invites the public to comment.

Background

The process for attaining permits to construct in the French Broad River is manifold and requires consultations and applications to multiple agencies. The Section 404 Permit required by the USACE, for example, is tasked with ensuring that a project meets the requirements of the Clean Water Act. A Floodplain Development Permit, which is required under Federal Emergency Management Agency (FEMA) regulations and administered by Buncombe County, ensures that a project will not yield increased adverse flood impacts. The easiest and most preferable way to attain this permit is to pursue a "no-rise" approach to designing such that the project can be shown to have no negative effect to the 100-year floodplain.

Floodplain Permitting

Floodplains in the United States, particularly those near insurable structures, are highly regulated to prevent and mitigate future risks to life and property. A Floodplain Development Permit is required when development is undertaken in a Special Flood Hazard Area (SFHA). The Woodfin project is in such an area. Permits are required to ensure that proposed development projects meet the requirements of the National Flood Insurance Program (NFIP) and the local floodplain management ordinance. This permit establishes that the professional engineer designing the work has evaluated the risks and impacts of the project and found either a) no impact (a no-rise), or b) an impact to the regulatory floodplain that meets FEMA's requirements and that can be accommodated through a Letter of Map Revision (LOMR). Typically, the floodplain manager in a particular region may choose, based on the impacts of a particular project, to pursue the LOMR process even if there is no rise due to the project. Discussions with Buncombe County suggest that they will request a LOMR in this instance in spite of the

[1] It should be noted that the purpose of this study was not to complete a detailed hydraulic flood study that could be used to acquire a floodplain development permit in Buncombe County, rather, to determine whether such an effort would be feasible.

project's no-rise status, as the local permitting authority has stated that this project will likely require a LOMR for other impacts meeting FEMA's requirements.

Establishing a no-rise determination for a whitewater park is typically done in several defined steps using the USACE's own HEC-RAS software to create modeled 100-year flood elevations for varying geometric configurations. The defined steps include running a common model with varying geometries including:

> Regulatory Model: The first step is obtaining the effective, regulatory FIS in HEC-RAS format. In some cases, as in Woodfin, this regulatory model must be re-created from output files created in an earlier version of HEC[2].
>
> Corrected Effective Model: Once the model is re-created, any discrepancies are corrected, creating the corrected effective model.
>
> Existing Conditions Model: The existing conditions model includes any updated topographic surveys as well as any additional cross-sections that may be necessary to accurately portray the existing conditions at the project site. The existing conditions model also includes any man-made changes that may have been made since the effective model was developed.
>
> Proposed Conditions Model: The proposed conditions model is created from the corrected effective model, where survey information is updated and cross-sections are added. The proposed model shows the preliminarily designed whitewater park structures. The proposed model is compared to the corrected effective/existing conditions model to demonstrate that proposed development will not cause a rise in the 100-year flood water surface elevations.

Pursuing a no-rise certification will be an extensive process for the French Broad River at the project site, given the lack of an effective existing regulatory model for the reach in a current software format (HEC-RAS). See Appendix A: *NC NFIP Guidance Document #1: NC NFIP Review of No-Rise Submittals* for more information on this process.

Modeling the French Broad River

S_2O recreated the original regulatory HEC-2 model in HEC-RAS 5.0.3, a more current modeling software, in order to better evaluate impacts to the existing regulatory floodplain due the revised geometry of the project. A request for a digital copy of the HEC-2 model was submitted to the FEMA Engineering Library and we were unable to attain a copy. S_2O utilized the available recreated HEC-2 model outputs to create an effective model that duplicates the results in the Flood Insurance Study (NC NFIP Guidance Document).

Regulatory Studies

The FEMA Flood Insurance Study (FIS) is based on two significant inputs. The first is the flood model which establishes the geometry of the watershed, as discussed above. The second is a hydrologic study, which studies the entire basin and its tributaries to establish regulatory flow rates. These are the statistically determined 1% chance flood (100-year), and other key benchmark flow rates such as the 10-

[2] S_2O put a request into FEMA for the existing conditions model but has been advised that this model does not exist. S_2O utilized output from the previous model to recreate the model. Results from this process are shown in this study.

year, 25-year, 500-year floods, etc. The current regulatory 100-year flood flow levels are determined by the Flood Insurance Study hydraulic model that was updated in 1996. While the regulatory hydraulic model is not available at the time of this report, a Flood Insurance Study (FIS) for the Buncombe County was completed by FEMA (FEMA, 2010).

One output of the FIS is a digital Flood Insurance Rate Map (FIRM) that provides water surface elevations for six cross-sections on the French Broad River that are located within the study area (Figure 2). These elevations can be used as preliminary comparisons for water surface elevations. A full-page view of the FIRM panel can be viewed in Appendix B and the water surface elevations are shown below in Table 1. While S_2O does not have the model that produced these flow rates, they provide a basis for comparison against the existing and proposed modeled conditions.

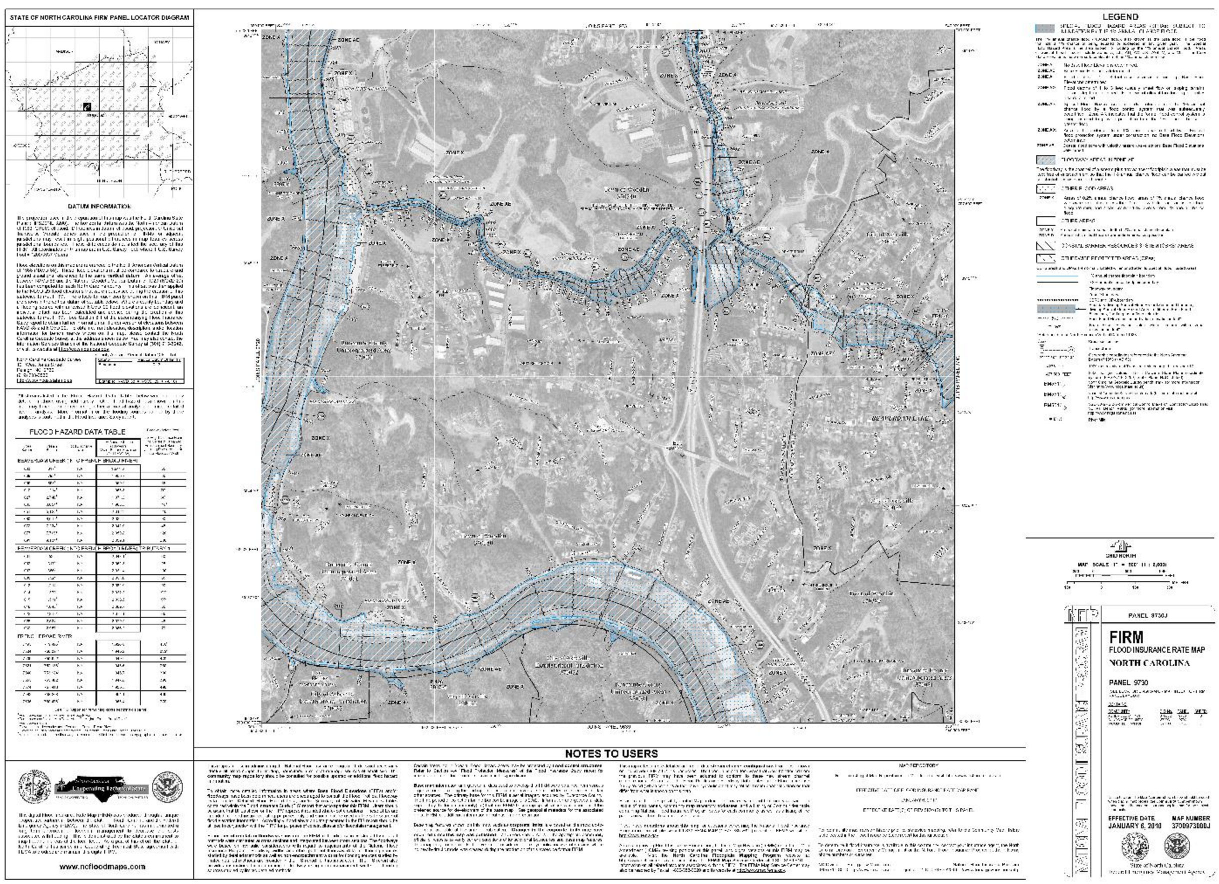

Figure 2. The FEMA Flood Insurance Rate Map for the French Broad River near Woodfin, North Carolina

Table 1. FIS water surface elevations

FIS Water Surface Elevations		
Firm 7574	6732.67	1950.5
FIRM 7555	5021.39	1947.8
FIRM 7540	3592.25	1945.7
FIRM 7521	1824.76	1943.6
FIRM 7509	391.53	1940.9
FIRM 7504	30.45	1940.2

The NC NFIP Guidance Document requires that the updated model that is provided to establish a no-rise includes a Corrected Effective Model that is within 0.5’ of the existing HEC-2 Model. Therefore, the whitewater park structure designed and modeled within this study needs to a) show no rise in comparison to an existing conditions model and, b) be within 0.5’ of the existing FIS study in order to be considered feasible.

Methodology

The study that was undertaken had three parts. The first step established existing conditions, the second modeled the proposed conditions, and the third was an iterative design process that maximized project objectives (primarily the quality of recreational experience and aesthetics) while meeting regulatory requirements.

Existing Conditions

As part of S_2O’s services under this phase, a detailed survey was completed by our associate, Kee Mapping and Surveying, for the reach downstream of the Old Leicester Bridge. This survey is shown in Appendix C. The survey was completed between March 8 and March 31, 2017, and included 15 cross-sections between the Old Leicester Road and the Craggy Dam.

The survey information was imported into AutoCAD as a Civil 3D drawing and an existing conditions surface was created. Additional cross-sections were interpolated within Civil 3D at the location of the proposed structure as needed. The existing topography for these cross-sections was determined in Civil 3D by sampling the 3D surface along the cross-section. Defined cross-sections were then imported into the hydraulic modeling software, HEC-RAS, to create an existing conditions model.

The existing conditions model was run at the following flow rates:

Table 2. Woodfin Wave regulatory and design flows

FIS determined flows (CFS)	**River Park Design Flows (CFS)**			
100 Year Return Period	Low Low	Low	Medium	High
63000	1200	2000	2800	3500

As noted above, regulatory flow rates are the result of a hydrologic study that was conducted as a part of FEMA’s Flood Insurance Study (FIS). The Woodfin Wave design flows were determined from a hydrologic analysis of the French Broad River based on stream gauge data (USGS, 2017). These flows are determined by averaging expected flows. The Woodfin Wave will be designed to create features within a range of flows that are commonly seen throughout the year.

For S_2O's model, the 100-year regulatory flow was run through the existing conditions model, which was created based on survey data and defined water surface elevations (WSE) for the 100-year flood event at each cross section. The HEC-RAS model outputs of these water surface elevations are displayed in Table 3 below[3]:

Table 3. Results for the existing conditions model for the 100-year flood event

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
5152.67	100 yr	63000	1926.4	1947.47		1949	0.001933	10	6947.86	605.57	0.41
4777.71	100 yr	63000	1923.79	1947.08		1948.31	0.001358	9.01	7918.24	539.38	0.35
4610.52	100 yr	63000	1926.27	1947.23		1947.9	0.001473	6.79	11023.92	788.72	0.28
4564.75	100 yr	63000	1925.21	1947.23		1947.82	0.001042	6.34	11756.6	805.37	0.25
4475.2	100 yr	63000	1925.18	1946.89		1947.71	0.00097	7.42	9977.24	671.17	0.29
4424.88	100 yr	63000	1923.48	1946.85		1947.66	0.000959	7.38	10081.17	669.96	0.29
4400	100 yr	63000	1924.07	1946.84		1947.64	0.000946	7.38	10104.88	669.94	0.29
4390	100 yr	63000	1923.94	1946.76		1947.62	0.000999	7.6	9926.46	669.49	0.3
4380	100 yr	63000	1924.42	1946.72		1947.61	0.001024	7.74	9880.64	669.39	0.3
4329.98	100 yr	63000	1924.87	1946.62		1947.55	0.001114	8	9819.75	670.84	0.32
4129.85	100 yr	63000	1923.14	1946.27		1947.3	0.001241	8.44	9682.08	724.22	0.33
3866.89	100 yr	63000	1924.44	1945.93		1946.98	0.001222	8.34	8860.8	618.26	0.33
3364.76	100 yr	63000	1923.2	1945.04		1946.28	0.001491	9.12	8121.01	572.35	0.36
2338.92	100 yr	63000	1922.95	1943.92		1944.84	0.001155	8.09	10609.29	813.46	0.32
1393.1	100 yr	63000	1922.36	1942.08		1943.43	0.001871	9.56	8244.24	717.77	0.4
555.61	100 yr	63000	1923.72	1940.01		1941.58	0.002534	10.16	6735.96	554.97	0.46
144.7	100 yr	63000	1912.34	1940.3	1930.17	1940.76	0.0007	5.44	11624.01	761.02	0.24

Once the flood surface elevation results were established per the above table, the conceptual design for the preferred alternative in the earlier conceptual design study was input and run under the model. This involved a process modifying the existing conditions cross sections to reflect proposed conditions.

The proposed drop structure that would create the wave was placed as located in S_2O's Conceptual Design Study and was initially modeled as a fixed rock structure adjacent to Riverside Park with no articulating or mechanical parts. A fixed rock structure is the most cost-efficient way to build a whitewater surf wave in the United States. This initial geometric modeling, which was iterated extensively to prevent an impact to the 100-year floodplain, caused an 18-inch rise in the water's surface. This does not meet the floodplain development requirements defined by FEMA and required by Buncombe County. The fact that the fixed rock structure caused a rise that S_2O could not mitigate through reasonable design steps suggested that a fixed rock structure was not feasible at this site. S_2O therefore devised three alternative designs, described further below, that included sections of articulating mechanical gates to see if adjustability in the structure would mitigate the flood impacts.

Articulating gates is a technology that can create a significant drop in a river at lower flows, but then collapse to reduce the impact to a 100-year flood event. In some instances, the gates can be configured to cause no impact to the 100-year flood elevations. The gates modeled by S_2O are the industry standard Obermeyer Hydro Gates shown below:

[3] Note that these elevations are not the regulatory elevations (shown later), but the modeled elevations created by running a floodplain model with the regulatory flows based on the survey information gathered in this study.

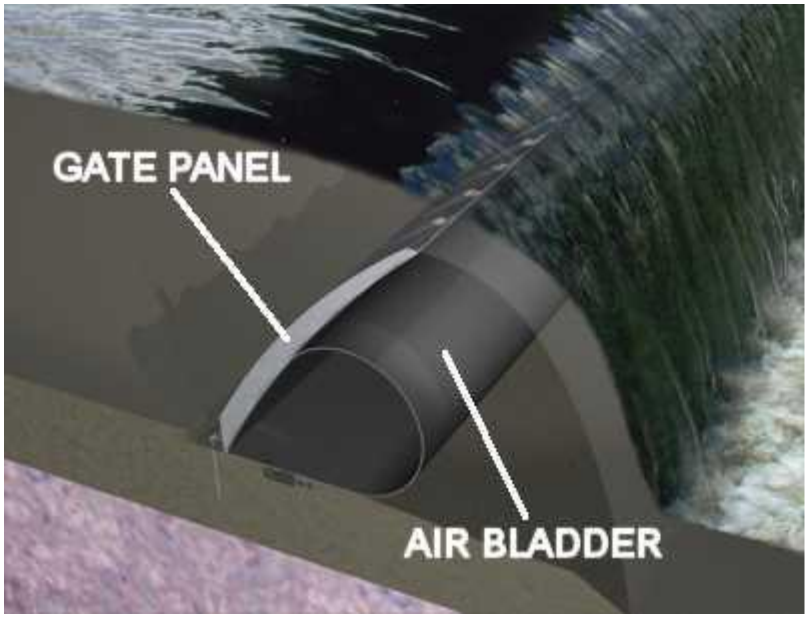

Figure 3. An Obermeyer-type gate can be used to raise the water surface elevation and create a surf feature in the river.

Obermeyer Gates, which are adjustable diversion structures that can be used to send water over a drop structure when raised, but cause little or no impact when lowered, are one option to utilize when floodplain constrictions limit the viability of a project in the United States. This technology can be costly compared to simpler rock-drop structures, so most communities try to minimize the use of this type of technology in order to avoid the costs. The gates, however, do provide an attractive way to create ideal wave features that are tunable and adjustable. This functionality can be used to create a wave feature that is better at a greater number of flow rates than a solid rock-drop structure. These gates function like air brakes on an airplane wing and can be designed and configured to raise the water surface elevation during lower flow events, but then collapse and disappear during higher water events. This can have the effect of not causing a rise, for that particular element of flow, during a 100-year event.

When it was determined that a rock-drop structure was not feasible at the Riverside Park location S_2O began a process of modeling Obermeyer-type gates to check the viability of this solution. In this process, S_2O attempted to create a balance between budget (i.e. how wide the adjustable cross section needed to be to meet floodplain development requirements) and performance. S_2O found that a significant amount of these adjustable gates had to be included in order to make the project feasible. In the end, a width of at least 172 feet of 6-foot high adjustable gates were required to attain a no-rise.

What follows are three conceptual design alternatives. S_2O is confident that each of the three would ultimately meet regulatory requirements and be permittable. Alternatives 1 and 2 would be sited adjacent to Riverside Park – the same site as the preferred alternative under the earlier study. They both would require mechanical gates, and represent the ends of the spectrum in terms of number and total scale of gates required – one that minimizes the utilization of gates and the other with a much more extensive usage of gates. The third alternative represents the rock-drop structure approach sited upstream alongside the WastePro property.

Alternative 1: Riverside Park—Minimal Adjustability Configuration

This proposed design alternative is shown below in Figure 4:

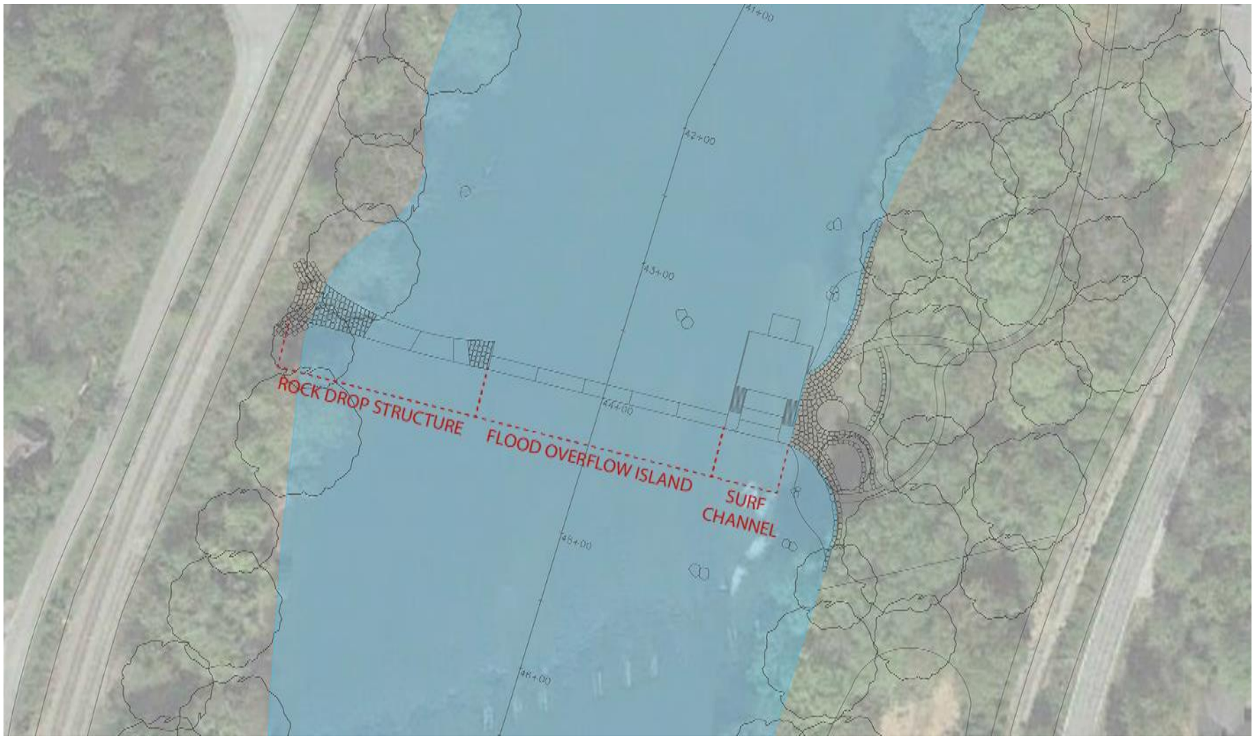

Figure 4. Configuration 1 split the water into three channels: A rock drop channel, a flood overflow channel, and a surf channel.

The cross section of the river in this configuration as modeled is shown below. Note that the Obermeyer Gates, which are closed in this image, are modeled in Black:

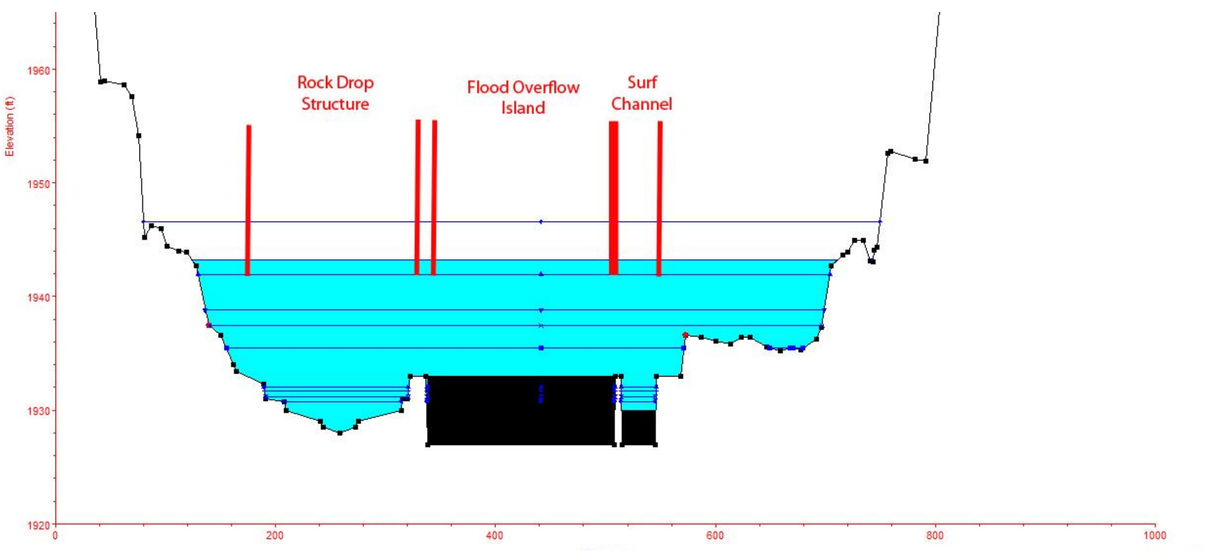

Figure 5. The minimum amount of required head-gates, shown in black, was found to be 200-215 linear feet of Obermeyer-type head-gates.

The costs for this are higher than those in the earlier study due to a combination of additional elevation of the drop structure and more extensive utilization of head-gates. The total costs expected for this option are $2,738,230. A detailed cost estimate may be found in Appendix D.

In this cross-section, the flow has been divided into three channels with the Obermeyers being used to maximize the potential of the rock drop structure. The lower horizontal lines show that all of the average flows fit within the Surf Channel and Rock Drop Structure Channel. As flood flows increase the Flood Overflow Island/Channel (actually not a real island, but a section incorporating the Obermeyer gates) would be dropped (the black panels in Figure 5 would be lowered) allowing higher flows to pass through the middle as well. S_2O expects that the feature can be designed such that there are also surfing opportunities in the Flood Overflow Island/Channel. This approach has moderate functionality for recreation purposes, but would not yield a world-class surf wave. As shown below, S_2O was not able to activate the required drop in the Surf Channel to provide for an ideal surfing wave with this configuration due to the fact that significant amounts of water would flow through the Rock Drop Channel leaving only a modest amount of opportunity to build up drop in the remaining channels.

The results of the proposed conditions model for this alternative design are displayed below in Table 4 which show no rise when compared to the Existing Conditions Model.

Table 4. Downstream Proposed Conditions Hydraulic Modeling Results.

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
5152.67	100 yr	63000	1926.4	1947.32		1948.88	0.001988	10.09	6860.04	596.42	0.41
4777.71	100 yr	63000	1923.79	1947.01		1948.16	0.001312	8.77	8749.28	683.26	0.34
4610.52	100 yr	63000	1926.5	1947.18		1947.84	0.000792	6.68	11390.49	786.81	0.27
4564.75	100 yr	63000	1926.5	1947.16		1947.8	0.000754	6.57	11536.35	802.44	0.26
4475.2	100 yr	63000	1926.5	1946.85		1947.7	0.001022	7.55	9819.17	671.1	0.3
4424.88	100 yr	63000	1926.3	1946.77		1947.65	0.001087	7.69	9717.19	669.83	0.31
4400	100 yr	63000	1927	1946.61		1947.63	0.000257	8.15	9229.39	669.56	0.34
4390	100 yr	63000	1925	1946.68		1947.59	0.000239	7.77	10213.36	669.29	0.31
4380	100 yr	63000	1924.42	1946.65		1947.58	0.000867	7.95	9721.37	669.2	0.31
4329.98	100 yr	63000	1924.87	1946.6		1947.53	0.001117	7.99	9809.68	670.8	0.32
4129.85	100 yr	63000	1923.14	1946.25		1947.28	0.001245	8.45	9668.11	723.54	0.33
3866.89	100 yr	63000	1924.44	1945.93		1946.96	0.001219	8.29	8857.63	618.24	0.33
3364.76	100 yr	63000	1923.2	1945.04		1946.27	0.001481	9.04	8125.27	572.4	0.36
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144.7	100 yr	63000	1912.34	1940.29	1930.17	1940.75	0.000701	5.45	11620.3	761.01	0.24

However, the 100-year flood elevations only tell a part of the story—these elevations show that the structure has virtually no drop at the 100-year flood flows. S_2O balanced the geometry such that there is still significant drop at more common flows. Figure 5, shown below, shows that the minimum adjustability configuration was found to have between 1.2 to 1.5 feet of drop at most common flows with the least number of adjustable gates.

Figure 6, shown below, is an output from the HEC-RAS software and shows the modeled water surface elevation at the modeled flow rates:

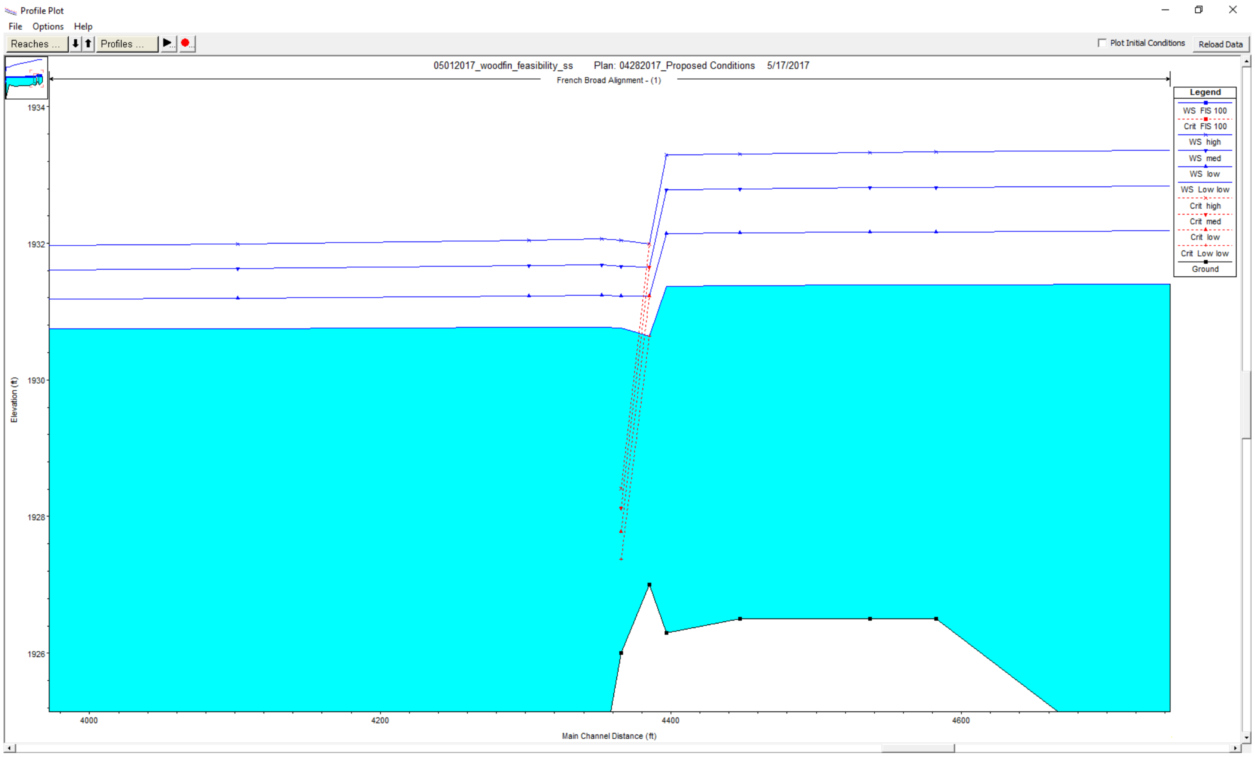


Figure 6. The total drop at low, medium, and high regular flows is between 1.2 and 1.5 feet

This figure shows that there is a modest amount of drop at the drop structure at these flows. This amount of drop suggests that, at lower flows the drop structure will have minimal power and will create a small feature but this feature will grow in power as the flows increase. We typically see this type of feature being a beginner-type feature at flows less than 1000 cfs. At higher flows, this feature will gain in power with some of S_2O's best waves having roughly 1-1.5 feet of drop at flows greater than 2000 cfs.

This amount of drop, however, does not provide for a significant surf wave in the narrower Surf Channel. The Surf Channel typically requires more than 2.5 feet of drop with 3 feet of drop being the optimal level for creating a large, glassy surf wave conducive to surfboarding. This type of configuration has been shown to be very popular in other locations. There is sufficient drop in this channel to create smaller features however, and this channel would function well as a bypass channel for novices, tubers, and those not wishing to navigate the main channel.

The results of this exercise to this point suggested that a whitewater park structure of a design that minimizes the use of gates is feasible at the site. However, the modeling exercise revealed that only a modest amount of force for creation of an ideal surf wave would be generated under this configuration, and it would function well at a narrower range of typical flow rates.

As a result, S_2O did undertake to understand how much energy could be generated in a single chute over a broader range of flows if the maximum amount of articulating gates and adjusting elements were to be deployed in a design at the same site.

Alternative 2: Riverside Park—Maximum Adjustability Configuration

The type of structure for the second design alternative would have a higher cost than the first design, but could provide more drop and power at this location and thus a higher quality, world-class surf wave. The Maximum Adjustability Structure was envisioned to use the full width of the river for deployment of gate and adjustability, thereby creating the greatest amount of force for wave creation in the surf channel. This configuration is shown below in Figure 7.

Figure 7. In the Maximum Adjustability Configuration, the full width of the river was utilized for Obermeyers in order to focus the full amount to flow into the surf channel.

Figure 8, shown below, shows the cross section of the Maximum Adjustability Configuration.

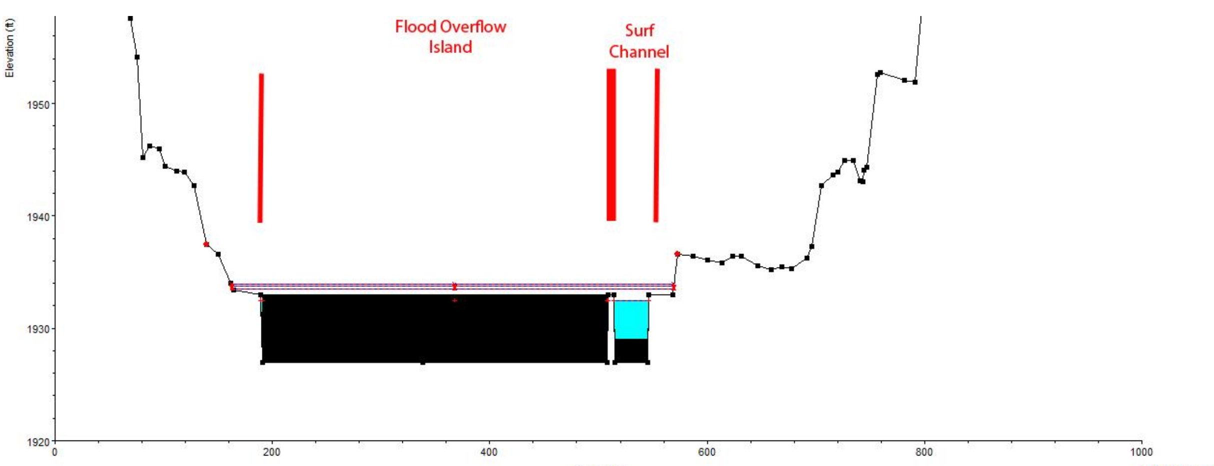


Figure 8. Another configuration was created that shows the maximum amount of adjustability possible at this location (closed Obermeyer Gates are shown in black).

In this design iteration, nearly the entire width of the river is taken up with adjustable gates. This would require 347 linear feet of adjustable gates that are 6 feet in height when closed. This configuration allows for the maximum amount of total drop at the surf wave channel on the right. As above, S_2O would expect to be able to design a surfable wave in the Flood Overflow Island/Channel portion as well that could function well during higher flows. Additional discussions with North Carolina Wildlife Resources suggest that some of the panels would need to connect with a fish-passage portion of the cross-section that would preferentially get water in this type of configuration.

Figure 9, shown below, shows this same cross section, but with the gates dialed open, illustrating how the water surface drops significantly when the gates are dropped during a flood event:

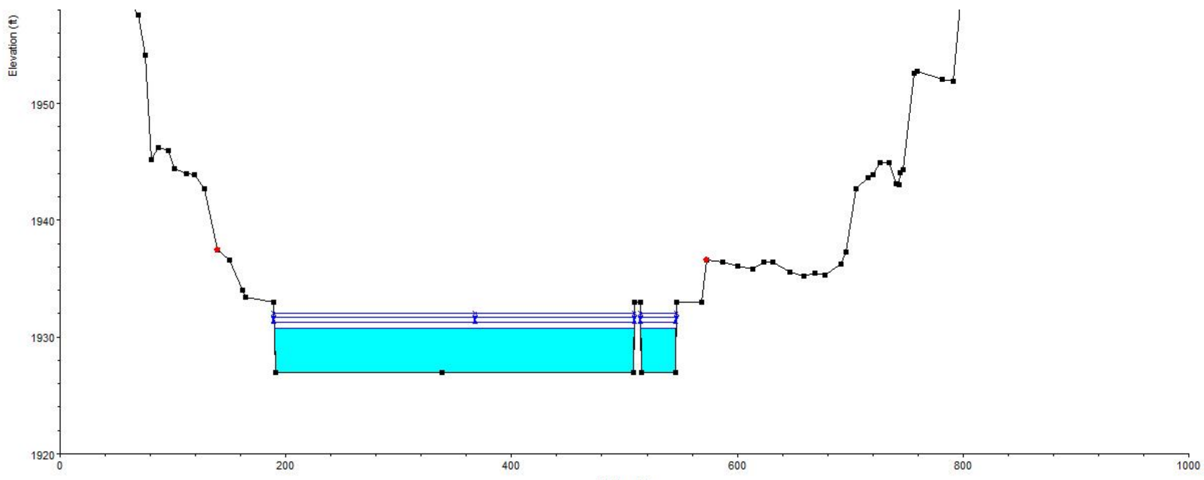


Figure 9. The adjustable head gates are dropped to accommodate larger flood flows in the channel.

This configuration creates significantly more drop at the cross section than the first design alternative. Figure 10, shown below, illustrates the amount of available drop.

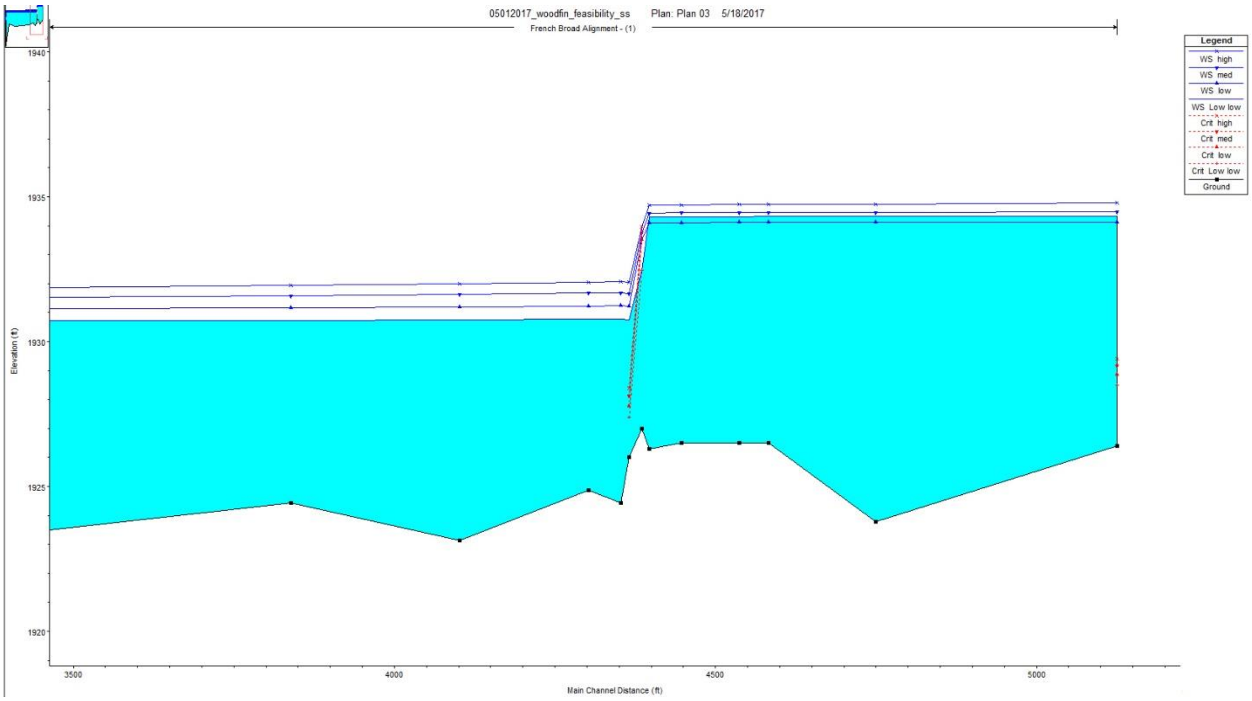


Figure 10. The maximum adjustability-type structure had significantly more drop with a total of 3.5' of drop available.

In this figure, it can be seen that more than 3.5 feet of drop is available at most common flows. The operator would be able to drop the water surface elevation in the Surf Channel by lowering the gates in the overflow areas in order to configure an ideal surfing feature. This type of structure could be a great world-class surf wave attraction and would reliably create whitewater at a wide range of flows.

There are examples in the world of drop structures utilized for kayaking and surfing that are full-width adjustable. The Boise Wave, for example, is a full-width structure where overflow flood control is used to push water into a surfing channel. This design would not provide an alternative milder by-pass channel for novices, tubers, and others that do not wish to navigate the more powerful wave that would result. An example of this type of drop structure can be seen below in Figure 11.

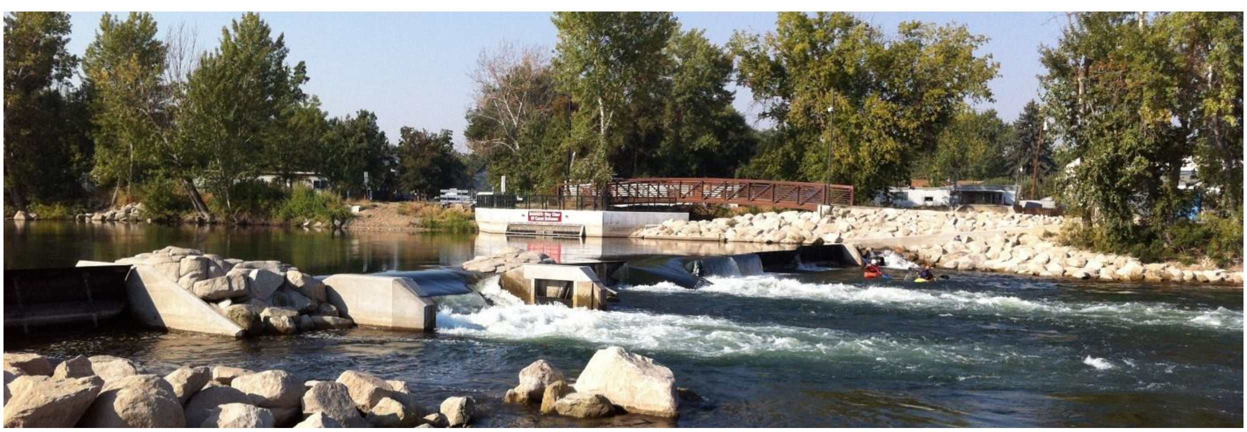


Figure 11. The Boise wave features sections of overflow and sections of surfing wave controlled by Obermeyer-type adjustable obstacles.

The costs to this fully adjustable configuration are greater than for Alternative 1, and are estimated at $3,337,617 as detailed in Appendix D. It should be noted that this configuration is an extreme example of how much adjustability could be used, and it is laid out establish both ends of the spectrum of likely designs at this location.

Note that under both Alternatives 1 & 2, adjustable articulating elements would be included in the designs. Maintenance of Obermeyer gates like this has proven to be very modest in other implementations. There would be ongoing operating costs involved in human management of gate positioning in order to optimize performance of the Wave and also to control gates during flood events.

Alternative 3: WastePro Site Rock-Drop Structure

In seeking alternative solutions to the utilization of mechanical adjustable features, S_2O noted a possible alternative site approximately 350 feet upstream of the originally-preferred Riverside Park site. That site is alongside property owned by WastePro of North Carolina, Inc. Its feasibility is rooted in the potential for removal of a significant amount of non-native fill material from the floodplain that currently rests on the site. Simple removal of a significant portion of the fill material from the site would have the effect of considerable lowering of the 100-year flood elevation. As long as the removal of the sufficient fill material was included as part of the comprehensive design and covered under the same Floodplain Permit Application as the Wave structure at this site, it would easily provide enough mitigation, or "flood credit," to allow for the construction of a rock-drop structure for the Wave there.

The WastePro site is approximately 3.35 acres in size, and most of the site consists of a level-top bench of fill material. It appears from the surface and sloping edges that the fill material consists primarily or entirely of construction and demolition debris (concrete, stone, metal, asphalt, etc.) and soil. The bench is capped with concrete and asphalt paving over much of the site, which extends upstream underneath the Craggy Bridge. The site includes two buildings and driveway access to Riverside Drive. There are indications that the Town of Woodfin might consider acquiring and excavating the site in conjunction with the Wave project, and create additional parking and park amenities in so doing. It is estimated that removal of most of the fill material would be required to gain the flood credit necessary for the permitting of a rock-drop Wave project at this site.

It is also important to note that the cost estimate of $1,936,477 for the rock-drop Wave project under this alternative is significantly less than the other two alternatives, however, it does not include the cost of acquiring the WastePro property, the costs of removal of fill material, nor the cost of landscaping and other amenities that would be required for park development. A detailed cost estimate is included in Appendix D. Not part of the scope of the S_2O study, developing estimates for those costs would be important to determine feasibility of this approach. In doing so, a critical step would be to determine environmental status of the bench of fill material. Having a local firm conduct Phase I and Phase II environmental site surveys, including core sampling of the fill, should be considered.

A rock-drop structure at this location meets many of the objectives outlined for the original proposed location. It does not include mechanical gates or other articulating elements. As such, it is very similar to the rock-drop structure contemplated in the preferred alternative laid out in the original feasibility study last fall. Its more-natural appearance would be aesthetically more positive than the other two alternatives. One key change from the preferred alternative in the earlier study is that the proposed structure is modeled with two channels and a central island. The reason for this is two-fold. First, our modeling indicates that a narrower main surf channel would provide greater performance than a single channel structure. The second is that providing a narrower secondary “by-pass” channel would provide a convenient way for tubers, novices, and others not wishing to encounter a more powerful wave to navigate.   Because remnant bridge structures consisting of timbers, sharp rocks, and protruding steel bars are located mid-channel just downstream and would present a safety hazard, removal of those elements would be required.

The proposed design is shown below in Figure 12.

Figure 12. An upstream site was modeled that proved to be easier to create and configure.

A cross section of the proposed solid rock design is shown below. This rock design features multiple stages that allow the river to widen naturally as flows rise. The widths of these stages are configured, preliminarily, to create a similar drop at low and high flows. The cut area includes the removal of construction debris as a part of a cleanup process.

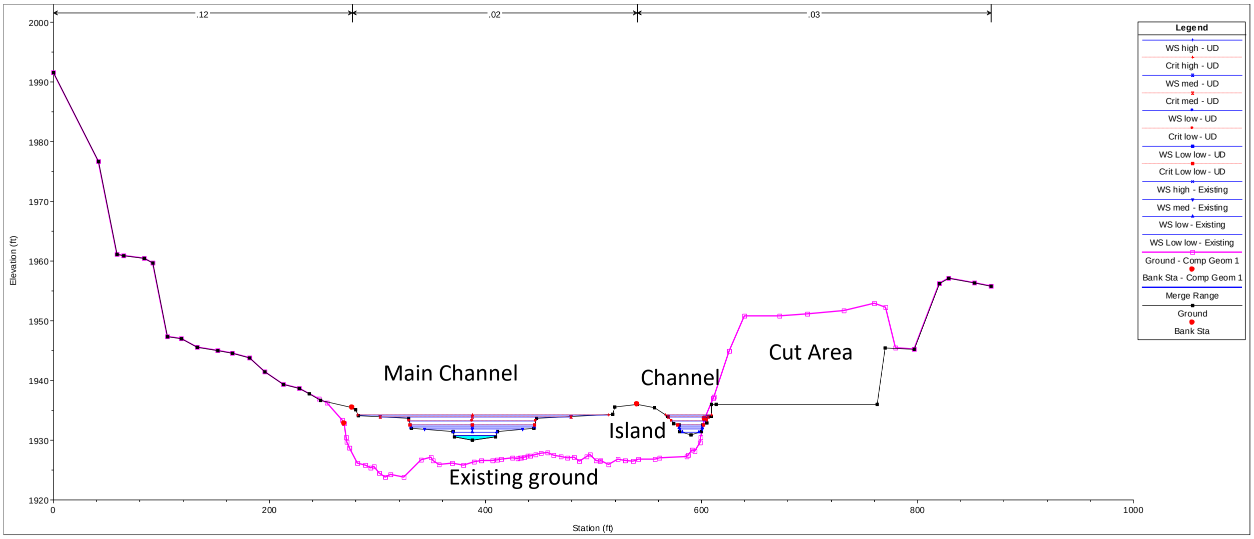


Figure 13. The alternative site features two channels with a mid-stream island. There is a significant amount of cut on this side.

The drop was preliminarily designed with 2 feet of drop at common flow rates. This can be seen below in Figure 14.

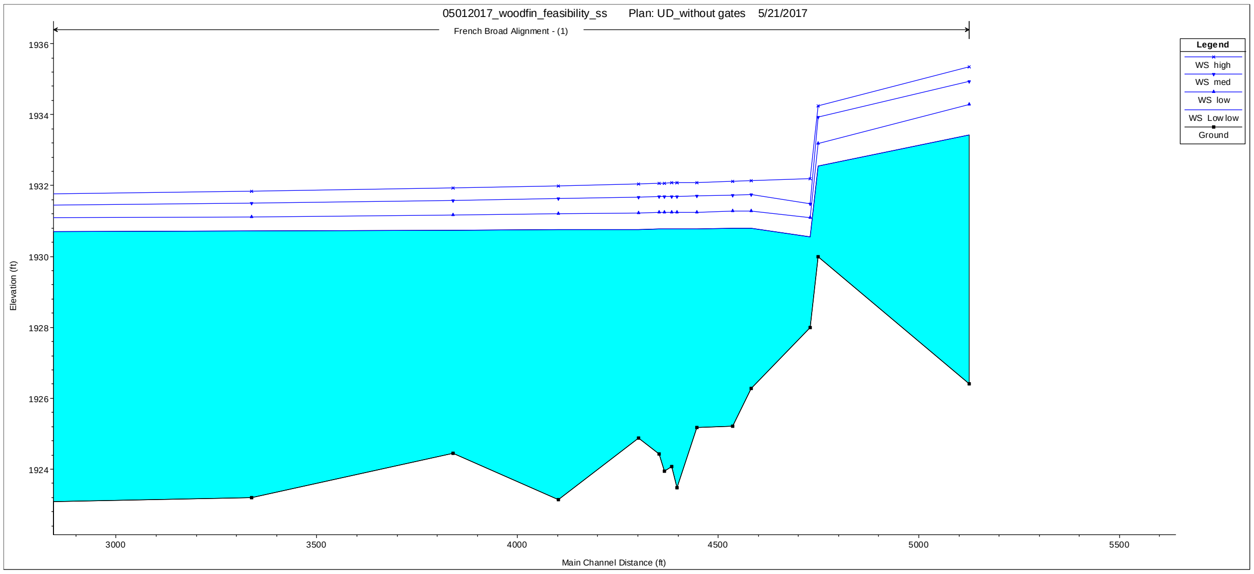


Figure 14. S_2O was able to generate a significant amount of drop across many common flow levels at this site without impacting the 100-year floodplain.

Comparative water surface elevations are shown below in the Results section.

Results

It is important to establish the results of the study in the context of the Floodplain Development Permit. As noted before it is a requirement, at this point, that the proposed drop structures be within 0.5 feet of the previously defined 100-year flood elevations and that proposed conditions do not exceed existing conditions.

Comparison with FIS Elevations

In order to better understand the study's results, we have graphed the three flow profiles. These include:

1) Water surface elevations from the 2010 FIS report[4] (FEMA, 2010),

2) The modeled existing conditions, and

3) The modeled proposed conditions under the three design alternatives.

S_2O created this comparison for both the downstream and originally proposed site, as well as the upstream alternative location just downstream of Old Leicester Bridge.

Models for Design Alternative 1 & 2

The FIS, existing, and downstream proposed water surface elevations are displayed below in Figure 15. The figure below assumes that all water surface elevations are presented in NAVD 88.

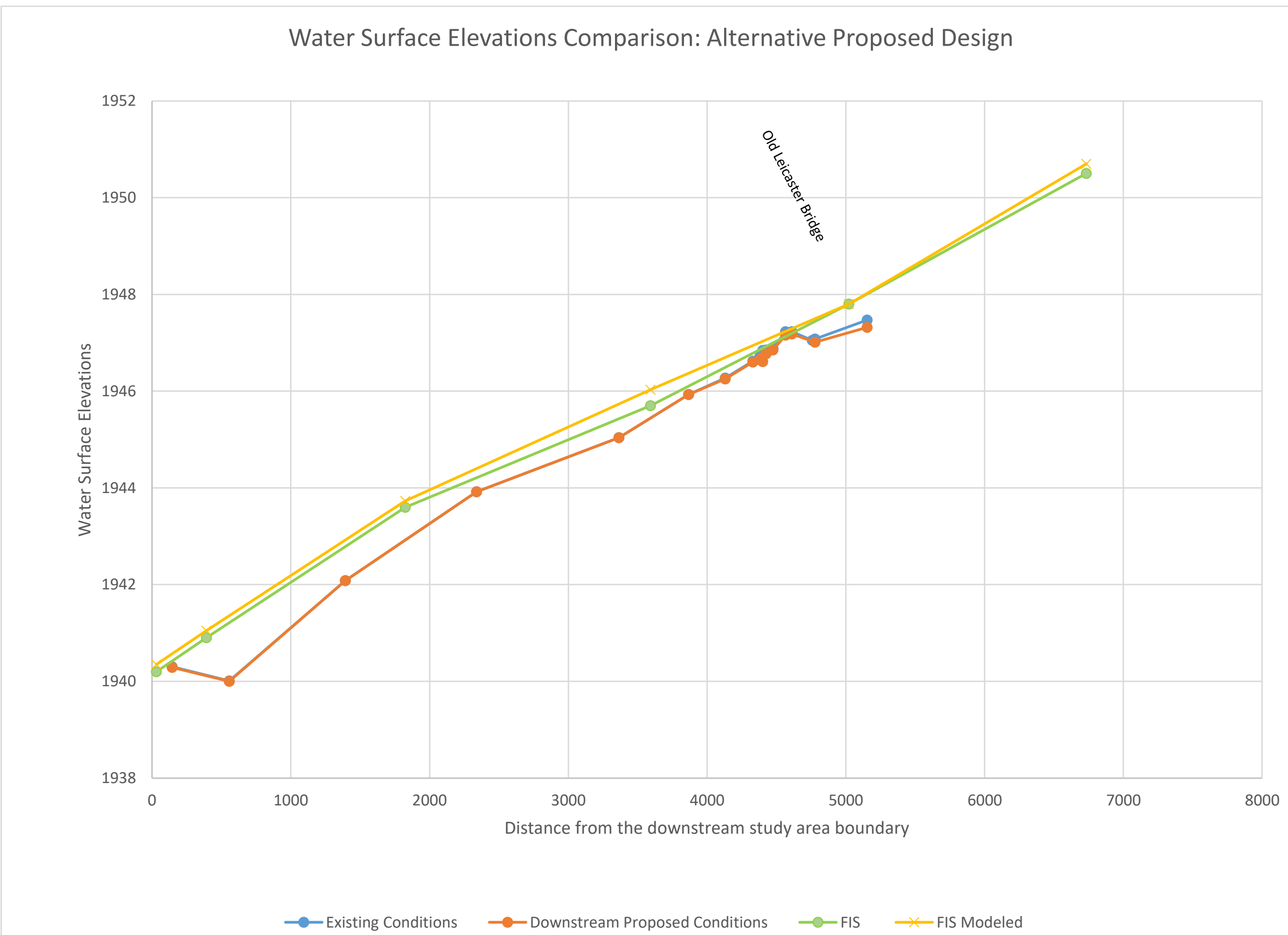


Figure 15. Comparison of Water Surface Elevations between FIRM, modeled FIRM, Existing, and the design alternative located at Riverside Park.

[4] The FIRM cross sections were interpolated and do not exactly match the location of the modeled cross-sections.

The results of this comparison show that the project meets the objectives of the study. The results suggest that the proposed conditions water surface levels are close to (less than 0.5 feet rise) or below the water surface elevations listed on the FIRM and that these water surface elevations do not cause a rise when compared to an existing conditions model created for this purpose. In fact, the results show that there is a greater rise between the Existing Conditions Model and the FIRM. Table 5, shown below, shows these results numerically.

Table 5. Comparison of Water Surface Elevations between FIRM, Existing, and the Downstream Proposed design at the 100-year flow rate (63,000 cfs). Cells in pink show a rise.

FIRM	S2o	FIRM (interpolated)	Existing conditions	Difference	Proposed Conditions	Difference	Difference
Stations	Stations (HEC-RAS)	WSE	W.S. Elev	(Existing-FIRM)	W.S. Elev	Proposed - FIRM	Proposed-Existing
		NAV 88 (feet)	NAVD88	NAVD88 (feet)	NAVD88 (feet)	NAVD88 (feet)	NAVD88 (feet)
7574	**6732.67**	**1950.50**					
	5152.67	*1948.01*	1947.47	-0.54	1947.32	-0.69	-0.15
7555	**5021.39**	**1947.8**					0
	4777.71	*1947.44*	1947.08		1947.01		
	4610.52	*1947.20*	1947.23	0.033738612	1947.18	-0.016261388	-0.05
	4564.75	*1947.13*	1947.23	0.10	1947.16	0.03	-0.07
	4475.2	*1947.00*	1946.89	-0.11	1946.85	-0.15	-0.04
	4424.88	*1946.92*	1946.85	-0.073479155	1946.77	-0.15	-0.08
	4400	*1946.89*	1946.84	-0.046920106	1946.61	-0.28	-0.23
	4390	*1946.87*	1946.76	-0.112225954	1946.68	-0.19	-0.08
	4380	*1946.86*	1946.72	-0.137531802	1946.65	-0.21	-0.07
	4329.98	*1946.78*	1946.62	-0.164031655	1946.6	-0.18	-0.02
	4129.85	*1946.49*	1946.27	-0.219957597	1946.25	-0.24	-0.02
	3866.89	*1946.10*	1945.93	-0.173560183	1945.93	-0.17	0
7540	**3592.25**	**1945.7**					
	3364.76	*1945.43*	1945.04	-0.389713322	1943.92	-1.51	-1.12
	2338.92	*1944.21*	1943.92	-0.290886625	1942.08	-2.13	-1.84
7521	**1824.76**	**1943.6**					0
	1393.1	*1942.79*	1942.08	-0.706814398	1942.08	-0.71	0
	555.61	*1941.21*	1940.01	-1.199103214	1940	-1.21	-0.01
7509	**391.53**	1940.9					
	144.7	*1940.42*	1940.3	-0.121488313	0	-1940.42	-1940.3
DAM 7504	**30.45**	1940.2					

Model for Design Alternative 3

This study also evaluated the proposed location at the upstream WastePro site and found that this site was feasible and actually provides the greatest assurance of regulatory approval given the ability to remove the fill material on-shore in order to gain flood credit. The FIS, existing, and downstream proposed water surface elevations are displayed below in Figure 15. This figure assumes that all water surface elevations are presented in NAVD 88.

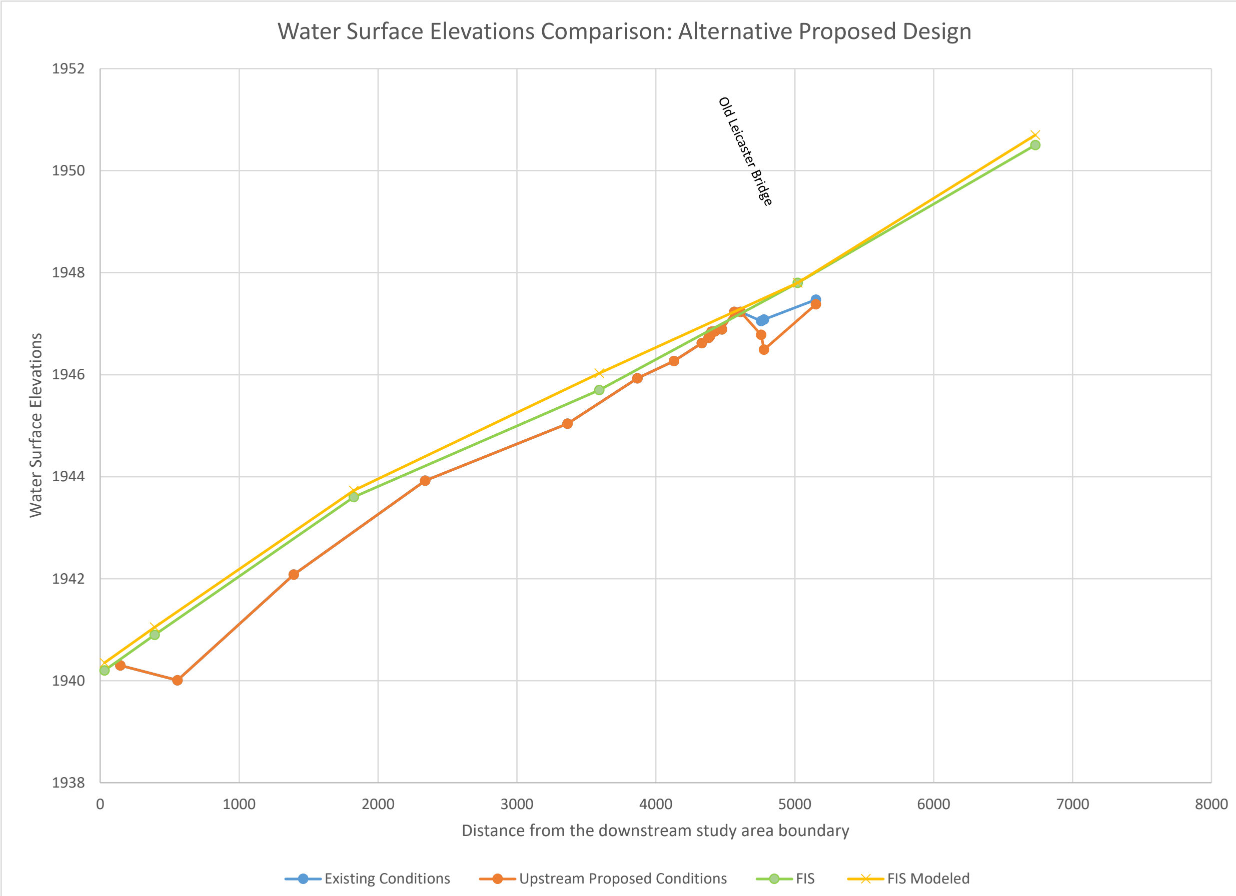


Figure 16. Comparison of Water Surface Elevations between FIRM, Modeled Firm, Existing, and the Upstream Proposed design.

These results show that Alternative 3 also meets the objectives of the study. The results suggest that the proposed conditions water surface levels are close to (less than 0.5 feet rise) or below the water surface elevations listed on the FIRM and that these water surface elevations do not cause a rise when compared to an existing conditions model created for this purpose. Table 6, shown below, shows these results numerically.

Table 6. Comparison of Water Surface Elevations between FIRM, Existing, and the Alternative Proposed design.

FIRM	S2o	FIRM (interpolated)	Existing conditions	Difference	Proposed Conditions	Difference	Difference
Stations	Stations (HEC-RAS)	WSE	W.S. Elev	(Existing-FIRM)	W.S. Elev	Proposed - FIRM	Proposed-Existing
		NAV 88 (feet)	NAVD88	NAVD88 (feet)	NAVD88 (feet)	NAVD88 (feet)	NAVD88 (feet)
FIRM 7574	**6732.67**	**1950.50**					
	5152.67	*1948.01*	1947.47	-0.54	1947.38	-0.63	-0.09
FIRM 7555	**5021.39**	**1947.8**					
	4777.71	*1947.44*	1947.08	-0.361932911	1946.49	-0.951932911	-0.59
	4757.71	*1947.41*	1947.05	-0.362544607	1946.78	-0.632544607	-0.27
	4610.52	*1947.20*	1947.23	0.03	1947.23	0.03	0
	4564.75	*1947.13*	1947.23	0.10	1947.23	0.10	0
	4475.2	*1947.00*	1946.89	-0.107420127	1946.89	-0.11	0
	4424.88	*1946.92*	1946.85	-0.073479155	1946.85	-0.07	0
	4400	*1946.89*	1946.84	-0.046920106	1946.84	-0.05	0
	4390	*1946.87*	1946.76	-0.112225954	1946.76	-0.11	0
	4380	*1946.86*	1946.72	-0.137531802	1946.72	-0.14	0
	4329.98	*1946.78*	1946.62	-0.164031655	1946.62	-0.16	0
	4129.85	*1946.49*	1946.27	-0.219957597	1946.27	-0.22	0
	3866.89	*1946.10*	1945.93	-0.173560183	1945.93	-0.17	0
FIRM 7540	**3592.25**	**1945.7**					
	3364.76	*1945.43*	1945.04	-0.389713322	1945.04	-0.39	0
	2338.92	*1944.21*	1943.92	-0.290886625	1943.92	-0.29	0
FIRM 7521	**1824.76**	**1943.6**					
	1393.1	*1942.79*	1942.08	-0.706814398	1942.08	-0.71	0
	555.61	*1941.22*	1940.01	-1.208090174	1940.01	-1.21	0
FIRM 7509	**391.53**	**1940.9**					
	144.7	*1940.42*	1940.3	-0.121488313	1940.3	-0.12	0
DAM 7504	**30.45**	**1940.2**					

Summary of Results

The results suggest that a project in Woodfin in, or near, the existing Riverside Park is feasible. The study found that if the project is created within Riverside Park, at the site proposed in S_2O's previous study, then the project will require adjustable features that can be lowered during high water flood events such as the 100-year flood. The study found that a structure at this location would require between 170 and 350 feet of adjustable gates in order to provide an attractive feature and still meet State and Federal Floodplain requirements.

S_2O also investigated an alternative site located upstream along the WastePro site. This site, which is approximately 450 feet upstream of the original proposed site, is the location of a fill area where construction waste was removed on the river right (east) side of the river. Removal of this fill in concert with the construction effort would allow for the creation of a rock-drop structure at this site that does not require articulating gates. This would represent a significant cost savings for the in-stream work that must be balanced against the costs of acquiring this land and conducting the brownfield cleanup.

The below table provides a quick and simple comparison of the relative pros and cons of the three design alternatives.

Table 7. Comparison of design alternatives

Alternative Design	1	2	3
Location	Riverside Park	Riverside Park	WastePro Site
Cost	$ 2.7 million	$ 3.4 million	$1.9 million
Mechanical Gates?	Yes	Yes	No
Visual Aesthetics of Wave Structure	Weak Due to Gates	Weak Due to Gates	Strong – Rock and Concrete Only
Quality of Surf Wave	Good	World-Class	World-Class
Width of Surf Channel	Wide	Narrow	Wide
Mechanical Adjustability of Surf Wave?	No	Yes	No
Operation and Maintenance Required?	Yes	Yes	No
Functionality Over Range of Flows	Medium	High	Medium-High
By-Pass Novice Channel?	Yes	No	Yes
Costs of On-Shore Site Acquisition and/or Development	Low	Low	Significantly Higher
Outlook for Approval Under Flood Regulations	High Confidence	High Confidence	Very High Confidence
Includes Bypass Channel for Fish/Navigation	Yes	Available to include	Yes

Permitting Summary

S_2O met at the project site with representatives from the USACE, NCWRC, USFWS, and NC DWR to discuss the proposed project and define the permitting process. The meeting defined a process, supported by the Clean Water Act's requirements, in which Woodfin would pursue an individual permit with the USACE in order to proceed with the project. The individual permit includes input from associated regulatory agencies, project stakeholders, such as rafting companies in the area, and the public. The project owner is required to consider and address comments from this process as a part of the design process. All of the agencies involved in the meeting expressed a preference for the two-channel design to allow for mitigating impacts possibly created by the wave feature by providing a safe boater and fish bypass. The specific objectives of this bypass will be addressed by the design team. A full set of minutes from this meeting is included in Appendix E of this report and should be used by the future design team to guide the design and permitting process.

Next Steps

The study suggests that the Town has several choices including adjustable and non-adjustable structures, which can be built at either the proposed site, or the upstream alternative site along the WastePro property. In order to move the project forward, the Town of Woodfin will need to select a preferred alternative and scope for the next phase. This scope may also include tasks for brownfield clean-up and park design at the WastePro Site. The defined scope of the project can be used to bid the project for design and permitting, the next step in the process. A subsequent phase will later be solicited for construction and tuning of the final design.

Appendix A: NC NFIP Guidance Document #1: NC NFIP Review of No-Rise Submittals

NC NFIP Guidance Document #1: NC NFIP Review of No-Rise Submittals

Background

44 CFR Section 60.3(d)(3) states that a community shall "prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge." In order to comply with this regulation, local communities must obtain, review, and approve a certification to that effect prepared by a professional engineer and supported by hydraulic modeling. This is commonly referred to as a "No-Rise" or "No-Impact" certification, although these terms are not interchangeable.

Issue

The North Carolina Department of Public Safety National Flood Insurance Program (NC NFIP) will, upon request from a North Carolina community, review No-Rise certifications for projects within their jurisdictions. The *Procedures for "No-Impact" Certification for Proposed Developments in Regulatory Floodways* prepared by FEMA Region IV provides a basic outline of the submittal requirements, but further explanation, based on experience and precedent, is needed.

The FEMA Region IV guidance also specifically addresses "No-Impact" certifications. In a "No-Impact" certification, there is no *change* to flood elevations in any of the prepared hydraulic models. Because this would only apply when very minimal floodway encroachment occurs, specific guidance for the more common "No-Rise" certification is needed. A "No-Rise" certification simply states that the proposed project meets the requirements of 44 CFR Section 60.3(d)(3) and will not *increase* flood levels.

Final Guidelines

The following submittal requirements and guidance provides a description of the items needed to review a hydraulic model in order to confirm it complies with the requirements of 44 CFR Section 60.3(d)(3).

Submittal Requirements

A community should review a "No-Rise" submittal for completeness prior to forwarding it to NC NFIP for review. A complete "No-Rise" submittal shall include the following:

- Hydraulic models in a currently approved FEMA hydraulic model, including:
    - Effective Model (may be older than a currently approved model);
    - Duplicate Effective Model (Effective Model run on the modeler's software and hardware)
    - Corrected Effective Model (if needed to correct errors in the model);
    - Existing Conditions Model (model the existing project area and man-made changes since the Effective Model);
    - Proposed Conditions Model (model the proposed project area);
- Project narrative;
- Topographic work map;
- Cross-section plots;
- Property survey;
- Preliminary or Recorded Plat (if applicable)
- No-Rise Certification;
- Cover letter from the Community requesting review.

The Hydraulic models shall be in their computer program format. Other documentation can be either hard-copy or electronic format. PDF format is preferred.

In order to establish a "No-Rise", an engineer will perform hydraulic modeling in accordance with standard engineering practice to determine the impacts on the stream. The majority of these models are performed in HEC-RAS, since that is the original modeling software for most streams in North Carolina. Hydraulic models in FEMA's list of

Numerical Models Meeting the Minimum Requirement of the NFIP are also acceptable. See:

> https://www.fema.gov/hydraulic-numerical-models-meeting-minimum-requirement-national-flood-insurance-program

An electronic copy of the hydraulic modeling must be provided. It is preferred that each geometry file is contained within a single HEC-RAS project, but this is not required. A paper copy is not needed for review by NC NFIP. All models should have a precision matching the internal quality-assurance review by the North Carolina Floodplain Mapping Program (NCFMP), which is normally 0.01' for NCFMP produced studies.

Hydraulic Models

The EFFECTIVE model is simply the model used to develop the Flood insurance Study. Recent studies, and some older studies, are available for no fee from NC NFIP. If NC NFIP does not have the study on file, the requestor should contact the FEMA Engineering Library. If the model is not available, the requestor will need to create an effective model that duplicates the results in the Flood Insurance Study.

The DUPLICATE EFFECTIVE model is the Effective model run using the modeler's hardware and software. For HEC-RAS models, the software is preferably the current version of HEC-RAS (currently HEC-RAS 5.0.3), although any version 3.1.1 or later is currently acceptable. The Duplicate version should not be an earlier version than the Effective version. Occasionally floodway or NEA widths are set using Method 4 in the Effective model. The Duplicate Effective floodway limits should always be set using Method 1 to match the Effective model. Also, starting water surface elevations should always be set using a fixed water surface elevation to match the Effective model.

The CORRECTED EFFECTIVE model may or may not be required, depending on whether or not there are errors in the Effective model. These errors should be fixed in Corrected Effective model. Some of the errors may include:

- Inappropriate expansion and contraction coefficients;
- Datum adjustments;
- Bridge modeling errors (appropriate loss calculations, weir coefficients, pier coefficients, bridge rails);

- Culvert modeling errors (size, materials, entrance and exit losses);
- Incorrect ineffective flow locations and elevations;
- Incorrect or unreasonable Manning's roughness coefficients (supporting documentation is required);
- Gross errors in topography at existing sections;
- Negative surcharges and surcharges over 1.00'.
- Man-made changes prior to the Effective Model that are not captured in the model.

The EXISTING CONDITIONS model inserts cross-sections and/or modifies effective cross-sections to accurately portray the existing conditions at the project site. These cross-sections should not be duplicated or interpolated, but should be based on field surveys at the project site and field surveys and/or other available topographic data away from the project site. Enough sections should to be added in order to accurately model the proposed changes. Encroachment stations shall be added to new cross-sections, based on the FIRM or interpolated from the NEA tables. The encroachment stations should then be adjusted so that the floodway water surface elevations match the Corrected Effective (or Duplicate Effective, if the Corrected Effective is not required) and do not exceed 1.00' surcharge. The Existing Conditions model should also incorporate any man-made changes since the Effective Model. Non-permitted floodway encroachments associated with the project (current violations) should not be included in the Existing Conditions model. The non-permitted encroachments should be included in the Proposed Conditions model or removed prior to permitting.

The Existing Conditions model may also need to include additional cross-sections upstream or downstream of the existing model. This will be necessary if the boundary water surface elevations do not match between the Existing Conditions model and the Proposed Conditions model. Sometimes, this may not be possible, or the effect is so large that the models simply will not match. In these cases, run the model a minimum of one mile past the project limits. When the effect of a project extends upstream through a different model, either that model or the information contained in the model should be used to analyze the hydraulics upstream.

The PROPOSED CONDITIONS model is a modification of the Existing Conditions model. FEMA has provided NC NFIP guidance that all elements of a proposed project must be modeled, so all revisions associated with the project should be included, even if those revisions are not within the floodway itself. For example, changes outside of the floodway that are integral to the project should be included, such as approach fill for bridges or "conveyance easements." There should be no increase in the water surface elevations for both the base flood and the floodway / NEA runs. There should be no change in the floodway widths on either side of the stream compared to the Existing Conditions model.

Documentation

The submittal shall include a detailed NARRATIVE of the project and the modeling methodology. Document all modifications to the Effective model integrated into the Corrected Effective and Existing Conditions models. Provide the source of additional cross-section topographic data. Provide copies of the floodway data tables and flood profiles or LDS tables, the current FIRM, supporting calculations and documentation, and photographs. Also, include any special conditions of the No-Rise, including establishing "conveyance easements" or specific landscaping allowances or restrictions.

Include a TOPOGRAPHIC WORK MAP of the project site, to include:

- Floodplain and Floodway Limits;
- Topography;
- Locations and labels on effective and new cross-sections;
- Vicinity map;
- Existing and proposed features and structures;
- Building corridors and conveyance easements.

Provide CROSS-SECTION PLOTS of all cross-sections within the project boundary. Features, structures, and changes should be labeled. Grid squares or elevations should also be noted on the cross-sections.

A certified PROPERTY SURVEY is also required. A scaled plat is acceptable, provided the local floodplain administrator considers it current and accurate for the purposes of the No-Rise Certification.

A PRELIMINARY or RECORDED PLAT SURVEY is required if a building corridor (an area set aside for construction) and/or a conveyance easement (an area of increased conveyance set aside to mitigate obstructions) are conditions of the certification. The plat should indicate that the property owners agree and acknowledge that they have granted permission for the mitigation areas to be placed on their property in perpetuity. The maintenance specifications for the conveyance easement should be included. The location, dimensions, and duration of the building corridors and conveyance easements should be specified on the plat. Conveyance easements will be checked during Community Assistance Visits (CAVs), and failure to maintain an easement may be considered a violation of the community's flood damage prevention ordinance.

A template for the NO-RISE CERTIFICATION is provided at the end of this document. It should be sealed by the design engineer. For work in North Carolina, the certification shall be sealed by an engineer registered in North Carolina. The certification shall address base flood elevations, floodway or NEA elevations, and floodway widths. The community may sign off on the form itself, or provide other written response (approval or denial) following the review.

When NC NFIP is asked to review the No-Rise, a COVER LETTER should be included with the No-Rise Certification from the local floodplain administrator formally requesting a technical review of the submittal.

Additional Considerations

It is the interpretation of NC NFIP that the term FLOOD LEVELS as contained in 44 CFR 60.3(d)(3) refers to both base flood elevations and the surcharge elevations associated with the base flood discharge. The base flood is normally considered the 1% annual-chance, or 100-year flood. In communities that enforce a higher base flood, such as future conditions or 0.2% annual-chance (500-year), the standard enforced by the community should be reflected in the No-Rise hydraulic model.

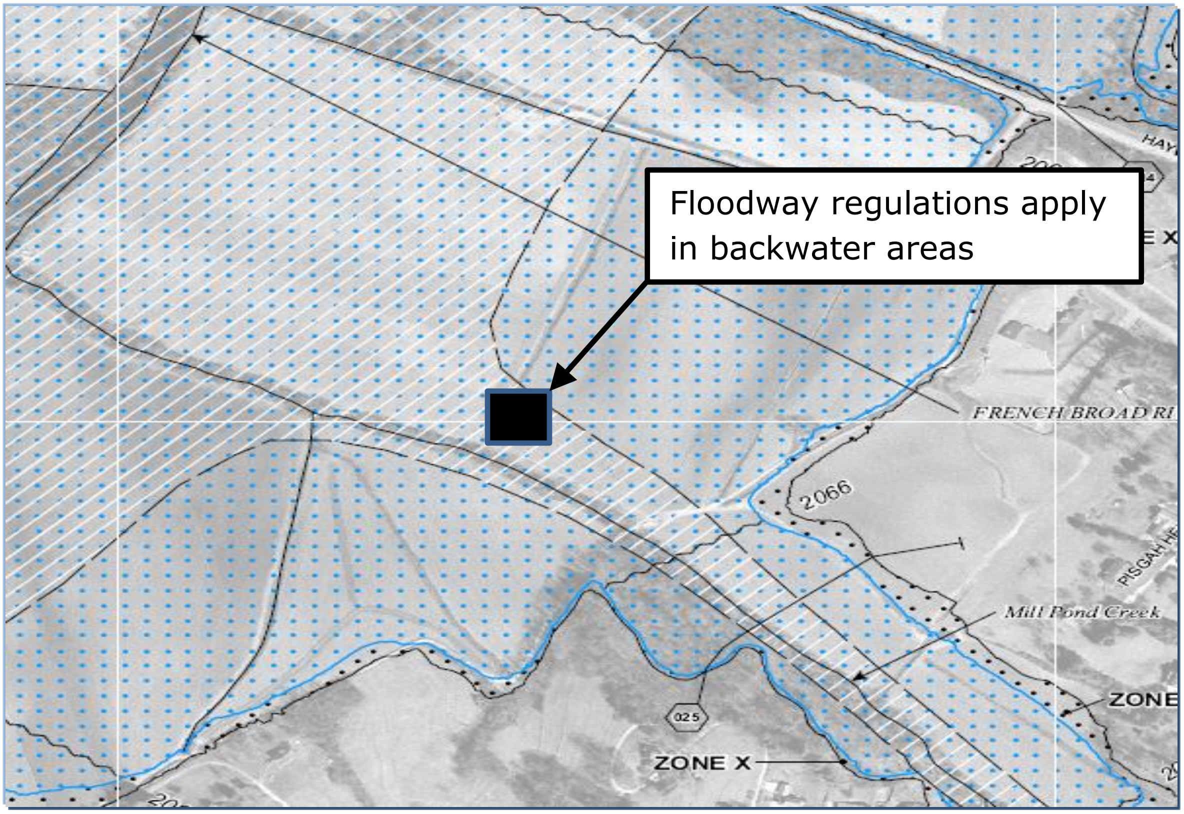
In North Carolina, Limited Detail Study streams include a NON-ENCROACHMENT AREA (NEA), which, at the local level, is generally regulated the same as a floodway. Projects affecting streams modeled using limited detailed methods shall meet the same criteria as detailed streams. The non-encroachment limits and the surcharge water surface elevation established in the original hydraulic model for the Limited Detail Study shall be used as the effective model limits.

No-Rise submissions should not OPTIMIZE floodway and non-encroachment widths. Because the purpose of the No-Rise is to determine the *impact* on the flood levels, the parameters (including encroachment stations) should remain as unchanged as possible from the effective model. Changes in encroachment stations require a Letter of Map Revision (LOMR).

Some projects, due to their nature or the size of the project, MAY NOT REQUIRE A HYDRAULIC ANALYSIS to comply with 44 CFR 60.3(d)(3). However, these projects still require an engineer's certification that the project will not cause an increase in flood elevations in accordance with 44 CFR 60.3(d)(3). A hydraulic analysis may not be needed for:

- Permanent removal of an existing structure;
- Replacement of a structure within the same footprint, as long as there is no new vertical obstruction;
- Projects that do not increase existing grade, such as driveways;
- Small, isolated obstructions, such as a mailbox, a park bench set parallel to flow, or single utility pole;
- Light-duty fences that will likely collapse or not provide obstruction in a flood event;
- Development in the conveyance shadow of an existing structure;
- Greenway trails placed at grade with minimal clearing (not including structures);
- Structures that span the entire floodway above the surcharge elevation, with no encroachments (piers, piles, trusses, etc.) within the floodway;
- Maintenance of existing uses, such as bridges, rights-of-way, and easements.

No-Rise reviews are applicable in all floodways and non-encroachment areas even if the base flood elevation is driven by BACKWATER or coastal flooding effects from a downstream waterbody.



NC NFIP does not "APPROVE" a No-Rise. NC NFIP will determine: A) Does the No-Rise Certification meet FEMA's guidelines for a No-Rise, and B) Does the documentation meet the requirements of 44 CFR 60.3(d)(3)? The community is responsible for final approval and permitting of all projects within the Special Flood Hazard Area.

All communities, including counties, municipalities, and Native American Tribes, should insure compliance with the ENDANGERED SPECIES ACT (ESA) as it relates to all projects within their jurisdiction, including projects within the Special Flood Hazard Area. FEMA requires ESA compliance documentation with CLOMRs and CLOMR-Fs. However, FEMA and NC NFIP do not require ESA compliance documentation for a No-Rise review.

NC NFIP REVIEW TIME for a No-Rise submittal is generally less than four weeks. NC NFIP will coordinate with the local floodplain administrator if the review time is anticipated to be longer. The submitter is encouraged to contact the NC NFIP several days after submittal to ensure the documents were received.

NC NFIP does not charge a FEE to North Carolina municipalities for reviewing a "No-Rise" certification.

A rise within an INTERNAL BRIDGE SECTION does not necessarily invalidate a No-Rise. For example, if the rise is due to an increase in the low chord height of the bridge, but there is a reduction in flood elevation upstream of the bridge, the "No-Rise" may still be valid.

Changes in ROUGHNESS COEFFICIENT from the Existing Conditions Model to the Proposed Conditions Model should be documented and justified.

Due to the availability of LiDAR topographic data and the ability for GIS and CAD systems to import topographic data into RAS, the use of cross-section INTERPOLATION is discouraged. Interpolated cross-sections may be allowed outside of the project area where increased precision is needed. Interpolated cross-sections shall be identical in the Existing Conditions and Proposed Conditions models.

Hydraulic models generally should not be TRUNCATED. Even modest modern computers can currently process large model runs in seconds, so there is no appreciable gain to be made by truncating a model. The model shall never be truncated if the water surface elevations and velocities do not match between the Existing and Proposed models at the upstream cross-section to the nearest 0.01'.

When the effects of a project extend past the end of the effective model into an area analyzed by a DIFFERENT MODEL, the modeler may adjust the boundary conditions accordingly in the upstream model. Alternatively, the modeler may use the effective information from the upstream model inserted into the Corrected, Existing, and Proposed models to analyze the effects of the project.

NC NFIP will review hydraulic model submittals from communities where the ORDINANCE DIFFERS from the requirements of 44 CFR provided those criteria are outlined in the written request from the community.

There should be no changes to the HYDROLOGY in the model unless there is an obvious and significant error in the original model. Changes to hydrology based just on the methodology should not be considered, but should be only based on gross errors in drainage area or land cover.

Changes in hydrology will be rare, and should be coordinated with the NC NFIP in advance.

Just because a project does not cause a rise does not mean that a follow-up LETTER OF MAP REVISION (LOMR) is not required. 44 CFR 65.3 states "A community's base flood elevations may increase or decrease resulting from physical changes affecting flooding conditions. As soon as practicable, but not later than six months after the date such information becomes available, a community shall notify the Administrator of the changes by submitting technical or scientific data in accordance with this part. Such a submission is necessary so that upon confirmation of those physical changes affecting flooding conditions, risk premium rates and flood plain management requirements will be based upon current data." FEMA's guidance has generally been that a decrease of less than 0.10' does not require a map change, but reductions greater than 0.10' or changes in the floodway or non-encroachment width on either side of the stream, or changes in the location of the stream as shown on the Flood Insurance Rate Maps, will require a LOMR from the community within six months of completion of the project. Changes in hydrology also require a LOMR.

References

- 44 CFR 60.3(d)(3)
- 44 CFR 60.3(c)(10)
- FEMA Region IV Procedures for "No-Impact" Certification for Proposed Developments in Regulatory Floodways, September 2004

Discussion Summary

- North Carolina Association of Floodplain Managers Spring 2012 *Flash Flood News*
- North Carolina Association of Floodplain Managers Spring 2012 Conference, May 9, 2012, New Bern, NC
- North Carolina Association of Floodplain Managers Fall 2012 Conference, October 26, 2012, Asheville, NC
- Association of State Floodplain Managers National Conference, June 4, 2015, Atlanta, GA
- North Carolina Association of Floodplain Managers Spring 2016 Conference, May 12, 2016, Myrtle Beach, SC

Points of Contact

- John Gerber, PE, CFM, North Carolina NFIP Coordinator
- Dan Brubaker, PE, CFM, North Carolina NFIP Engineer

NO-RISE CERTIFICATION

This document is to certify that I am duly qualified engineer licensed to practice in the State of North Carolina. It is to further certify that the attached technical data supports the fact that the proposed _____[Project]___ will not increase the base flood elevations or floodway elevations, or impact the floodway widths, on _____[Stream]_____________ at published cross-sections in the Flood Insurance Study for _____[Community]_________, dated _____[Date]_____ and will not increase the base flood elevations or floodway elevations, or impact the floodway widths at unpublished cross-sections in the area of the proposed development.

Seal and Signature

____
Name

____
Title

____

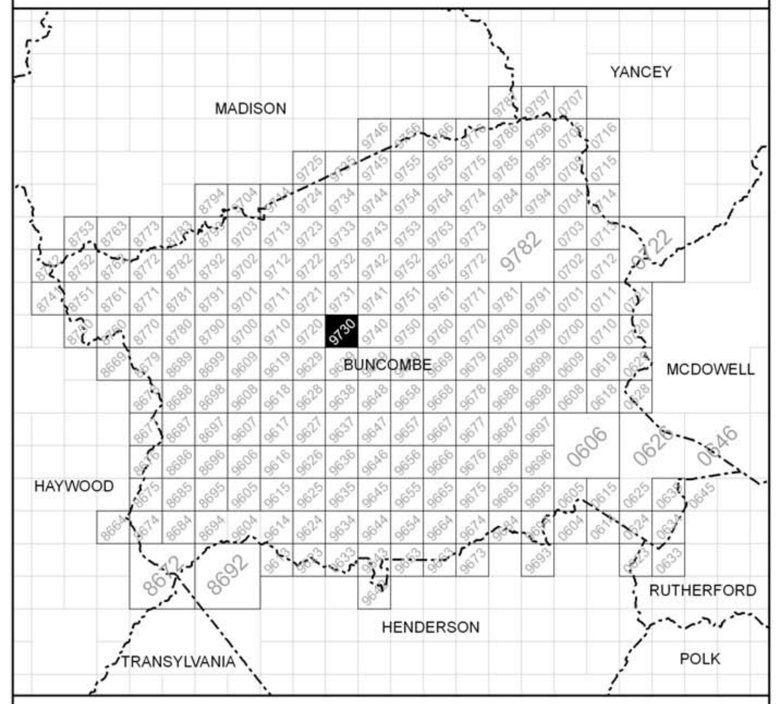
____
Address

____
Date

FOR COMMUNITY USE ONLY		
☐ Approved	☐ Disapproved	
______________________	______________________	____________
Name and Title	Signature	Date

Appendix B: Firm Panel for the French Broad River near Woodfin, NC

STATE OF NORTH CAROLINA FIRM PANEL LOCATOR DIAGRAM



DATUM INFORMATION

The **projection** used in the preparation of this map was the North Carolina State Plane (FIPSZONE 3200). The **horizontal datum** was the North American Datum of 1983, GRS80 ellipsoid. Differences in datum, ellipsoid, projection, or Universal Transverse Mercator zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdictional boundaries. These differences do not affect the accuracy of this FIRM. All coordinates on this map are in U.S. Survey Feet, where 1 U.S. Survey Foot = 1200/3937 Meters.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988 (NAVD 88). These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. An average offset between NAVD 88 and the National Geodetic Vertical Datum of 1929 (NGVD 29) has been computed for each North Carolina county. This offset was then applied to the NGVD 29 flood elevations that were not revised during the creation of this statewide format FIRM. The offsets for each county shown on this FIRM panel are shown in the vertical datum offset table below. Where a county boundary and a flooding source with unrevised NGVD 29 flood elevations are coincident, an individual offset has been calculated and applied during the creation of this statewide format FIRM. See Section 6.1 of the accompanying Flood Insurance Study report to obtain further information on the conversion of elevations between NAVD 88 and NGVD 29. To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the North Carolina Geodetic Survey at the address shown below. You may also contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

North Carolina Geodetic Survey
121 West Jones Street
Raleigh, NC 27601
(919) 733-3836
http://www.ncgs.state.nc.us

County Average Vertical Datum Offset Table

County	Vertical Datum Offset (ft)
Buncombe	-0.16
Example: NAVD 88 = NGVD 29 + (-0.16)	

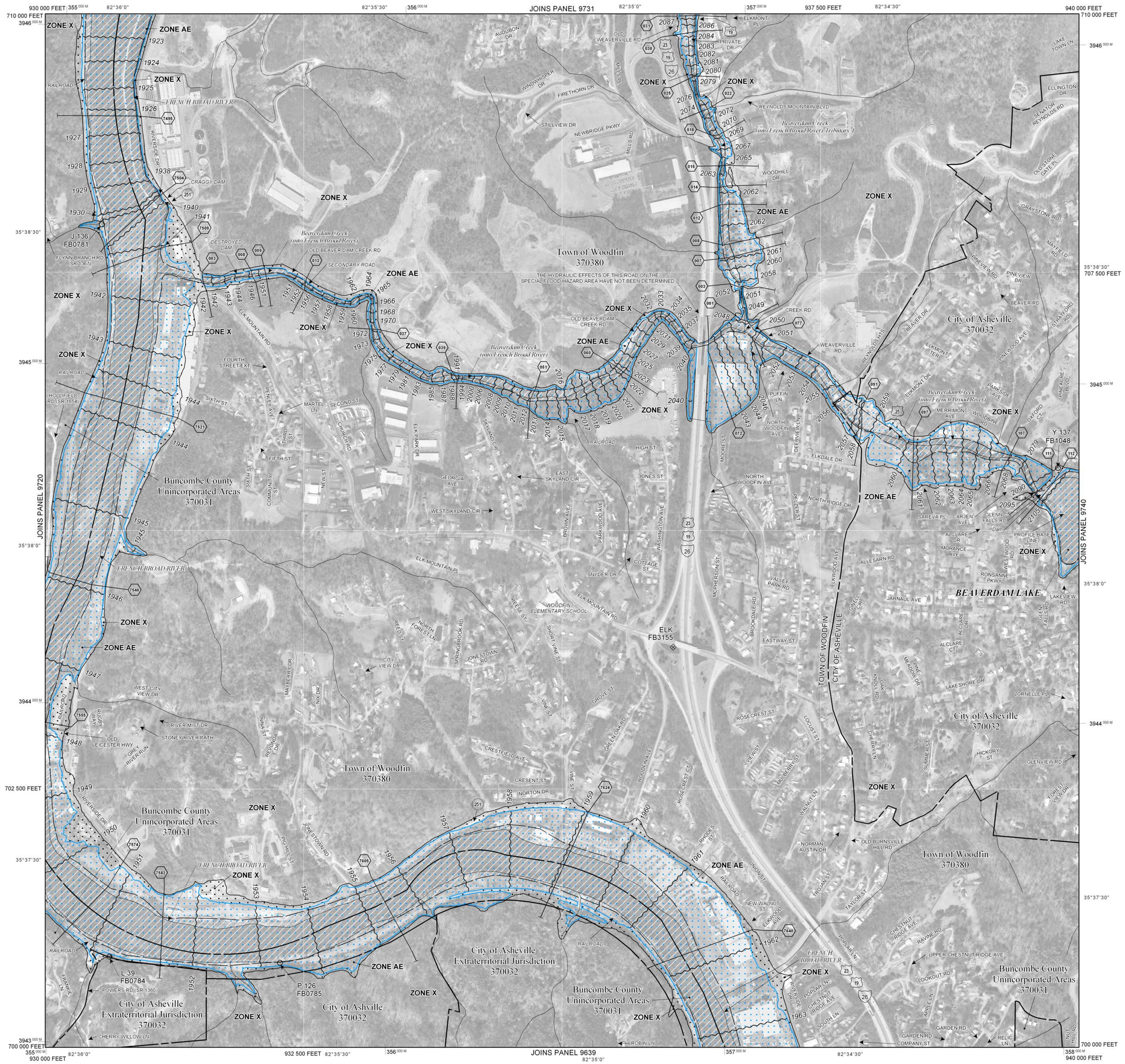
All streams listed in the **Flood Hazard Data Table** below were studied by detailed methods using field survey. Other flood hazard data shown on this map may have been derived using either a coastal analysis or limited detailed riverine analysis. More information on the flooding sources studied by these analyses is contained in the Flood Insurance Study report.

FLOOD HAZARD DATA TABLE

Cross Section	Stream Station	Flood Discharge (cfs)	1% Annual Chance (100-year) Water-Surface Elevation (feet NAVD 88)	Floodway Width (feet): Left/Right Distance From The Center of Stream to Encroachment Boundary (Looking Downstream) or Total Floodway Width
BEAVERDAM CREEK (INTO FRENCH BROAD RIVER)				
003	317[1]	NA	1,941.6[4]	55
008	792[1]	NA	1,950.7	55
009	898[1]	NA	1,950.9	55
012	1,214[1]	NA	1,955.5	70[6]
027	2,746[1]	NA	1,971.3	60[6]
039	3,854[1]	NA	1,988.5	110[6]
051	5,122[1]	NA	2,012.3	110
060	6,019[1]	NA	2,022.2	90
072	7,234[1]	NA	2,042.0	45
077	7,709[1]	NA	2,050.8	120
091	9,134[1]	NA	2,059.1	200
BEAVERDAM CREEK (INTO FRENCH BROAD RIVER) TRIBUTARY 1				
001	53[2]	NA	2,048.1[5]	60
003	317[2]	NA	2,052.8	25
007	686[2]	NA	2,061.4	100
008	792[2]	NA	2,061.6	65
012	1,214[2]	NA	2,062.0	90
014	1,373[2]	NA	2,062.3	90[6]
015	1,531[2]	NA	2,063.5	55[6]
018	1,848[2]	NA	2,069.7	55
022	2,218[2]	NA	2,073.1	65
025	2,534[2]	NA	2,079.9	45
030	2,957[2]	NA	2,086.2	70
FRENCH BROAD RIVER				
7495	749,496[3]	NA	1,926.0	430[6]
7504	750,394[3]	NA	1,940.2	632[6]
7509	750,922[3]	NA	1,940.9	470
7521	752,136[3]	NA	1,943.6	380
7540	753,984[3]	NA	1,945.7	380
7555	755,462[3]	NA	1,947.8	390
7574	757,416[3]	NA	1,950.5	490
7582	758,208[3]	NA	1,951.1	400
7605	760,478[3]	NA	1,955.4	370

See FIS Report for remaining cross sections on panel

[1] Feet above confluence with French Broad River
[2] Feet above confluence with Beaverdam Creek (into French Broad River)
[3] Feet above mouth
[4] Elevation includes backwater effects from French Broad River
[5] Elevation includes backwater effects from Beaverdam Creek (into French Broad River)
[6] Value is inaccurate, as the floodway has been adjusted in this area to match topographic-based redelineation



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.
ZONE AE Base Flood Elevations determined.
ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513 Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*
*Referenced to the North American Vertical Datum of 1988
012 Cross section line
23 23 Transect line
97°07'30", 32°22'30" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4276 000 M 1000-meter Universal Transverse Mercator grid ticks, zone 17
1 477 500 FEET 2500-foot grid values: North Carolina State Plane coordinate system (FIPSZONE 3200, State Plane NAD 83 feet)
BM5510 North Carolina Geodetic Survey bench mark (for more information Visit http://www.ncgs.state.nc.us).
BM5510 National Geodetic Survey bench mark (for more information visit http://www.ngs.noaa.gov).
BM5510 NGS-58 GPS 2-5 cm Vertical Control Marks or Contractor-Established NCFMP Bench Marks (for more information visit http://www.ncgs.state.nc.us)
● M1.5 River Mile

GRID NORTH

MAP SCALE 1" = 500' (1 : 6,000)

250 0 500 1000 FEET

150 0 150 300 METERS

This digital Flood Insurance Rate Map (FIRM) was produced through a unique cooperative partnership between the State of North Carolina and the Federal Emergency Agency (FEMA). The State of North Carolina has implemented a long term approach of floodplain management to decrease the costs associated with flooding. This is demonstrated by the State's commitment to map floodplain areas at the local level. As a part of this effort, the State of North Carolina has joined in a Cooperating Technical State agreement with FEMA to produce and maintain this digital FIRM.

NORTH CAROLINA Cooperating Technical State
FEMA'S COOPERATING TECHNICAL PARTNER

www.ncfloodmaps.com

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles, Floodway Data, Limited Detailed Flood Hazard Data, and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of **regulatory floodways** shown on the FIRM for flooding sources studied by detailed methods were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data for flooding sources studied by detailed methods as well as **non-encroachment widths** for flooding sources studied by limited detailed methods are provided in the FIS report for this jurisdiction. The FIS report also provides instructions for determining a floodway using non-encroachment widths for flooding sources studied by limited detailed methods.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 4.4 "Flood Protection Measures" of the Flood Insurance Study report for information on the flood control structures in this jurisdiction.

Base map information and geospatial data used to develop this FIRM were obtained from various organizations, including the participating local community(ies), state and federal agencies, and/or other sources. The primary base for this FIRM is aerial imagery acquired by Buncombe County. The time period of collection for the Buncombe imagery is 2002. Information and geospatial data supplied by the local community(ies) that met FEMA base map specifications were considered the preferred source for development of the base map. See geospatial metadata for the associated digital FIRM for additional information about base map preparation.

Base map features shown on this map, such as **corporate limits**, are based on the most up-to-date data available at the time of publication. **Changes in the corporate limits may have occurred since this map was published.** Map users should consult the appropriate community official or website to verify current conditions of jurisdictional boundaries and base map features. This map may contain roads that were not considered in the hydraulic analysis of streams where no new hydraulic model was created during the production of this statewide format FIRM.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

If you have **questions about this map**, or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov.

An accompanying Flood Insurance Study report, Letter of Map Revision (LOMR) or Letter of Map Amendment (LOMA) revising portions of this panel, and digital versions of this FIRM may be available. Visit the **North Carolina Floodplain Mapping Program** website at http://www.ncfloodmaps.com, or contact the **FEMA Map Service Center** at 1-800-358-9616 for information on all related products associated with this FIRM. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov.

MAP REPOSITORY

Refer to listing of Map Repositories on Map Index or visit http://www.ncfloodmaps.com.

EFFECTIVE DATE OF FLOOD INSURANCE RATE MAP PANEL

JANUARY 6, 2010

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to statewide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent, the North Carolina Division of Emergency Management or the National Flood Insurance Program at the following phone numbers or websites:

NC Division of Emergency Management
(919) 715-8000 http://www.nccrimecontrol.org/nfip

National Flood Insurance Program
1-800-638-6620 http://www.fema.gov/business/nfip

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 9730J

FIRM
FLOOD INSURANCE RATE MAP
NORTH CAROLINA

PANEL 9730

(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	CID No.	PANEL	SUFFIX
ASHEVILLE, CITY OF	370032	9730	J
BUNCOMBE COUNTY	370031	9730	J
WOODFIN, TOWN OF	370380	9730	J

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

EFFECTIVE DATE
JANUARY 6, 2010

MAP NUMBER
3700973000J

State of North Carolina
Federal Emergency Management Agency

Appendix C: Site Survey

CERTIFICATE OF SURVEY AND ACCURACY

I, NOLAN R. CARMACK, CERTIFY THAT THE GROUND TOPOGRAPHIC SURVEY PORTION OF THIS PROJECT WAS COMPLETED UNDER MY DIRECT SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY DIRECT SUPERVISION; THAT THIS SURVEY WAS PERFORMED AT THE 95% CONFIDENCE LEVEL TO MEET THE FEDERAL GEOGRAPHIC DATA COMMITTEE STANDARDS; THAT THIS SURVEY WAS PERFORMED TO THE CLASS A HORIZONTAL AND CLASS C VERTICAL WHERE APPLICABLE; THAT THE ORIGINAL DATA WAS OBTAIN BETWEEN THE DATES OF 3/08/17–3/31/17; THAT THE CONTOURS SHOWN AS BROKEN LINES MAY NOT MEET THE STATED STANDARD AND ALL COORDINATES ARE BASED ON NAD 83 (NSRS 2011) AND ALL ELEVATIONS ARE BASED ON NAVD 88; THAT THE GPS PORTION OF THIS PROJECT WAS TO PERFORM A GRID TIE TO THE NC STATE PLANE COORDINATE SYSTEM AND INFORMATION USED IS SHOWN & NOTED HEREON; THAT THIS MAP MEETS THE SPECIFICATIONS FOR TOPOGRAPHIC SURVEYS AS STATED IN TITLE 21, CHAPTER 56, SECTION .1606; THAT THIS MAP WAS NOT PREPARED IN ACCORDANCE WITH G.S. 47–30, AS AMENDED AND DOES NOT REPRESENT AN OFFICIAL BOUNDARY SURVEY.

GPS METADATA
CLASS OF SURVEY: HORIZONTAL: A VERTICAL: C
FIELD PROCEDURE: STATIC NETWORK
DATES: 03/9/17
DATUM: NAD83(2011) NAVD 88
EPOCH: 2010
GEOID: 12B
AVERAGE COMBINED FACTOR: .99979836
POSITIONAL ACCURACY: HORIZONTAL: 0.03 VERTICAL: 0.08
UNITS: USFT
CORS USED: NCMA, NCSW, NCBR, HAYW, NCHE

WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER, AND SEAL THIS 5TH DAY OF APRIL, 2017, A.D.

THIS DOCUMENT IS NOT VALID UNLESS SIGNED AND SEALED.

NOLAN R. CARMACK, PLS L–5076

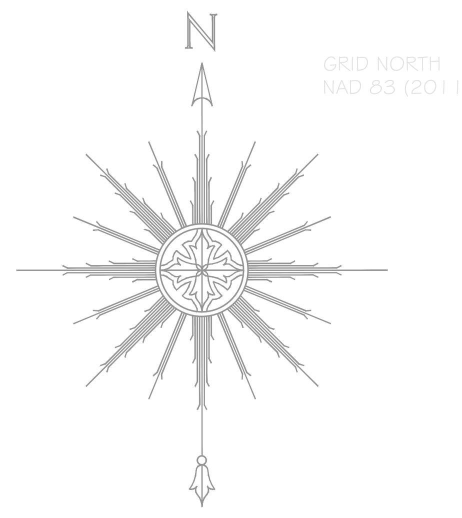
SURVEYOR'S NOTES:

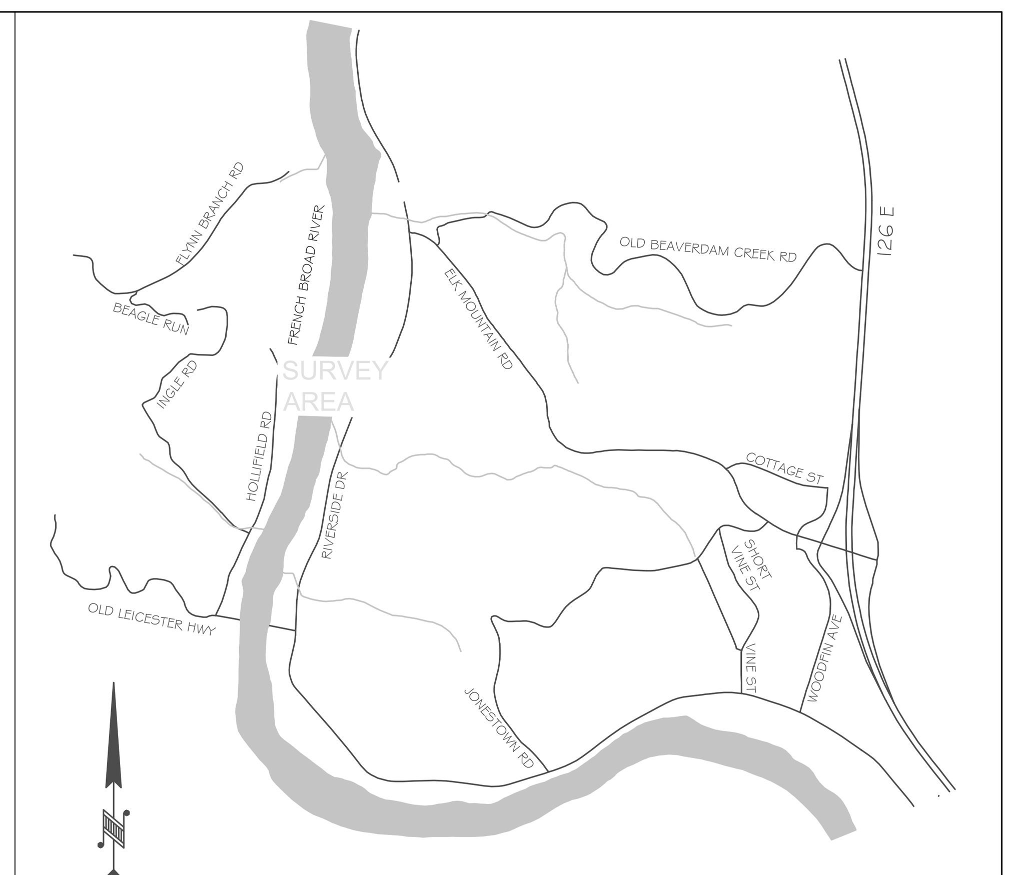
1. ALL DISTANCES ARE GROUND MEASUREMENTS IN US SURVEY FEET UNLESS OTHERWISE NOTED.
2. AREAS CALCULATED BY THE COORDINATE METHOD.
3. BY GRAPHIC DETERMINATION, A PORTION OF THE SUBJECT PROPERTY APPEARS TO LIE WITHIN A SPECIAL FLOOD HAZARD AREA (SFHA) AS DETERMINED BY THE F.E.M.A. MAP#'S 3700973000J & 3700972000J DATED 01/06/2010.
4. THE WATER SURFACE ELEVATIONS FOR CROSS SECTIONS 1–2 WERE OBSERVED ON 3/30/17, CROSS SECTIONS 3–11 ON 3/27/17–3/29/17 & CROSS SECTIONS 12–15 ON 3/21/17–3/22/17
5. ALL LOCATION OUTSIDE OF DETAILED SURVEY AREA WAS TAKEN FROM AERIAL PHOTOGRAPHY AND GIS DATA SUPPLIED BY NCONEMAP.

LEGEND:

	CROSS–SECTION
	STRUCTURE
1925	MAJOR CONTOUR
	MINOR CONTOUR
	DETAILED SURVEY AREA
	RAILROAD
	CONCRETE
	ASPHALT
	BEDROCK OUTCROP
	CROSSTIE/ROCK PYLON

	PERMANENT BENCHMARK
	SET IRON PIN (SIP) 5/8" RBR/CAP
	NOT TO SCALE (NTS)
N.A.D.	NORTH AMERICAN DATUM
N.A.V.D.	NORTH AMERICAN VERTICAL DATUM
SPC	STATE PLANE COORDINATES
NGS	NATIONAL GEODETIC SURVEY
USCGS	US COAST AND GEODETIC SURVEY
CF	COMBINED FACTOR
BM	BENCHMARK

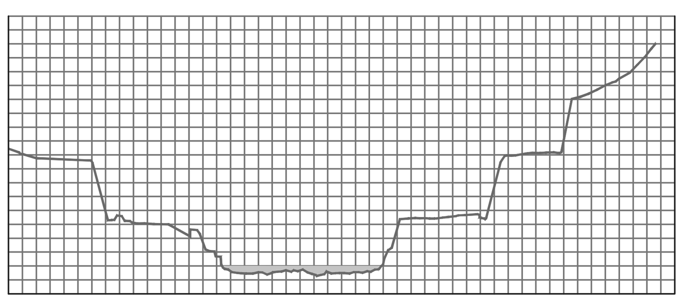




VICINITY MAP
(NOT TO SCALE)

CONTROL POINT INFORMATION

NGS BM X-179 "USCGS DISK" LOCALIZED SPC'S N: 703166.90' E: 929562.79' ELEV: 1947.80' (NAVD 88)	CONTROL POINT #7 RBC "KEE" LOCALIZED SPC'S N: 705711.06' E: 930801.84' ELEV: 1933.21' (NAVD 88)
CONTROL POINT #501 RBC "KEE" SPC'S N: 708891.12' E: 930978.69' ELEV: 1940.11' (NAVD 88)	CONTROL POINT #9 RBC "KEE" LOCALIZED SPC'S N: 704602.09' E: 930535.62' ELEV: 1936.34' (NAVD 88)
CONTROL POINT #500 RBC "KEE" LOCALIZED SPC'S N: 708388.15' E: 931071.57' ELEV: 1945.03' (NAVD 88)	CONTROL POINT #10 RBC "KEE" LOCALIZED SPC'S N: 704229.28' E: 930424.12' ELEV: 1935.46' (NAVD 88)
CONTROL POINT #503 RBC "KEE" LOCALIZED SPC'S N: 703730.37' E: 929635.81' ELEV: 1956.31' (NAVD 88)	CONTROL POINT #12 RBC "KEE" LOCALIZED SPC'S N: 703814.81' E: 930177.70' ELEV: 1936.35' (NAVD 88)
CONTROL POINT #504 RBC "KEE" LOCALIZED SPC'S N: 703969.64' E: 929745.68' ELEV: 1958.11' (NAVD 88)	CONTROL POINT #11 RBC "KEE" LOCALIZED SPC'S N: 704023.90' E: 930282.13' ELEV: 1935.02' (NAVD 88)



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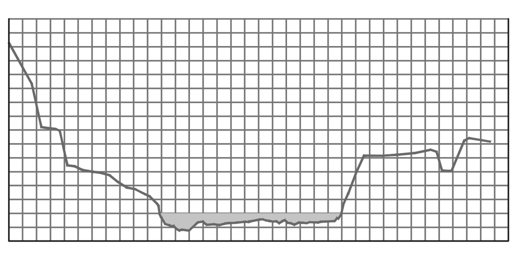

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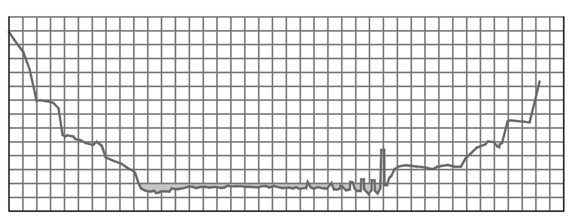

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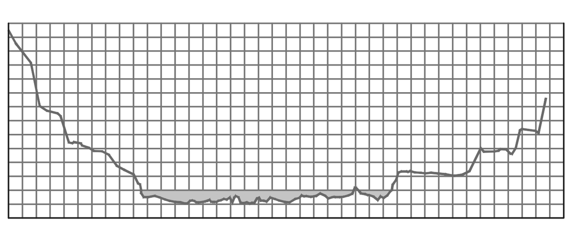

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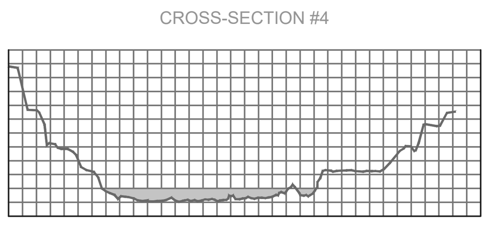

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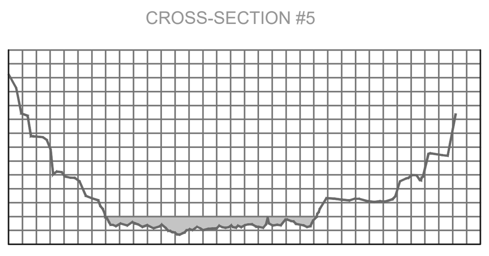

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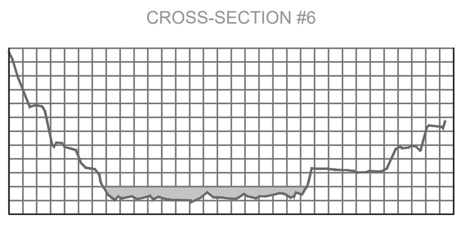

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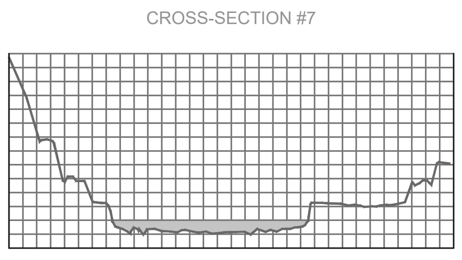

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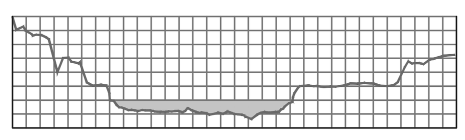

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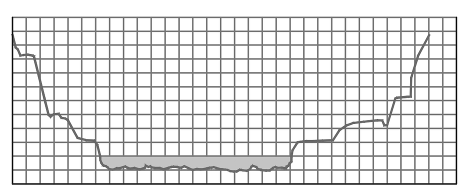

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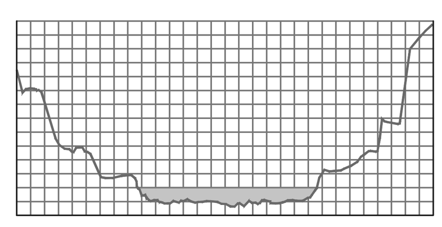

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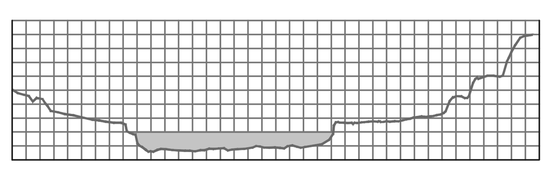

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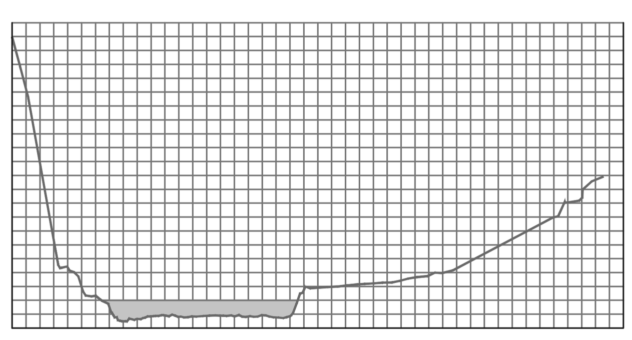

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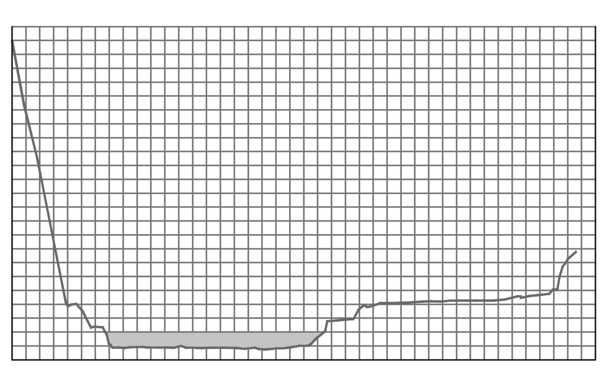

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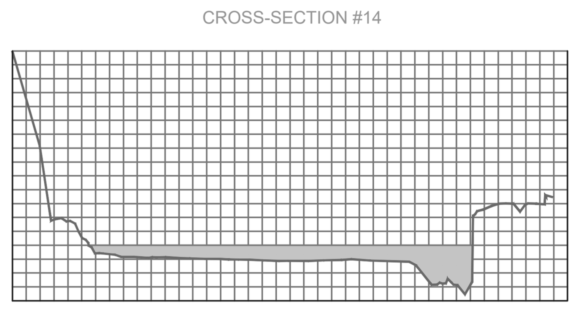
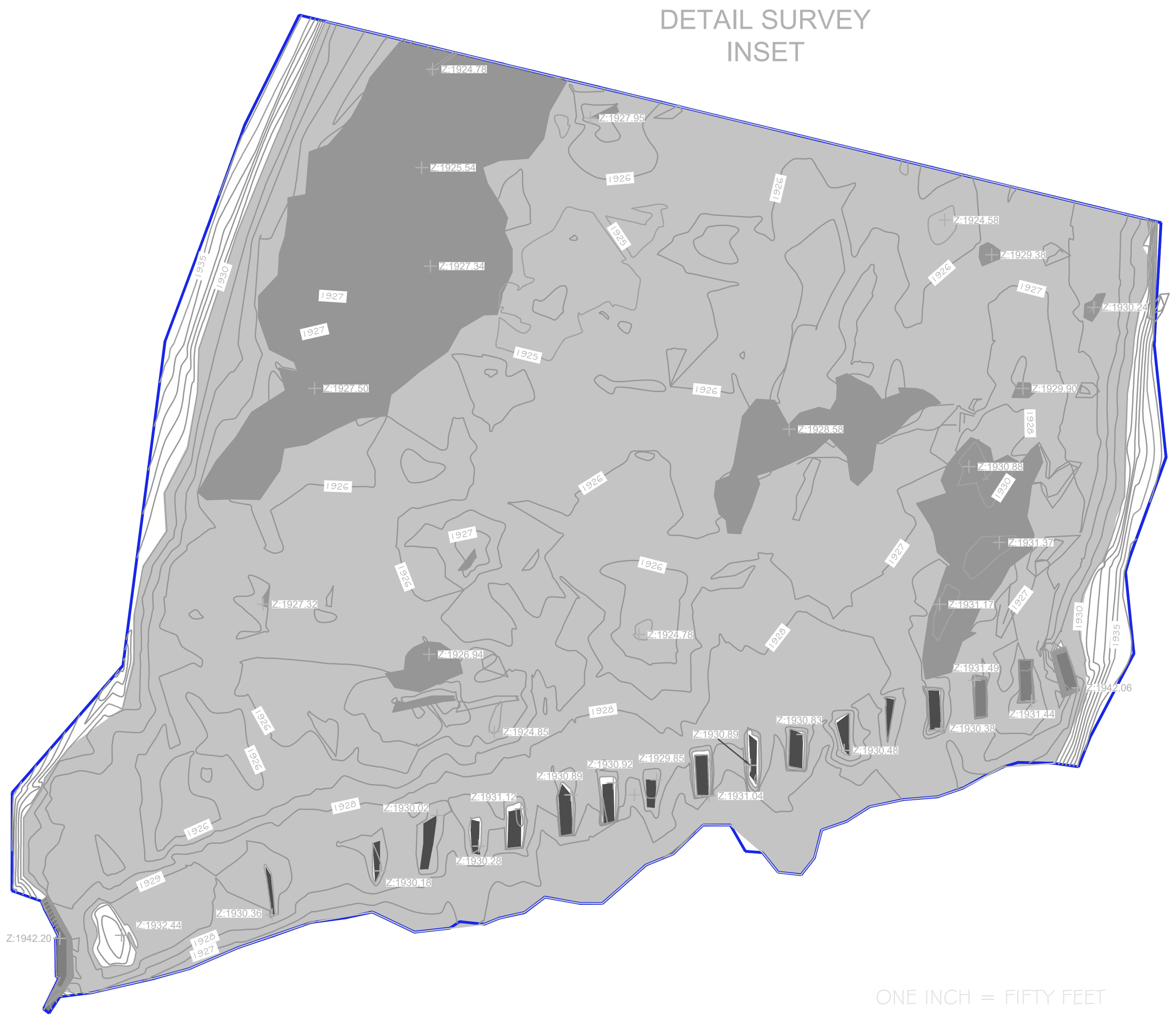
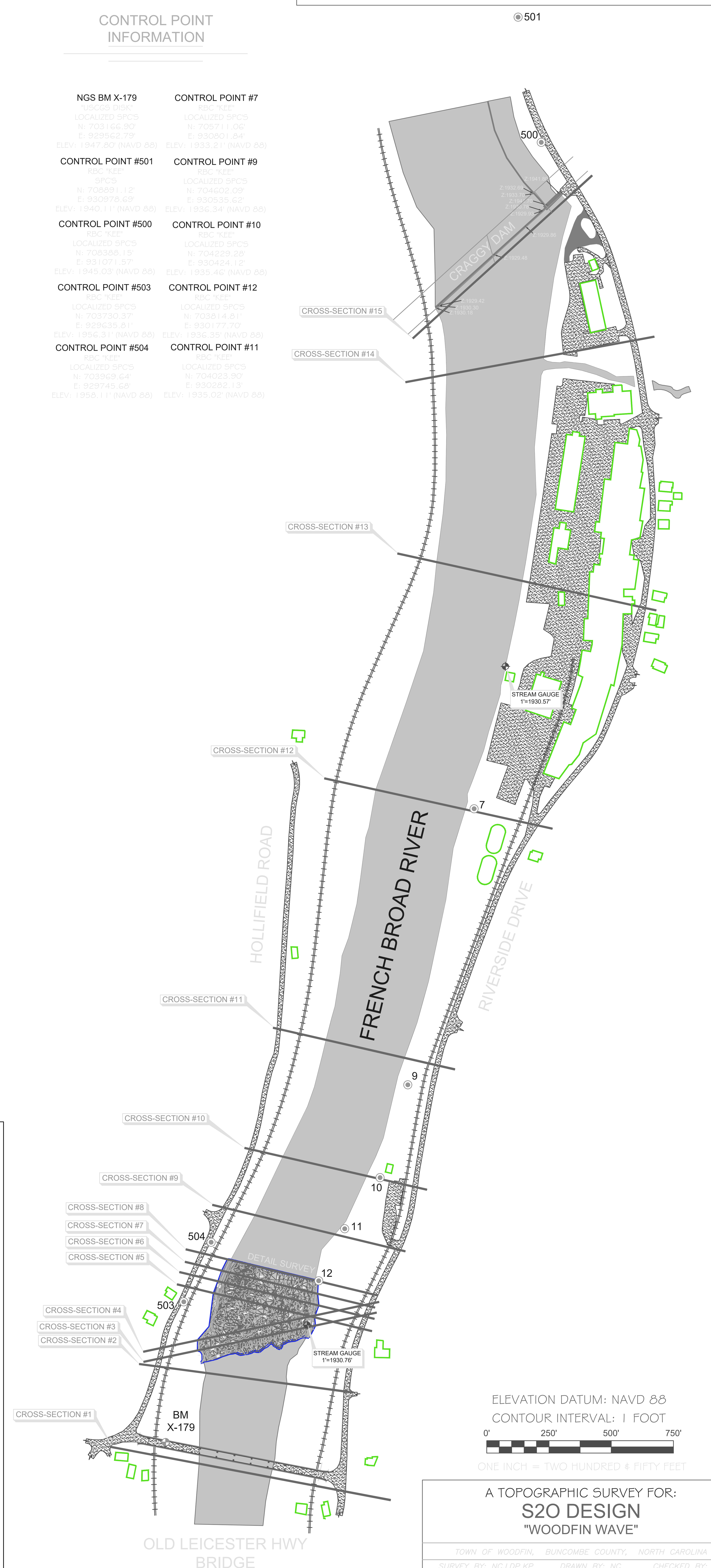


CROSS-SECTION #15

DETAIL SURVEY INSET



ONE INCH = FIFTY FEET



ELEVATION DATUM: NAVD 88
CONTOUR INTERVAL: 1 FOOT

0' 250' 500' 750'

ONE INCH = TWO HUNDRED & FIFTY FEET

A TOPOGRAPHIC SURVEY FOR:
S2O DESIGN
"WOODFIN WAVE"

TOWN OF WOODFIN, BUNCOMBE COUNTY, NORTH CAROLINA		
SURVEY BY: NC,LDP,KP	DRAWN BY: NC	CHECKED BY: NC
SURVEY DATES: 3/8/17–3/31/17		JOB #170336
SHEET SIZE: 24"X36"	SHEET #: 1 OF 1	SCALE: 1"=250'

P.O. Box 2566
Asheville, NC 28802
(828) 575–9021
www.keemap.com
License # C–3039

Appendix D: Cost Estimates

Project: Woodfin Whitewater Park Opinion of Probable Cost
Estimated Construction Costs of Riverside Park Site
Minimum Adjustable Structure
Developed By: SS

Description	Quantity	Unit	Unit Cost	Item Total Cost
Site Setup				
Traffic Control	1.0	LS	$ 5,000.00	$ 5,000.00
Install & Maintain Best Management Practices	1.0	LS	$ 5,000.00	$ 5,000.00
Operate & Maintain Water Control	2.0	LS	$ 75,000.00	$ 150,000.00
Whitewater U-Structure				
Install Equipment Access Ramps & Roads	2.0	LS	$ 1,500.00	$ 3,000.00
Reclaim Equipment Access Ramps, Roads, & Staging Areas	2.0	LS	$ 2,500.00	$ 5,000.00
Excavate & Grade Native Bedrock	194.0	CY	$ 350.00	$ 67,890.38
Excavate & Grade Native Alluvium	65	CY	$ 22.00	$ 1,422.47
Furnish & Install Bedding Material	209.7	CY	$ 10.00	$ 2,097.00
Furnish & Install Mirafi 180n Filter Fabric	900.9	SY	$ 3.00	$ 2,702.70
Furnish & Install Boulder (Avg 36" B Axis)	1079.8	Ton	$ 85.00	$ 91,781.32
Furnish & Install Riprap Armoring (Type VH)	297.4	Ton	$ 50.00	$ 14,870.37
Furnish & Install Concrete Grout, Including Rebar, & Marine Epoxy	341.8	CY	$ 272.00	$ 92,968.10
Unclassified Hauloff	259	CY	$ 20.00	$ 5,172.60
Bypass Island and Surf Channel				
Excavate & Grade Native Bedrock	324.0	CY	$ 350.00	$ 113,416.10
Excavate & Grade Native Alluvium	100	CY	$ 22.00	$ 2,200.00
Furnish & Install Bedding Material	324.0	CY	$ 10.00	$ 3,240.46
Furnish & Install Riprap Armoring (Type VH)	582.2	Ton	$ 50.00	$ 29,108.75
Furnish & Install Obermeyer Pneumatic Gates	203	LF	$ 4,000.00	$ 812,000.00
Furnish and Install Formed Concrete	375	CY	$ 290.00	$ 108,733.53
Furnish & Install Unistrut Rails	1368	LF	$ 3.05	$ 4,172.40
Furnish & Install Rapidblocks	70	LF Channel	$ 937.00	$ 65,590.00
Terracing, Steps and Circulation Path				
Furnish & Install Boulder (Avg 36" B Axis)	718.5	Ton	$ 85.00	$ 61,072.00
Excavate & Grade Native Alluvium	143	CY	$ 22.00	$ 3,155.06
Furnish & Install Bedding Material	232.6	CY	$ 10.00	$ 2,325.60
Furnish & Install Mirafi 180n Filter Fabric	473.7	SY	$ 3.00	$ 1,421.20
Furnish & Install Crusher Fine Path	6100	SF	$ 0.65	$ 3,965.00
Unclassified Hauloff	143	CY	$ 20.00	$ 2,868.24
Additional Included Items				
Physical Model	1	LS	$ 120,000.00	$ 120,000.00
Additional Excavator Time as directed by S2o	30	HR	$ 220.00	$ 6,600.00
PROJECT SUBTOTAL				$ 1,786,773.27
Contingency (25%)				$ 446,693.32
CONSTRUCTION SUBTOTAL				$ 2,233,466.59
Bathymetric/Topographic Survey				$ 33,502.00
Engineering Design				$ 134,008.00
Hydraulic Modeling				$ 22,334.67
Permitting 404, 401				$ 35,735.47
Permitting Floodplain				$ 44,669.33
Construction Bonding/Ins				$ 67,004.00
Mob and Demob				$ 67,004.00
Construction Stakeout				$ 11,167.33
Construction Monitoring				$ 89,338.66
TOTAL PROJECT COST OPINION				**$ 2,738,230.04**

Project: Asheville Whitewater Park Opinion of Probable Cost
Estimated Construction Costs of Riverside Park Site
Maximum Adjustable Structure
Developed By: SS

Description	Quantity	Unit	Unit Cost	Item Total Cost
Site Setup				
Traffic Control	1.0	LS	$ 5,000.00	$ 5,000.00
Install & Maintain Best Management Practices	1.0	LS	$ 5,000.00	$ 5,000.00
Operate & Maintain Water Control	2.0	LS	$ 75,000.00	$ 150,000.00
Bypass Island and Surf Channel				
Install Equipment Access Ramps & Roads	2.0	LS	$ 1,500.00	$ 3,000.00
Reclaim Equipment Access Ramps, Roads, & Staging Areas	2.0	LS	$ 2,500.00	$ 5,000.00
Excavate & Grade Native Bedrock	483.9	CY	$ 350.00	$ 169,360.10
Excavate & Grade Native Alluvium	100	CY	$ 22.00	$ 2,200.00
Furnish & Install Bedding Material	362.9	CY	$ 10.00	$ 3,629.15
Furnish & Install Mirafi 180n Filter Fabric	3236.0	SY	$ 3.00	$ 9,708.00
Furnish & Install Riprap Armoring (Type VH)	166.6	Ton	$ 50.00	$ 8,329.63
Unclassified Hauloff	584	CY	$ 20.00	$ 11,677.72
Furnish & Install Obermeyer Pneumatic Gates	347	LF	$ 4,000.00	$ 1,388,000.00
Furnish and Install Formed Concrete	503	CY	$ 290.00	$ 145,816.41
Furnish & Install Unistrut Rails	1368	LF	$ 3.05	$ 4,172.40
Furnish & Install Rapidblocks	70	LF	$ 937.00	$ 65,590.00
Terracing, Steps and Circulation Path				
Furnish & Install Boulder (Avg 36" B Axis)	718.5	Ton	$ 85.00	$ 61,072.00
Excavate & Grade Native Alluvium	143	CY	$ 22.00	$ 3,155.06
Furnish & Install Bedding Material	232.6	CY	$ 10.00	$ 2,325.60
Furnish & Install Mirafi 180n Filter Fabric	473.7	SY	$ 3.00	$ 1,421.20
Furnish & Install Crusher Fine Path	6100	SF	$ 0.65	$ 3,965.00
Unclassified Hauloff	143	CY	$ 20.00	$ 2,868.24
Additional Included Items				
Physical Model	1	LS	$ 120,000.00	$ 120,000.00
Additional Excavator Time as directed by S2o	30	HR	$ 220.00	$ 6,600.00
PROJECT SUBTOTAL				$ 2,177,890.51
Contingency (25%)				$ 544,472.63
CONSTRUCTION SUBTOTAL				$ 2,722,363.13
Bathymetric/Topographic Survey				$ 40,835.45
Engineering Design				$ 163,341.79
Hydraulic Modeling				$ 27,223.63
Permitting 404, 401				$ 43,557.81
Permitting Floodplain				$ 54,447.26
Construction Bonding/Ins				$ 81,670.89
Mob and Demob				$ 81,670.89
Construction Stakeout				$ 13,611.82
Construction Monitoring				$ 108,894.53
TOTAL PROJECT COST OPINION				**$ 3,337,617.20**

Project: Woodfin Whitewater Park Opinion of Probable Cost
Estimated Construction Costs of Riverside Park Site
Upper Full Rock Structure
Developed By: SS

Description	Quantity	Unit	Unit Cost	Item Total Cost
Site Setup				
Traffic Control	1.0	LS	$ 5,000.00	$ 5,000.00
Install & Maintain Best Management Practices	1.0	LS	$ 5,000.00	$ 5,000.00
Operate & Maintain Water Control	2.0	LS	$ 75,000.00	$ 150,000.00
Whitewater U-Structure				
Install Equipment Access Ramps & Roads	2.0	LS	$ 1,500.00	$ 3,000.00
Reclaim Equipment Access Ramps, Roads, & Staging Areas	2.0	LS	$ 2,500.00	$ 5,000.00
Excavate & Grade Native Bedrock	345.2	CY	$ 350.00	$ 120,833.86
Excavate & Grade Native Alluvium	100	CY	$ 22.00	$ 2,200.00
Furnish & Install Bedding Material	818.2	CY	$ 10.00	$ 8,182.20
Furnish & Install Mirafi 180n Filter Fabric	2140.5	SY	$ 3.00	$ 6,421.43
Furnish & Install Boulder (Avg 36" B Axis)	5055.8	Ton	$ 85.00	$ 429,741.42
Furnish & Install Riprap Armoring (Type VH)	297.2	Ton	$ 50.00	$ 14,861.11
Furnish & Install Concrete Grout, Including Rebar, & Marine Epoxy	1083.0	CY	$ 272.00	$ 294,577.55
Unclassified Hauloff	445	CY	$ 20.00	$ 8,904.79
Terracing, Steps and Circulation Path				
Furnish & Install Boulder (Avg 36" B Axis)	718.5	Ton	$ 85.00	$ 61,072.00
Excavate & Grade Native Alluvium	345	CY	$ 22.00	$ 7,595.27
Furnish & Install Bedding Material	232.6	CY	$ 10.00	$ 2,325.60
Furnish & Install Mirafi 180n Filter Fabric	473.7	SY	$ 3.00	$ 1,421.20
Furnish & Install Crusher Fine Path	6100	SF	$ 0.65	$ 3,965.00
Unclassified Hauloff	345	CY	$ 20.00	$ 6,904.79
Additional Included Items				
Physical Model	1	LS	$ 120,000.00	$ 120,000.00
Additional Excavator Time as directed by S2o	30	HR	$ 220.00	$ 6,600.00
PROJECT SUBTOTAL				$ 1,263,606.22
Contingency (25%)				$ 315,901.56
CONSTRUCTION SUBTOTAL				$ 1,579,507.78
Bathymetric/Topographic Survey				$ 23,692.62
Engineering Design				$ 94,770.47
Hydraulic Modeling				$ 15,795.08
Permitting 404, 401				$ 25,272.12
Permitting Floodplain				$ 31,590.16
Construction Bonding/Ins				$ 47,385.23
Mob and Demob				$ 47,385.23
Construction Stakeout				$ 7,897.54
Construction Monitoring				$ 63,180.31
TOTAL PROJECT COST OPINION				**$ 1,936,476.54**

Appendix E: Pre-Permitting Meeting Minutes

Minutes

DATE: 8-9-2017
LOCATION: Riverside Park, Woodfin, NC
SUBJECT: Pre-Application Meeting for the Woodfin Wave Project
ATTENDEES: Scott Jones, USACE; Andrea Leslie, NCWRC; Zan Price, NC DWR; Scott Loftis, NCWRC; Doug Besler, NCWRC; Byron Hamsted, USFWS; Scott Shipley, S2o Design and Engineering; Marc Hunt, Friends of the Woodfin Greeway and Blueway

Summary: The meeting was hosted by S2o Design and Engineering and the Friends of the Woodfin Greeway and Blueway Public Interest Group. The purpose of the meeting was to describe the project and project status to regulatory agencies. S2o began the meeting by describing the project's purpose and need, location, site selection, and basic geometry and construction process for a potential surf wave drop structure located upstream of the MCD Dam in Woodfin. S2o then further stated that the purpose of the current study was to establish hydraulic feasibility, by vetting the potential to create a "no-rise" design, and to begin the process of vetting permitting requirements for the project.

S2o has provided two project-related reports to meeting participants as background including a conceptual design study and a hydraulic feasibility study.

It was noted that Friends of Woodfin Greenway and Blueway has organized various project background documents and information on its website, woodfingreenwayandblueway.org

Scott Jones, from the USACE noted several considerations that will be important for the project to address. These were summarized in the meetings and repeated in a follow up email distributed by Mr. Jones after the meeting. Those comments are shown below:

- The "Wave Project" is a part of the overall Blueway & Greenway Project for the Town of Woodfin. The Corps considers the Blueway & Greenway Project a unified comprehensive project and will need all of its components (at least conceptually) presented when evaluating CWA permit applications.
- Who will be the applicant? City? County? Partnering NGO? A combination?
- Alternatives analysis must take into consideration avoidance and minimization. The analysis must support the Town's preferred option as the least environmentally damaging practicable alternative.
- What are the geomorphological conditions of the alternative sites along the French Broad River at this location? Will proposed structure even work at a given location? Why the French Broad River? Why not another location on the French Broad, or the Green River? Other rivers?
- What were your selection criteria for choosing alternatives to study?
- Will need to address Ledges Park as a possible alternative.
- How would wave design be affected if/when Craggy Dam is removed?
- Liability questions to consider.
- Property owner issue - applicant will need to obtain easement from NC DOT and potentially others.
- NCDOT R-O-W issues. Railroad R-O-W issues.

- Floodway/floodplain ordinance HEC studies and permitting must be obtained as part of the 404 permit process.
- How will design avoid impacts to Skyland / Asheville FD / Woodfin rescue boat operations?
- The French Broad River is designated Section 10 (Rivers and Harbors Act 1899). Commercial and recreational usage / navigation will be taken into consideration.
- TVA obstruction – Section 26a permit will be required. https://www.tva.gov/Environment/Shoreline-Construction/26a-How-to-Apply

- Describe warning and river user notification signage.
- Address potential impacts to aquatic species.
- Provide flow regimes / hydraulic analysis for proposed structure and bypass channel.
- Describe secondary and cumulative impacts – additional stabilization structures, event infrastructure, greenway & blueway infrastructure, etc.
- How will anglers, tubers, and other boaters be impacted by the design? How can they get around the proposed structure in various watercraft?
- Who will be responsible for ongoing maintenance and operation?
- Maintenance after high water / flood events?
- How will design affect sediment transport?

US Fish and Wildlife noted that fish passage had been considered in the design through the use of a bypass channel. This agency noted the importance of understanding flow velocities and depths as well as quantity of attractive flows.

Ownership on river left was mentioned as an issue. Permission from the landowner will be a requirement of the project.

NCWRC noted that there are trailer-accessible boat ramps upstream of the project and that fishing boats are a consideration in the project. The agency asked questions with regards to navigability of the structure and bypass for a john boat. It was noted in conversation that the bypass would be designed for this type of boat passage and that the project might also add a boat ramp in Riverside Park or on the future park property, if available.

Further issues raised by NCWRC included:

- Impacts and implication of future maintenance.
- Concern about aquatic organisms and wildlife passage. This comment included acknowledgement that the dam was in place and a barrier downstream and that the primary species of concern are game fish as natives are not common in this reach.
- Questions about sediment back-up above the structure and transport at the structure.
- Questions about whether the Ledges Park might be an alternative location,.
- Ownership of the project and clarification on future responsibility were cited.
- A need for BMPs during construction.
- Acknowledgement of effects of project in a scenario where Craggy Dam would be removed at some point in the long-term future.

- The need to consult NC State Historic Preservation Office (SHPO) for the status of the former railroad bridge in the reach.

S2o concluded the discussion part of the meeting by stating that the above questions and concerns had been noted and that this phase of the project was preliminary and in very much a pre-permitting and pre-design phase. S2o committed that comments and questions would be recorded and provided to the Town of Woodfin to ultimately be passed them on to the selected design consultant to address in final design and permitting phases[1]. A site tour was given including inspection of an unnamed existing tributary creek that might be restored as a part of the project and visual inspection of the fill pile that might be removed on-site.

[1] The Town of Woodfin will go through a formal bid process for future work on the project. The future design team for this project has not yet been selected.