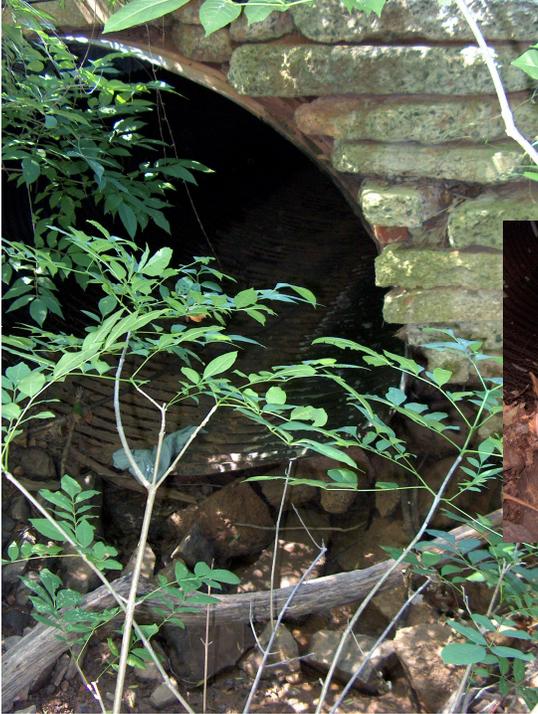


# Roquemore Road Stormwater System



Roquemore Road looking downstream at the 90x66-inch culvert



Pipe bottom deterioration in the 90x66-inch corrugated metal pipe (CMP)

Roquemore road downstream  
90x66-inch culvert outlet



## Preliminary Report and Recommendations March, 2009

# Roquemore Road Culvert system

## Introduction

The residence at 133 Roquemore Road experiences occasional flooding storm flows occasionally overtop the road. JEWELL Engineering Consultants (JEC) performed an analysis at the request of the Village of Clemmons to determine how the existing stormwater drainage system is functioning and where improvements could be made based on fully developed watershed conditions, following NCDOT guidelines where appropriate, and analyzing runoff for the 2-year, 10-year, and 25-year precipitation events. Culvert design guidelines should ensure that the system does not allow water to overtop the road or damage nearby, permanent structures.

## Existing System

The existing drainage system under Roquemore road consists of a single 90-inch x 66-inch corrugated metal arch pipe (CMAP) culvert. The culvert backs up frequently during small rain events causing water to flood the property at 133 Roquemore Road. The road elevation is higher than the basement elevation of the residence at 133 Roquemore Road so that when Roquemore Road is overtopped in a flooding event, approximately three feet of water will enter the structure. Examination of the culvert reveals that the bottom is rusted through in portions of the culvert and the CMAP is beginning to show signs of failure as the decaying process slowly removes the structure. The Roquemore Road culvert receives runoff from a watershed drainage area of approximately 232 acres and the stream is identified as Tributary 2 of Johnson Creek by the Federal Emergency Management Agency (FEMA). The tributary joins Johnson Creek just after passing through the culvert and Johnson Creek drains to the Yadkin River.

## Analyses

### Hydrologic Analysis

Precipitation data was obtained from the National Oceanic and Atmospheric Administration (NOAA) site for the location specified. The Rational Runoff method was used along with the Kirpich equation for time of concentration to calculate peak discharge flows at the culvert for the 2-yr, 10-yr, 25-yr precipitation events under fully developed land use conditions (as determined from existing zoning for the watershed).

In the preparation of the Flood Insurance Study (FIS) and revised Flood Insurance Rate Maps (FIRMs) for Forsyth County published on January 2, 2009, FEMA developed hydraulic models for Johnson Creek and for Tributary 2. A detailed study was developed for Johnson Creek, with modeling for the 10-year, 50-year, 100-year and 500-year storms. A limited detail study was done for Tributary 2, analyzing only the floodplain for the 100-year storm. The FEMA estimate of the 100-year discharge for Tributary 2, even though based on existing conditions, exceeded the JEC estimate of the 100-year discharge by about 30%. JEC ran the hydraulic analysis described below using prorated flow estimates based on the FEMA 100-year discharges and the JEC estimates for fully developed conditions. Because the JEC flow estimates result in flood elevations that better correlate with historical observations, these flows were used for the sizing the proposed culvert.

## Roquemore Road Culvert system

### Hydraulic Analysis

In the FEMA model for Tributary 2, the crossing at Roquemore Road was inadvertently omitted. Thus, the floodplain mapping for the tributary does not account for backwater from the existing culvert or overtopping of the road.

The existing culvert and several potential replacements were analyzed based on two different flow conditions: 1) the inlet capacity of the culvert (inlet control) and 2) the capacity of the culvert when subject to hydraulic influences from downstream and/or culvert barrel friction (outlet control). Either of these two flow conditions can govern the capacity of the culvert and both must be checked, with the one that results in the higher hydraulic (driving) head being the one that governs. Tailwater elevations were based on the FEMA model for Johnson Creek at the confluence of the tributary. The results of the analyses were used to determine appropriate pipe sizes when the watershed is fully developed while not exceeding a desired WSEL. Using the Federal Highway Administration's HY-8 culvert analysis computer program, this process of culvert hydraulic analysis was applied to determine the capacity of the existing culvert system as well as to size the culvert(s) needed to provide adequate capacity to meet Village design standards. The table below contains the results of the analysis.

### Existing Conditions Analysis

The 90-inch x 66-inch culvert that manages the stormwater at Roquemore Road lacks adequate capacity to handle the runoff entering the culvert. The homeowner at 133 Roquemore Drive reported that he had approximately 5" of water in his basement in the storm of January 2007. He also reported that the basement flooded in 1999. The existing conditions analysis, listed in the table below, indicates that several feet of water would flood the basement, even in relatively frequent storm events.

### Proposed Conditions Analysis

A variety of options were analyzed in order to accomplish culvert improvements to meet Village design standards. It was determined that an 8-foot x 5-foot double box culvert should replace the single 90-inch x 66-inch CMP currently in place. A headwall should be added at both the upstream and downstream ends with riprap protection at the downstream outlet to protect the drainage channel from eroding. As shown in the table below, the proposed culvert may not protect the home at 133 Roquemore Road from flooding in the basement. However, a larger culvert would not further lower the water surface elevations, which are largely a function of the flood levels in Johnson Creek. Note that the design assumptions are based on a "worst-case" scenario of the peak flow along Tributary 2 coinciding with the peak flow in Johnson Creek.

Based on preliminary survey data, the basement elevation for the home at 133 Roquemore Road is about two inches below the estimated peak flood elevation in Johnson Creek for the 25-year storm. Along Tributary 2, upstream of the Roquemore Road culvert, the water surface elevations could be high enough to flood the basement in a 10-year storm. A flood wall around the property would be necessary to ensure protection from flooding. Costs for a wall would be dependent on the storm used as a design standard and the backwater elevations resulting from the proposed culvert crossing. For preliminary estimates, it is assumed that the wall height would not exceed four feet. Estimated construction cost is approximately \$50,000. Permitting for the wall could require significant effort, including floodplain analysis, public notifications and preparation of new FIRMS, such that costs associated with the permitting could run as high as the construction cost. Nevertheless, the cost of a floodwall would still be far less than the cost of a buyout. Note that costs for a floodwall and

## Roquemore Road Culvert system

associated permitting are not included in the cost estimate for this project. The property value was estimated at \$220,000 in 2005.

### Analysis Results for Roquemore Road Culvert:

Rainfall Events	2-Year	10-Year	25-Year
Flow (cfs) (Fully Developed Watershed)	258	353	439
<b>Existing Conditions Culvert w/Fully Developed Watershed</b> WSEL (1-90" x 66" – outlet control)	708.6 <sup>2</sup>	710.55 <sup>1,2</sup>	711.36 <sup>1,2</sup>
<b>Proposed conditions</b> WSEL (2-8' x 5' concrete box)	705.9	707.45 <sup>2</sup>	707.89 <sup>2</sup>

<sup>1</sup> Overtops Roquemore Road, low point elevation 710.22

<sup>2</sup> 133 Roquemore Road residence, basement finished floor elevation 707.03

### Recommendations

The current 90-inch x 66-inch CMP has inadequate capacity to manage the runoff draining from the watershed. Backwater at the culvert has flooded the home at 133 Roquemore Road on two occasions in the past 10 years. We recommend replacing the single 90-inch x 66-inch CMP with a double 8-foot x 5-foot concrete box culvert. A headwall should be added at both the upstream and downstream ends along with some channel improvements to prevent erosion and degradation as it transitions to the natural drainage channel and Johnson Creek. The construction work will also impact the driveways in the vicinity of the construction at 133 and 130 Roquemore Road.

Because the culvert replacement may not protect the residence at 133 Roquemore Road from flooding in the larger storm events, the Village may want to consider constructing a flood wall at this location for protection up to the predicted level of the 25-year storm event.

Enclosed in this report are exhibits of the analysis area, a sketch of the recommended improvement configuration and a preliminary cost estimate for the stormwater system improvements at Roquemore Road.



# PRELIMINARY COST ESTIMATE

<b>JOB NO.:</b>	JEC	02-087-009-007		
<b>LOCATION:</b>	ROQUEMORE ROAD			
<b>JOB NAME:</b>	CAPITAL IMPROVEMENT PROJECT			
<b>COMPILED BY:</b>	BETTY A. FARR, PE			
<b>DATE:</b>	2/23/2008			

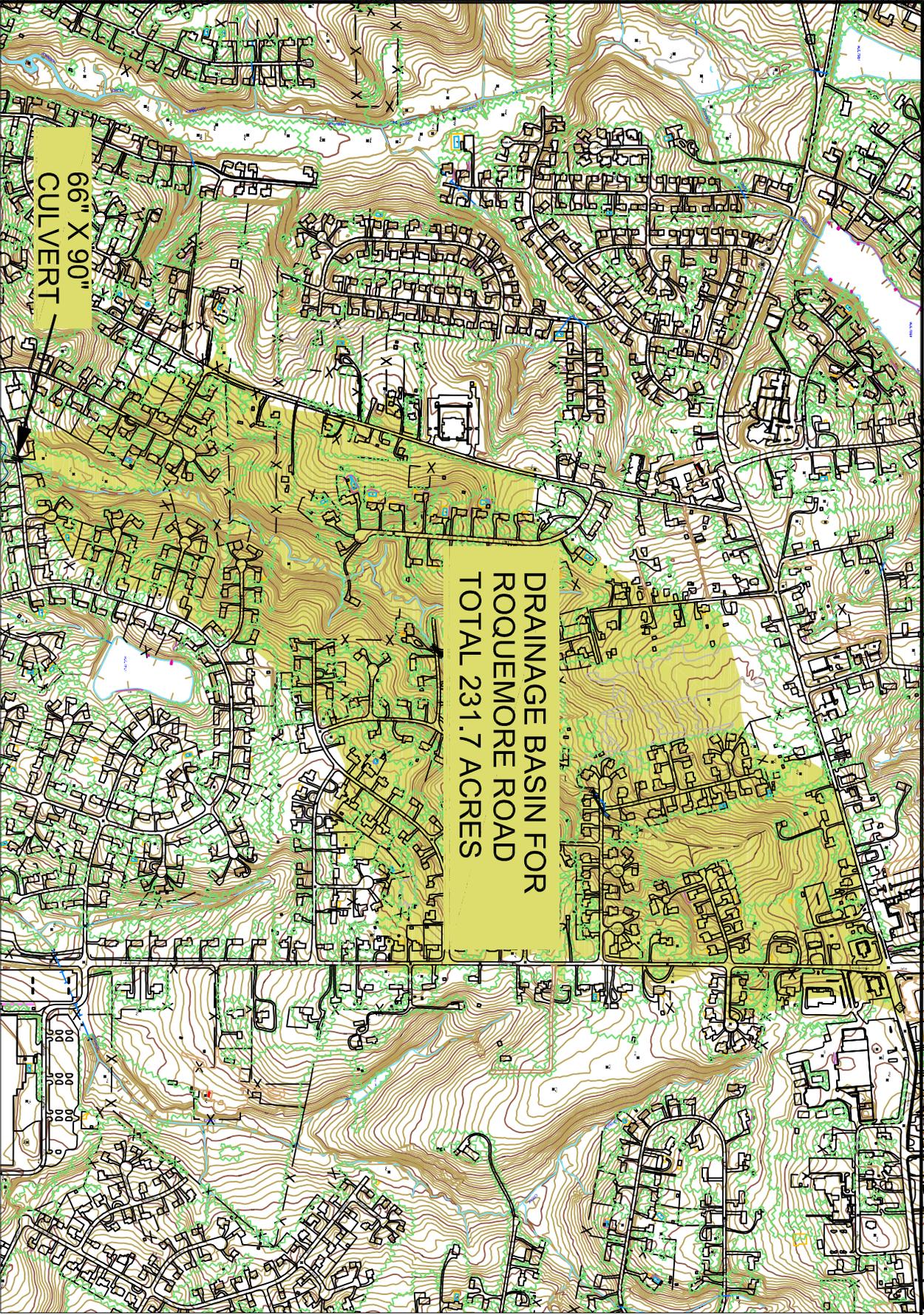
ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT COST	COST
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## CULVERT MODIFICATION AND ASSOCIATED SITE WORK

<b>Site work/culvert replacement at Roquemore Drive</b>					
	1	EA	Mobilization	\$ 2,500.00	\$ 2,500
	2	DAY	Traffic control (detour, cones and blockade with signage)	\$ 300.00	\$ 1,500
	3	LF	Remove 90"x66"-inch pipe	\$ 35.00	\$ 2,135
	4	LF	Install double 8'x5' Box Culvert	\$ 480.00	\$ 59,520
	5	TON	Box culvert bedding gravel	\$ 67.00	\$ 1,809
	6	1,660	CY Excavation	\$ 5.00	\$ 8,300
		450	CY Haul off excess soil	\$ 10.00	\$ 4,500
		105	CY Haul in suitable fill for roadway	\$ 15.00	\$ 1,575
	7	1	EA Conc headwall entrance	\$ 6,650.00	\$ 6,650
	8	1	EA Conc headwall at outlet	\$ 6,650.00	\$ 6,650
	9	180	TON Riprap Dissipator Class B at outlet channel (28ft channel length x 30" depth)	\$ 53.00	\$ 9,540
	10	250	SF Soil stabilization fabric under RipRap	\$ 3.50	\$ 875
	11	5	EA Inlet protection when construction crew not on site (5-days)	\$ 1,200.00	\$ 6,000
	12	27	TON RipRap Class B stabilization at inlet	\$ 53.00	\$ 1,431
	13	1	WEEK Pump around system with temp stone coffer dam	\$ 2,250.00	\$ 2,250
	14	16	CY concrete (6") driveway (2 driveways) replace/repair	\$ 225.00	\$ 3,600
	15	1,200	SF Fine finish grading may include hand raking	\$ 0.50	\$ 600
	16	60	LF Waterline Utility relocation-potential valve box, waterline, etc	\$ 25.00	\$ 1,500
	17	1,200	SF Seeding and stabilization	\$ 0.35	\$ 420
	18	43	TON ABC stone base under asphalt	\$ 50.00	\$ 2,150
	19	115	SY Asphalt repair-Remove	\$ 6.00	\$ 690
	20	14	TON Asphalt Surface (2-inch) I-19	\$ 110.00	\$ 1,540
	21	7	TON Asphalt Surface (1-inch) SF-9	\$ 105.00	\$ 735
	22	21	TON Asphalt placement	\$ 105.00	\$ 2,205
	23	4	TON Asphalt for plant mix pgPG64-22	\$ 500.00	\$ 2,000
	24				\$ -
	25				\$ -
					\$ -
<b>Work in Right-of-way if utility encountered</b>					
	26	1	EA Existing sewer leader in inlet channel if impacted	\$ 1,500.00	\$ 1,500
	27	1	EA Existing water line if impacted	\$ 1,500.00	\$ 1,500
	28	100	LF Cable-phone in ground coordination/relocation	\$ 10.00	\$ 1,000
					\$ -
<b>Erosion Control and finish work</b>					
	29	250	LF Silt Fence	\$ 3.50	\$ 875
	30	4	EA temporary Stone outlet	\$ 1,500.00	\$ 6,000
	31	25	TON Erosion Contro #57 misc stone	\$ 50.00	\$ 1,250
	32	1	Permitting fees, USACE, NC DENR	\$ 5,000.00	\$ 5,000
	33				\$ -
					\$ -
			<b>Subtotal</b>		<b>\$ 147,800</b>
					\$ -
			<b>SUBCONTRACTOR TOTAL</b>		<b>\$ 147,800</b>
			<b>CONTINGENCY</b>	<b>10%</b>	<b>14,780</b>
			<b>SUBCONTRACTOR TOTAL FOR SITE</b>		<b>\$ 162,580</b>
			<b>GENERAL CONTRACTOR OVERHEAD &amp; PROFIT</b>	<b>15%</b>	<b>24,387</b>
			<b>GENERAL CONTRACTOR TOTAL</b>		<b>\$ 201,747</b>
			<b>Engineering Plans, specifications, as-built drawings</b>	<b>15%</b>	<b>\$ 30,262</b>
			<b>Roquemore Road Total Cost</b>		<b>\$ 232,009</b>

<b>EXCLUSIONS:</b>					
	1) ASSUME ALL SURVEYING BY OTHERS				
	2) ASSUME NO SIGNIFICANT UTILITY RELOCATION REQUIRED				
	3) ASSUME VILLAGE WILL OBTAIN ALL NECESSARY TEMPORARY AND PERMANENT EASEMENTS				
<b>NOTES:</b>					
	1) THIS IS A PRELIMINARY COST ESTIMATE				





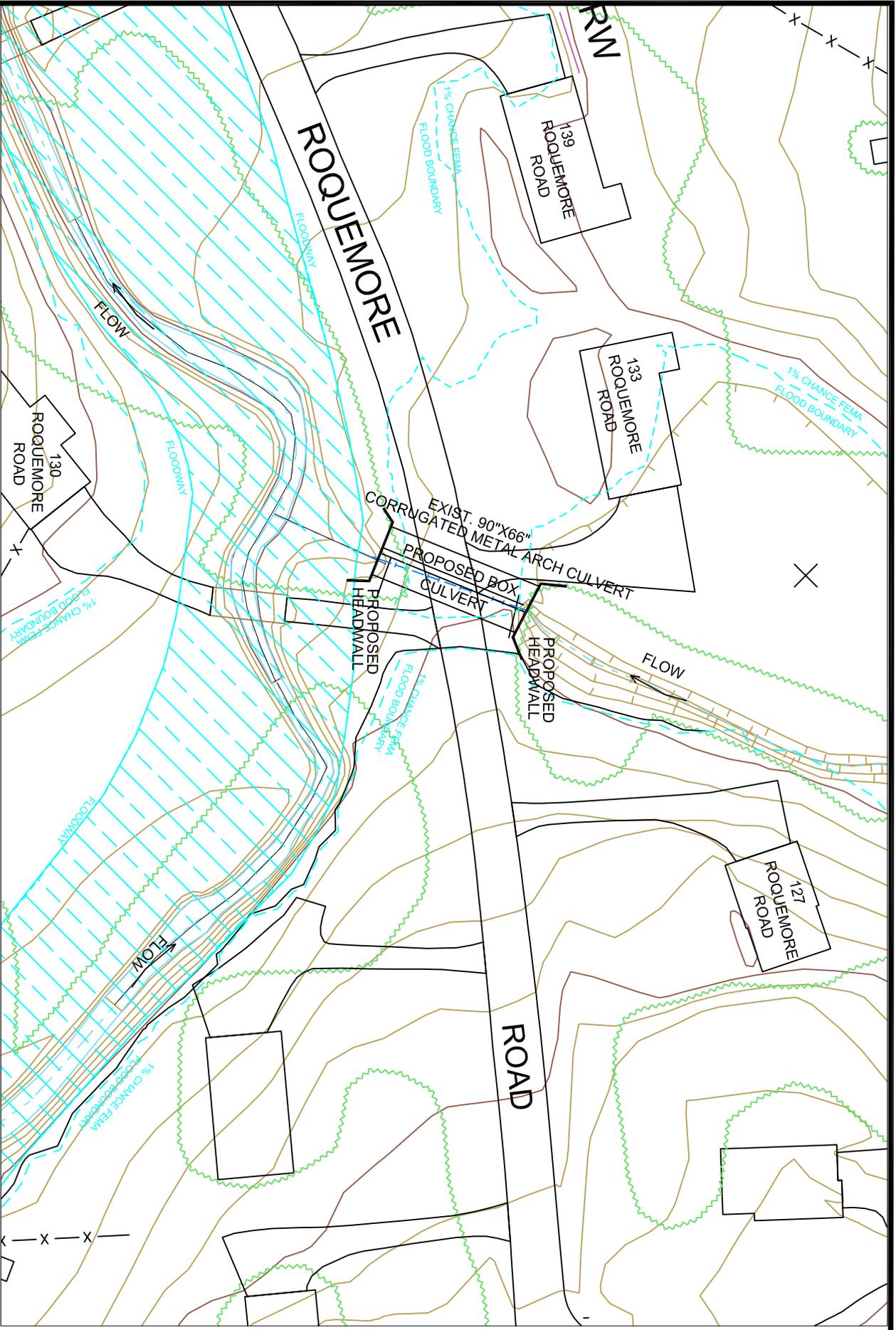
ROQUEMORE ROAD WATERSHED DRAINAGE BASIN

SCALE 1" = 850'



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**ROQUEMORE DRIVE DRAINAGE SYSTEM IMPROVEMENT**



**NOTES:**

- REPLACE 90"x66" CMAP CULVERT WITH 8' X 5' DOUBLE BOX CULVERTS
- ADD HEADWALLS AT UPSTREAM AND DOWNSTREAM END