M E M O

Date: November 26, 2001

To: Rosalind Gausman
Clerk Treasurer
Town of Dunn

cc: Warren Meyers, P.E.;
Town & County Engr. Inc.

From: Jim Bachhuber, P.H. and Caroline Brandt, EIT

Subject: Technical Memo on Meadowview Residential Area Flood Study
Earth Tech Project No. 45880

Background:

A residential area in the northwestern corner of the Town of Dunn has experienced periodic flooding from heavy rain events and during snowmelt periods. The Town contracted with Earth Tech to assess the hydrologic conditions which result in the flooding, and investigate alternative approaches to alleviate the severity and/or frequency of the flooding. The residential area of concern is located south of Meadowview Road and east of Larson Road. Several possible conditions are suspected as causing the flooding including: 1) the relatively low elevation of the area, 2) the flat slopes and overgrowth of vegetation in the drainage ditches, 3) development from the neighboring city of Fitchburg, 4) the driveway culverts along Meadowview Road, and 5) a culvert on the main drainage channel between Meadowview Road and Goodland Park Road.

Earth Tech performed a computer simulation of the drainage network. The purpose of the simulation was to assess existing flooding and determine potential impacts on flood elevations from several alternative management approaches. The alternatives are described in the "Alternatives Analysis" section of this memo.

Modeling Summary:

Earth Tech used XP-SWMM (Stormwater Management Model using the eXPert system interface) program distributed by XPSoftware Corporation.

The specific steps to conduct the modeling were:

1. Obtain topographic data from available sources. For this project, Earth Tech utilized the available data and plans from the town records, a Town & Country survey, digital contour maps, and orthographic photos for the town of Dunn, city of Fitchburg, and town of Blooming Grove (Source: Fly Dane 2000 Project).

2. Identify key drainage points: Earth Tech identified key points in the drainage system such as (1) the ditch running North/South between Nora Lane and Meadowview Road, (2) the culverts along the South side of Meadowview Road running underneath the driveways and View Road, (3) the culvert crossing under Meadowview Road from the Main Channel to the farm field in Blooming Grove, (4) the culvert under the driveway about 2/3 down the Main Channel, and (5) the culvert crossing under Goodland Road from the Main Channel out of the studied area.

3. Delineate the drainage areas (watersheds) to each drainage point Earth Tech delineated the watersheds,

(an area of land in which all water eventually flows to one point) using contour data, made available through the Town of Dunn and from the Dane County Land Information Office. Eleven (11) watersheds were delineated. The delineated watershed boundaries were field verified.

Table 1 lists the watersheds and their corresponding area. Figure 1 shows the entire project area and the boundaries of the eleven watersheds.

Table 1. Watershed Area

Watershed	Area (ac)
1	60.33
2	25.12
3	33.11
4	150.54
5	9.35
6	13.6
7	21.9
8	227.5
9	27.8
10	55.45
11	28.43

4. Obtain channel geometry data and condition: Earth Tech obtained the data for the geometry and condition of the channels (culverts and ditches) from available maps, Town & Country surveying, and field measurements. All culverts were modeled free of debris and assigned entrance and exit loss coefficients of 0.7 and 1.0 respectively. Drainage ditches were modeled using their existing conditions per field inspection September 21, 2001. A Manning's "n" is required as input for this model. The "n" value defines a channels roughness and depends on several physical properties. The higher the Manning's n value, the slower the water is able to flow though it. A Manning's n of 0.024 was used for corrugated metal, 0.020 for asphalt, 0.030 for areas with mowed grass, 0.080 for areas with moderate vegetation, and 0.120 for areas with heavy vegetation.

5. Input model hydrologic factors to the watersheds: For this application of the model, Earth Tech utilized SCS runoff hydrology. The SCS runoff hydrology relies on representative area curve numbers, time of concentration, and subbasin (watershed) characteristics to determine runoff quantities (hydrographs, peak flow, and volume of runoff) for specific design rain events.

Subbasin characteristics are defined by land use, type of soil, and slope of the land. Land use was derived from air photos and a field visit. Soil data was obtained from the Dane County Soil Survey (published by USDA-NRCS). Slopes of the watersheds were taken from of the 2-and 10-foot contour maps.

The curve numbers were calculated using TR-55 (Technical Release 55), developed by the Soil Conservation Service. When developing representative curve numbers, TR-55 takes into account the different land uses and soil types of each subbasin to determine a representative curve number for the subbasin.

Time of concentration was calculated based on flow paths derived from ArcView GIS Version 3.2a, a desktop geographic information system distributed by ESRI, and obtained from calculations performed by using TR-55. TR-55 uses the watershed's slopes and land use to determine a time of concentration for the subbasin.

Table 2 shows the composite curve number and time of concentration used for each watershed.

Table 2. Watershed Curve Number and Time of Concentration

Watershed	Curve Number	Time of Concentration (min)
1	81	22.2
2	77	20.4
3	77	32.4
4	79	30
5	74	25.2
6	80	33.6
7	80	37.8
8	78	31.6
9	78	21.5
10	79	31.8
11	79	22.2

6. Obtain rainfall values for design storms: Rainfall quantities were obtained from Dane County's Stormwater Management Ordinance. Rainfall quantities are based upon a statistical analysis of the amount of rain that is calculated to fall for a given recurrence interval, or probability of occurring. For example, the 2-yr, 24-hr storm is a storm that has an average recurrence interval of once every two years. It assumes a certain average amount of rain, or amount of rain greater than it, is going to fall in 24 hours. XP-SWMM model was run for the 2-, 10-, and 100- year 24-hour SCS type II storms.

Table 3 provides a summary of the precipitation values used.

Table 3: Precipitation Data (Design Rain Storms)

Recurrence Interval	Precipitation (inches)
2 – Year 24 Hour	2.9
10 – Year 24 Hour	4.2
100 – Year 24 Hour	6.0

7. Enter final model factors: The drainage network was modeled to allow temporary ponding behind culverts. Road overtopping was permitted to occur; all water was first routed through culverts with remaining water (if any) flowing over the road. The culverts and ditches were assumed to be empty at the beginning of the model runs. The top two drainage areas along the main channel were modeled as detention basins to replicate the properties of the existing wetlands. The drainage area north of Meadowview road was also modeled as a detention basin to mimic the existing subbasin properties.

Results:

Existing Conditions

Initially, the model was run to replicate the runoff and flooding conditions that could be expected under

existing conditions for the each design rain-storm. Results are summarized below for three key locations in the project area. The entire model was checked for stability under each storm event and for road overtopping at all culvert locations. Table 4 summarizes the results.

For purposes of this study the term "Depth of Flooding" (used in Tables 4-7) means the maximum depth of water above the general ground elevation near each site. The ground elevation varies slightly in these areas, however an elevation of 866.6 was used for ground elevation at the first two sites (Nora Lane and south of Meadowview Road) and 864.0 for the third site (culvert 2/3 of the way down the main channel).

Table 4: Summary of Modeling Results
Existing Conditions

Location and Description	Rain Event		
	2-year (2.9")	10-year (4.2")	100-year (6.0")
Ditch from Nora Lane N to Meadowview Road			
Max. Water surface elevation (ft)	866.1	867.0	868.0
Max. Flow rate (cfs)	16.1	19.3	28.1
Max. Depth of Flooding (ft) [1]	0	0.4	1.4
South Ditch along Meadowview Road			
Max. Water surface elevation (ft)	864.6	864.8	865.7
Max. Flow rate (cfs)	11.6	14.2	37.7
Max. Depth of Flooding (ft) [1]	0	0	0
Culvert 2/3 down Main Channel			
Max. Water surface elevation (ft)	863.0	863.5	864.1
Max. Flow rate (cfs)	24.7	27.8	31.6
Max. Depth of Flooding (ft) [2]	0	0	0.1

[1] Depth of flood water above elevation 866.6
[2] Depth of flood water above elevation 864.0

Alternative Management Analysis

After the model was successfully constructed to replicate the existing conditions, a series of alternative management measures were simulated with the model. As part of an alternative analysis, the potential for allowing more efficient drainage from the flooded area was examined with the following 7 alternatives:

a) Mow existing vegetation in the drainage ditches from Nora Lane to Meadowview Road and along the south side of Meadowview Road to the Main Drainage Channel.
b) Enlarge culverts along the south side of Meadowview Road to accommodate the maximum flow.
c) Concrete line the drainage ditches from Nora Lane to Meadowview Road and along the south side of Meadowview Road.
d) Concrete line the drainage ditches (as in c) and enlarge the existing culverts (as in b) to accommodate the maximum flow along the ditch.
e) Enlarge the culvert 2/3 down the Main Channel.
f) Store water in a detention basin north of Meadowview Road.
g) Build a new drainage ditch connecting to the present drainage ditch at Nora Lane and convey the water south through the existing wetlands to connect up with the main drainage channel.

Tables 5 - 7 provide a summary of the results for the three design storms.

Table 5: Impacts on Flood Conditions
2-yr Storm Event

Location and Description	Management Alternative						
	(a) mow ditches	(b) enlarge Meadowview culverts	(c) concrete line channels	(d) do (b) and (c)	(e) enlarge Main Channel culvert	(f) detention basin	(g) new south channel
Ditch from Nora Ln N to Meadowview Rd							
Change in Water surface elevation (ft)	-0.1	-0.5	-0.1	-1.1	0	-0.1	-1.7
Change in Max. Flow rate (cfs)	-0.5	4.7	-0.8	4.6	0	0.4	-2.7
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0
South Ditch along Meadowview Road							
Change in Water surface elevation (ft)	0	0.4	0	0.4	0	-0.5	-0.3
Change in Max. Flow rate (cfs)	0.2	17.2	0.3	20.1	0	1.3	-7.8
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0
Culvert 2/3 down Main Channel							
Change in Water surface elevation (ft)	0	0.1	0	0.1	0	-0.1	0
Change in Max. Flow rate (cfs)	0	0	0.1	0.1	4.1	-0.1	-0.2
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0

Table 6: Impacts on Flood Conditions
10-yr Storm Event

Location and Description	Management Alternative						
	(a) mow ditches	(b) enlarge Meadowview culverts	(c) concrete line channels	(d) do (b) and (c)	(e) enlarge Main Channel culvert	(f) detention basin	(g) new south channel
Ditch from Nora Ln N to Meadowview Rd							
Change in Water surface elevation (ft)	0	-0.8	0	-1.3	0	-0.1	-1.9
Change in Max. Flow rate (cfs)	-0.1	17.8	0.3	21.1	0	0.9	6.7
Change in Depth of Flooding (ft)	0	-0.4	0	-0.4	0	-0.1	-0.4
South Ditch along Meadowview Road							
Change in Water surface elevation (ft)	0	0.8	0	0.9	0	-0.5	-0.1
Change in Max. Flow rate (cfs)	0.1	37.6	0.2	46.2	0	1.5	-7.2
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0
Culvert 2/3 down Main Channel							
Change in Water surface elevation (ft)	1.3	0	0	0	-0.1	-0.2	0
Change in Max. Flow rate (cfs)	12.3	0.1	0	0	3.8	-1.6	-0.1
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0

Table 7: Impacts on Flood Conditions
100-yr Storm Event

Location and Description	Management Alternatives						
	(a) mow ditches	(b) enlarge Meadowview culverts	(c) concrete line channels	(d) do (b) and (c)	(e) enlarge Main Channel culvert	(f) detention basin	(g) new south channel
Ditch from Nora Ln N to Meadowview Rd							
Change in Water surface elevation (ft)	0	-1.1	-0.1	-1.5	0	0	-2.4
Change in Max. Flow rate (cfs)	0.6	26.7	1.2	35.1	0	0.8	31
Change in Depth of Flooding (ft)	0	-1.1	-0.1	-1.4	0	0	-1.4
South Ditch along Meadowview Road							
Change in Water surface elevation (ft)	-0.1	0.6	-0.1	0.7	1	-0.5	-0.7
Change in Max. Flow rate (cfs)	1	38.6	1.4	55.7	0	-0.6	-29.1
Change in Depth of Flooding (ft)	0	0	0	0	0	0	0
Culvert 2/3 down Main Channel							
Change in Water surface elevation (ft)	0	0	0	0	-0.1	-0.3	0
Change in Max. Flow rate (cfs)	-0.2	-0.1	-0.2	-0.1	6.4	-2.1	-0.2
Change in Depth of Flooding (ft)	0	0	0	0	-0.1	-0.1	0

Cost Comparison

A cost comparison of each alternative based on estimated unit costs was analyzed. Costs were estimated based on unit costs of similar projects in Wisconsin and from standard engineering estimating references. Table 8 summarizes these results.

Table 8: Cost Comparison of Alternatives for Area between Nora Lane and Meadowview Road
100-yr Storm Event

Scenario	Flood Elevation	Change from Existing Flood Conditions	Ground Elevation	Estimated Cost	Estimated Cost/ Ft. of Flooding Reduced
Existing Conditions	868.0	0	866.6	N/A	N/A
a) mow ditches	868.0	0	866.6	$2,400-$3600	$0
b) enlarge Meadowview culverts	866.9	1.1	866.6	$21,000-$31,000	$23,411
c) concrete line channels	867.9	0	866.6	$62,000-$94,000	$1,300,679
d) do (b) and (c)	866.5	1.5	866.6	$80,000-$120,000	$71,458
e) enlarge culvert 2/3 down Main Channel	868.0	0	866.6	$3,900-$5,800	$0
f) detention basin	868.0	0	866.6	$26,000-$39,000	$0
g) new south channel*	865.6	2.4	866.6	$14,000-$21,000	$12,374

* Cost does not include costs associated with acquisition of land

Conclusions

Overall, it can be concluded that the water from the neighboring city of Fitchburg does not contribute to the flooding at Nora Lane. In addition, the culvert 2/3 down the Main Channel does not contribute to flooding. The main causes of flooding were concluded to be the characteristics of the drainage ditches (the relatively flat slopes and overgrowth of vegetation) and the relatively small sizes of the culverts along Meadowview Road. These two factors greatly reduce the flow of water from Nora Lane to the Main Channel which in turn causes the water to back up and flood the area.

Table 4 indicates that the modeling analysis does show flooding in the area of Nora Lane during the 10-year and 100-year events. The model is most useful as a tool to predict the *relative* positive impacts the management alternatives will have on flood elevations from the selected design storms. The results of this analysis are shown in Tables 5-7. The alternatives with the most significant impact on decreasing flood elevations are:

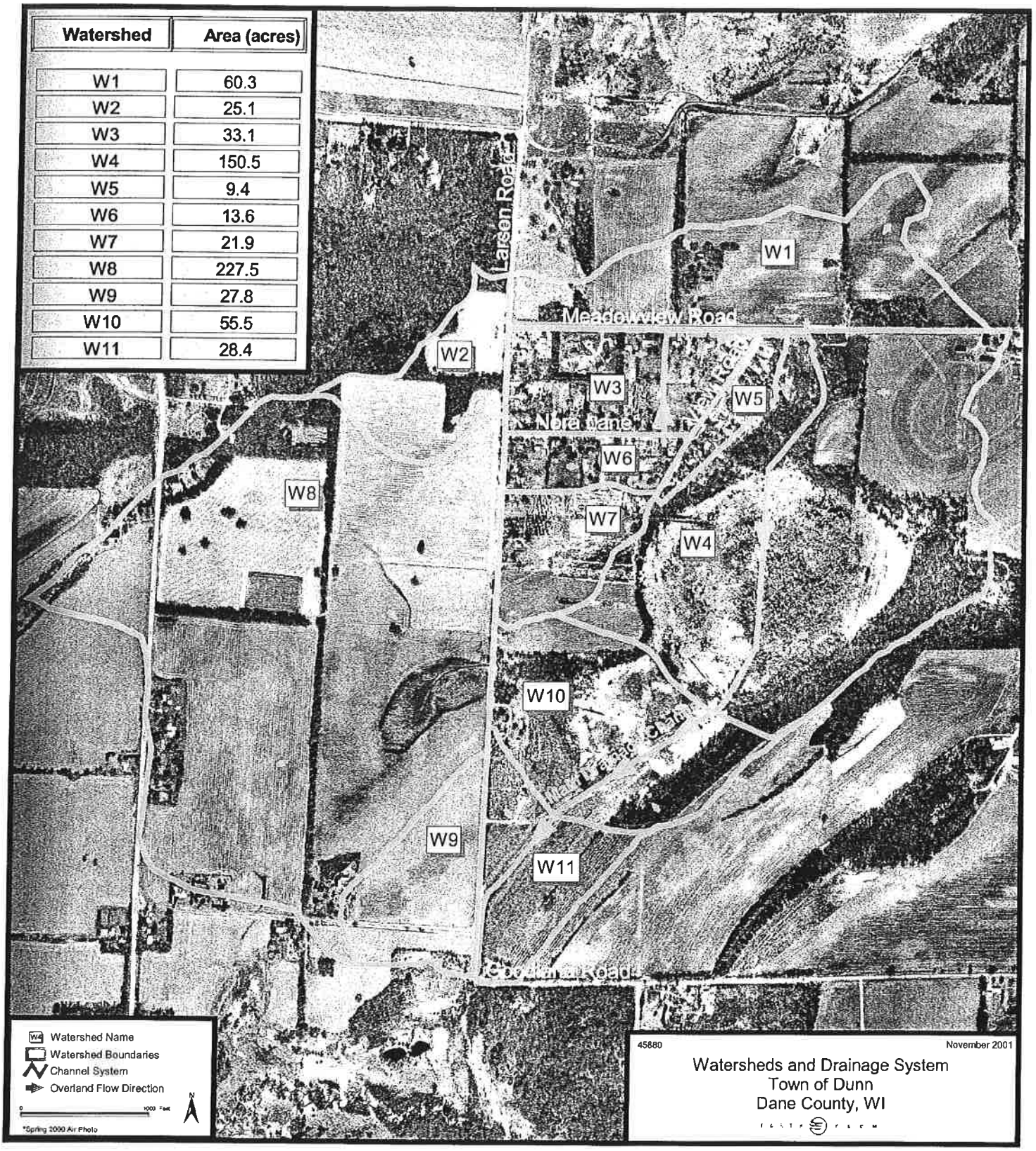
- Alternative (d) concrete lining the drainage ditches and enlarging the existing culverts to accommodate the maximum flow along the ditch and

- Alternative (g) building a new drainage ditch connecting to the present drainage ditch at Nora Lane and convey the water south into the existing wetlands to connect up with the main drainage channel.

Alternative (b), enlarging culverts along the south side of Meadowview Road to accommodate the maximum flow also had a significant effect, even though it did not appear to completely reduce the flooding from the storms analyzed.

DOCUMENT2

Watershed	Area (acres)
W1	60.3
W2	25.1
W3	33.1
W4	150.5
W5	9.4
W6	13.6
W7	21.9
W8	227.5
W9	27.8
W10	55.5
W11	28.4



Attachment A
Town of Dunn Meadowview Neighborhood Stormwater Study
Management Alternative Cost Estimate Factors

Conditions & Mgt. Alternatives	Mowing	Remove Existing Culverts	Culverts	Headwalls	Granular Base Material	Concrete	Excavation	Seed and Mulch	Buy Land	Total Cost	Plus/Minus 20%	Assumptions
Existing Condition	$0	$0	$0	$0	$0	$0	$0	$0	$0	N/A		
a) mow ditches	$3,000	$0	$0	$0	$0	$0	$0	$0	$0	$3,000	H $3,600	Once a month Spring through Fall
												2 days/month
											L $2,400	10 hr/day
												$25/hr
b) enlarge Meadowview driveway culverts	$0	$1,000	$12,600	$8,400	$0	$0	$3,519	$1,056	$0	$25,519	H $30,622	Cost to remove existing culvert is $250 each
												4 culverts to be removed
												3-36" culverts to carry maximum flow at each site
												4 culverts to be replaced
												Culvert cost is $42/ft
											L $20,415	2 apron walls per culvert
												Apron wall cost is $350 each
												Excavate ditch 1 ft to accommodate new culvert size
												Excavation cost is $5/yd^3
												Meadowview ditch length is 1,105 ft
												Seed and mulch ditch cost is $0.5/yd^3
c) concrete line channels	$0	$0	$0	$0	$1,056	$73,467	$3,519	$1,056	$0	$78,041	H $93,649	Excavate ditch 1 ft to accommodate concrete and pad thickness
												Excavation assumptions same as (b) except include N-S ditch
												N-S ditch length from Meadowview Rd to Nora Lane is 800 ft
											L $62,433	6" thick granular base material under concrete
												Granular base material cost is $3/yd^3
												6" thick concrete lining on bottom and 1 ft up each side
												Concrete cost is $29/yd^2
d) do (b) and (c)	$0	$1,000	$12,600	$8,400	$1,056	$73,467	$3,519	$1,056	$0	$100,041	H $120,048.9	Assumptions same as (b) and (c)
											L $80,032.6	
e) enlarge culvert 2/3 down Main Channel	$0	$250	$2,520	$2,100	$0	$0	$0	$0	$0	$4,870	H $5,844.0	Assumptions same as (b) except removing and replacing only one culvert
											L $3,896.0	
f) detention basin	$0	$0	$0	$0	$0	$0	$24,200	$0	$8,000	$32,200	H $38,640	1 acre detention pond N of Meadowview Rd
												3 feet deep
											L $25,760.0	Excavation assumptions are same as (b)
												Does not include seeding and mulching
												Land acquisition cost is $8,000
g) new south channel*	$0	$0	$0	$0	$0	$0	$16,343	$981	$0	$17,323	H $20,787.8	New ditch dimensions are 5' deep, 10' wide, 1765' long
											L $13,858.5	Excavation and seeding and mulching assumptions are same as (b)

Attachment B
Town of Dunn Meadowview Neighborhood Stormwater Study
Key Elevations Used in Study

Location	Invert Elevation (based on MSL NGVD 88 (ft))	Source
Nora Lane N-S Culvert upstream invert	865.10 (862.5*)	Digital Contour Map based on Fly Dane 2000
Nora Lane N-S Culvert downstream invert	864.00 (862.4*)	Digital Contour Map based on Fly Dane 2000
Intersection of N-S Ditch and Meadowview Road S side Ditch	863.00	Linear interpolation between known culvert elevations provided by local survey
View Road E-W Culvert upstream invert	862.48	Linear interpolation between known culvert elevations provided by local survey
View Road E-W Culvert downstream invert	862.47	Linear interpolation between known culvert elevations provided by local survey
Meadowview Road N-S Culvert (E of View Rd) upstream invert	862.55	Digital Contour Map based on Fly Dane 2000
Meadowview Road N-S Culvert (E of View Rd) downstream invert	862.20	Local Survey
Intersection of Proposed Ditch (management alternative (g)) and Main Channel	860.10	Linear interpolation between known culvert elevations provided by local survey
Goodland Road N-S Culvert upstream invert	858.55	Local Survey

*New invert elevation for proposed ditch (management alternative (g))