SECTION 6

Runoff Analysis

Runoff from each sub-basin was determined using the U.S. Army Corps of Engineers' HEC-HMS hydrologic computer model. This model uses the input parameters presented in Section 4, Basin Delineation and Model Parameters, to compute estimated peak flows from each sub-basin. Flows from each sub-basin were routed as shown in Figures 6-1 through 6-8. Detailed hydrologic analysis data, calculations, and results are provided in Appendix B.

6.1 Peak Sub-basin Flows

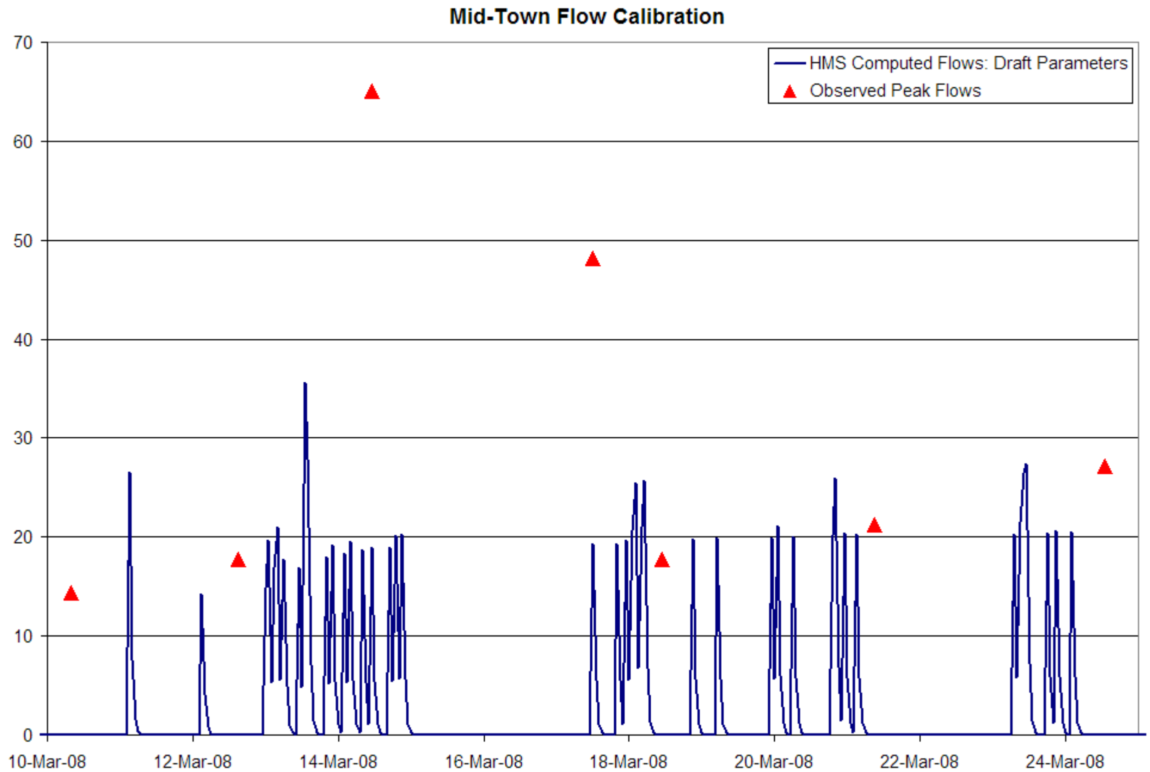
Peak flows from each sub-basin were computed for the 10-, 25-, 50-, and 100-year frequency events. The results of this analysis for the 10-year events from each individual sub-basin under both existing and future development conditions are presented in Figures 6-1 through 6-8. These flows should be used when estimating local flows generated from part of an individual sub-basin.

6.1.1 Flow Calibration

Using collected flow monitoring data from three locations distributed across the City, an effort was made to calibrate model flows to measured values. The graphs below show how the measured peak flows compare to the uncalibrated HEC-HMS model. A perfect calibration would show the highest value (peak) between two observation points equal to the observed Peak Flow. A tabular description on each figure summarizes the results by basin.

6.1.1.1 Midtown Basin

In the Midtown Basin, the HMS model matched well for the smaller rain events while underestimating the larger peak flows.



Midtown Basin/Dancer Outfall

Time	Measured Flow	Uncalibrated HMS Flows	% Flow Change Needed
3/10/08 8:00	14.4	14	3%
3/12/08 15:00	17.7	26	-47%
3/14/08 11:00	65.1	36	45%
3/17/08 12:00	48.1	21	56%
3/18/08 11:00	17.7	25	-41%
3/21/08 9:00	21.2	26	-23%
3/24/08 13:00	27.1	27	0%
		Average =	-1%

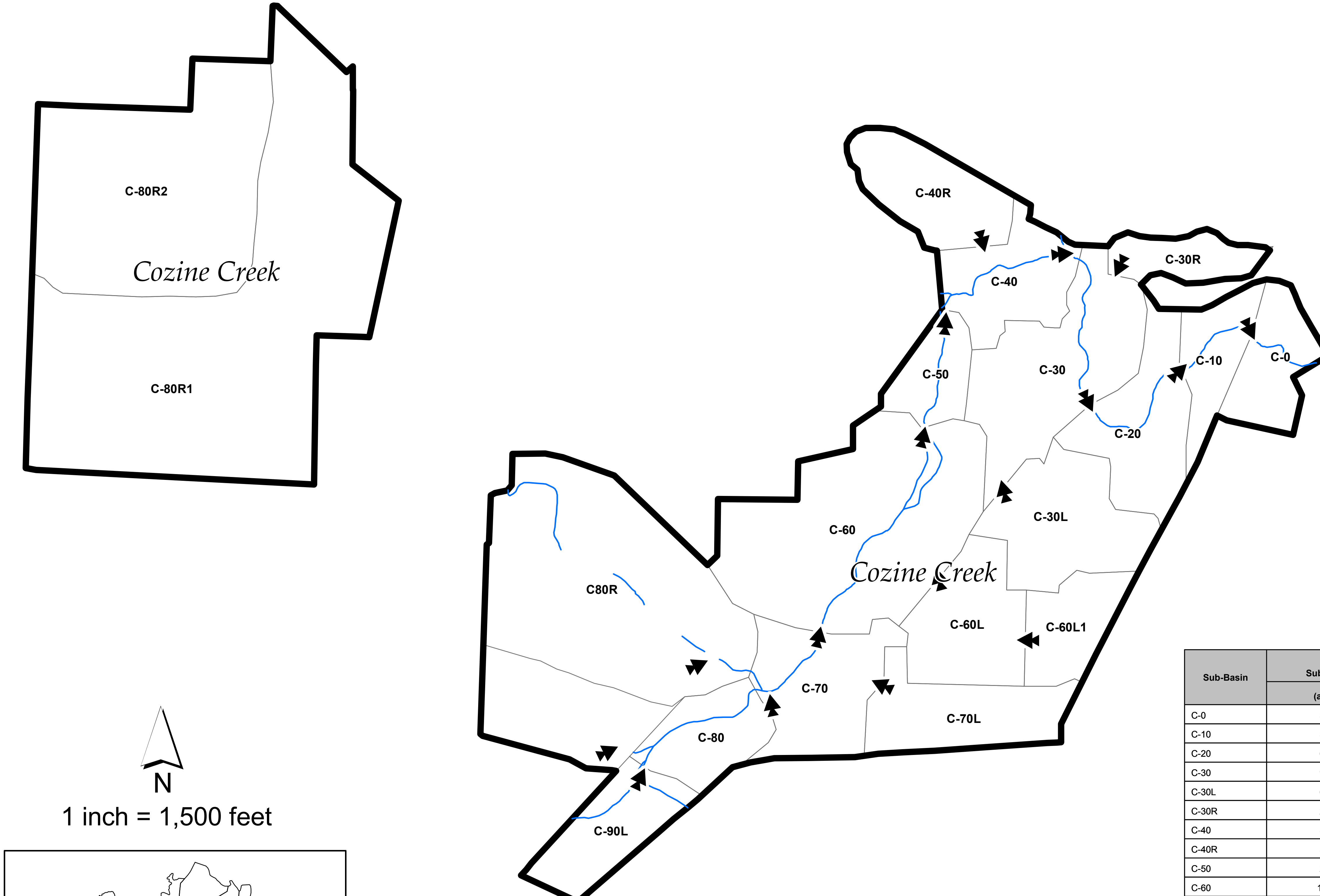
6.1.1.2 North Cozine Basin

The HMS model slightly over estimated peak flows in this basin with an average residual of 33 percent.

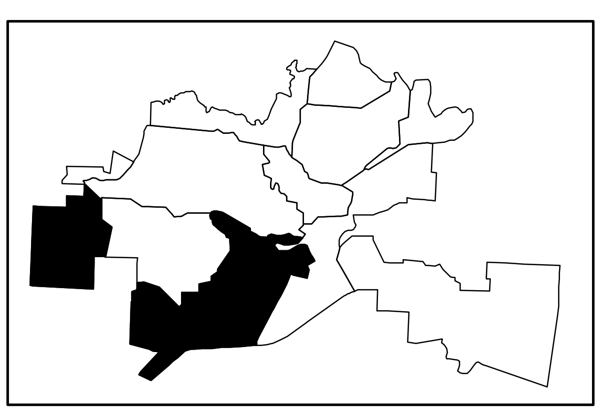
FIGURE 6-1

COZINE CREEK SUB-BASIN FLOWS

City of McMinnville Stormwater Drainage Master Plan



1 inch = 1,500 feet



Sub-Basin	Sub-Basin	Existing (Q10)	Future (Q10)
	(acres)	(cfs)	(cfs)
C-0	37.5	14	14
C-10	32.4	14	14
C-20	62.0	27	28
C-30	93.3	46	47
C-30L	68.9	44	46
C-30R	25.8	14	15
C-40	50.4	21	22
C-40R	51.8	20	21
C-50	28.5	11	11
C-60	171.8	65	68
C-60L	57.7	25	26
C-60L1	35.9	15	16
C-70	63.7	26	27
C-70L	56.2	33	34
C-80	39.3	23	24
C-80R	129.6	57	59
C-80R1	608.4	108	108
C-80R2	437.2	99	113
C-90	1,778.3	231	231
C-90L	33.3	11	11

Note: For Cumulative Drainageway Flows, See Table 6-1

Legend

- Creek\River
- *Sub-Basin Node with Direction of Flow*
- Major Basin
- Subbasins

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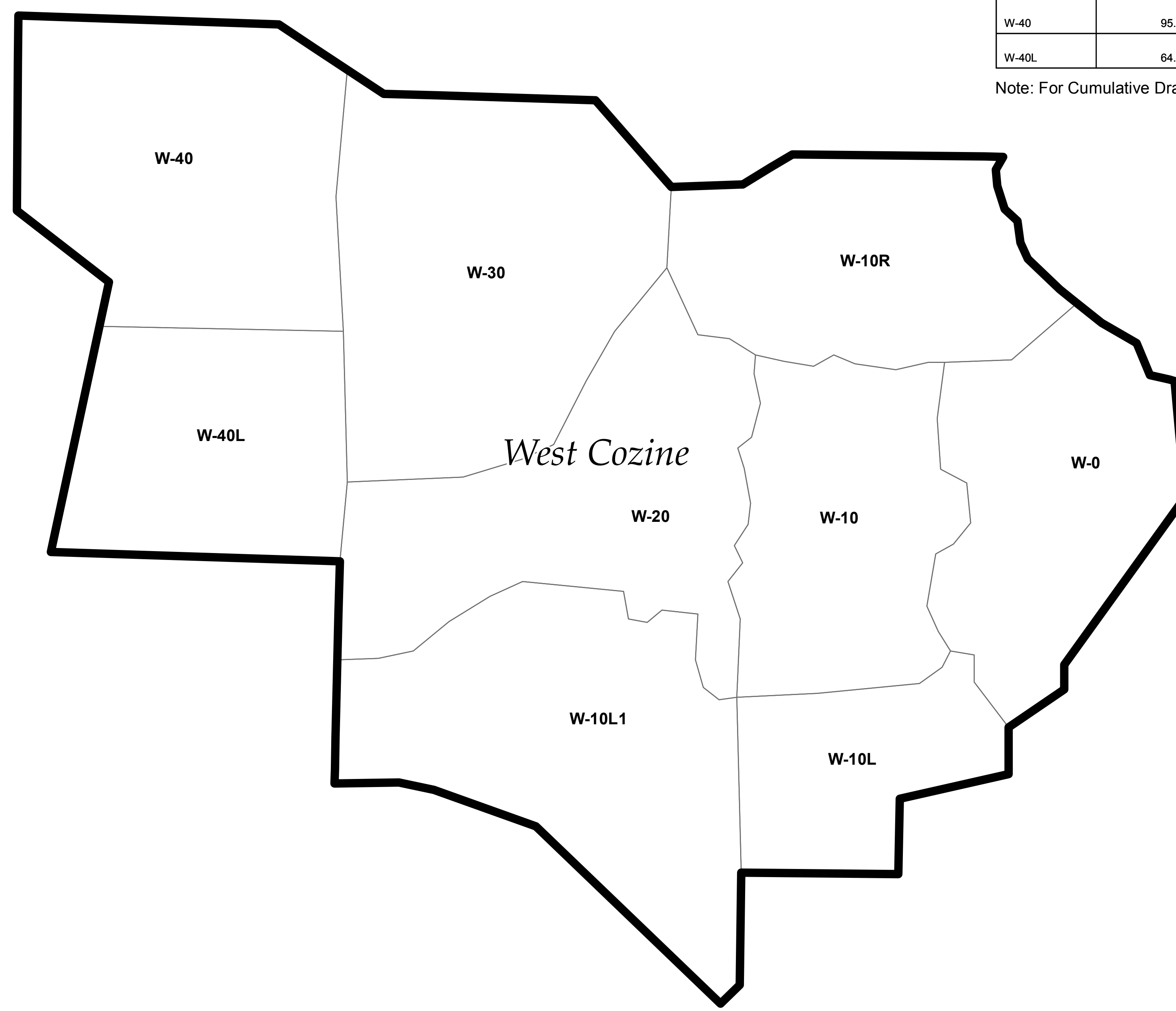
FIGURE 6-2

WEST COZINE SUB-BASIN FLOWS

City of McMinnville Stormwater Drainage Master Plan

Sub-Basin	Sub-Basin	Existing (Q10)	Future (Q10)
	(acres)	(cfs)	(cfs)
W-0	72.8	37	40
W-10	68.8	32	33
W-10L	42.8	21	21
W-10L1	100.4	49	49
W-10R	71.9	37	37
W-20	91.4	46	46
W-30	110.7	54	54
W-40	95.6	51	51
W-40L	64.9	35	36

Note: For Cumulative Drainageway Flows, See Table 6-1



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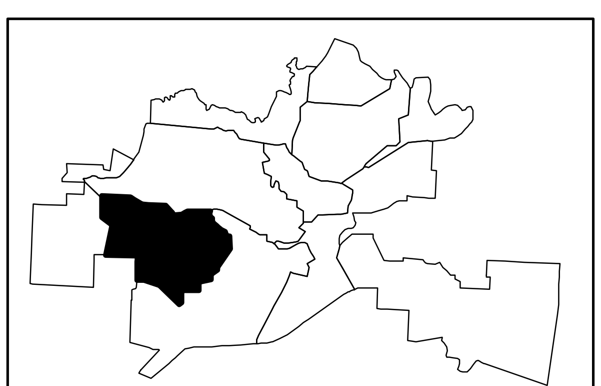
1 inch = 1,000 feet



Legend

Creek\River

Sub-Basin Node with Direction of Flow

Major Basin

Subbasins

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Date: 4/2/2009

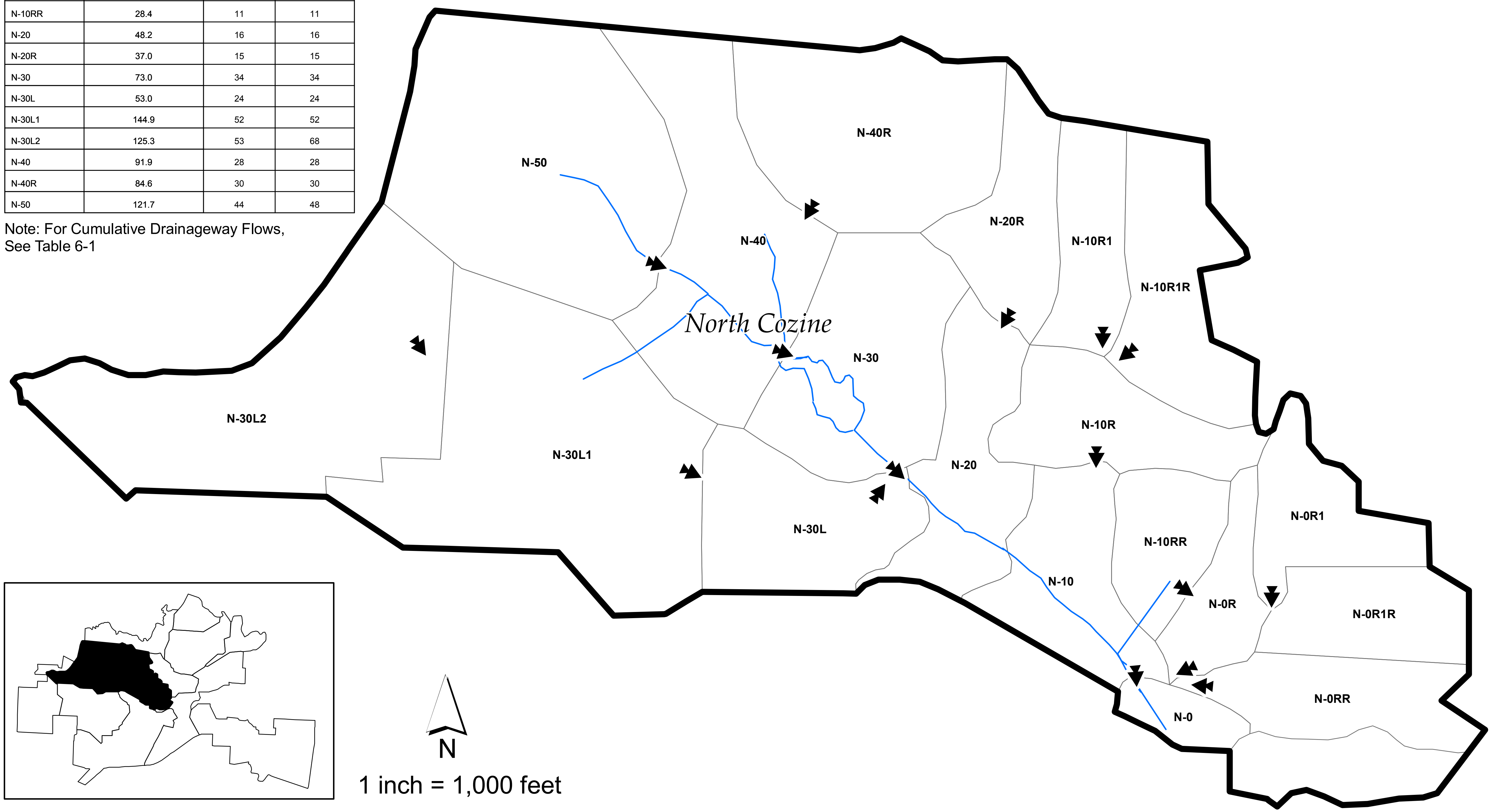
FIGURE 6-3

NORTH COZINE SUB-BASIN FLOWS

City of McMinnville
Stormwater Drainage Master Plan

Sub-Basin	Sub-Basin (acres)	Existing (Q10) (cfs)	Future (Q10) (cfs)
N-0	12.0	7	7
N-0R	22.7	10	10
N-0R1	34.7	15	15
N-0R1R	34.5	16	16
N-0RR	39.2	18	18
N-10	46.0	18	18
N-10R	42.1	19	19
N-10R1	31.2	13	13
N-10R1R	54.1	19	19
N-10RR	28.4	11	11
N-20	48.2	16	16
N-20R	37.0	15	15
N-30	73.0	34	34
N-30L	53.0	24	24
N-30L1	144.9	52	52
N-30L2	125.3	53	68
N-40	91.9	28	28
N-40R	84.6	30	30
N-50	121.7	44	48

Note: For Cumulative Drainageway Flows, See Table 6-1



Legend

- Sub-Basin Node with Direction of Flow
- Creek\River
- Major Basin
- Subbasins

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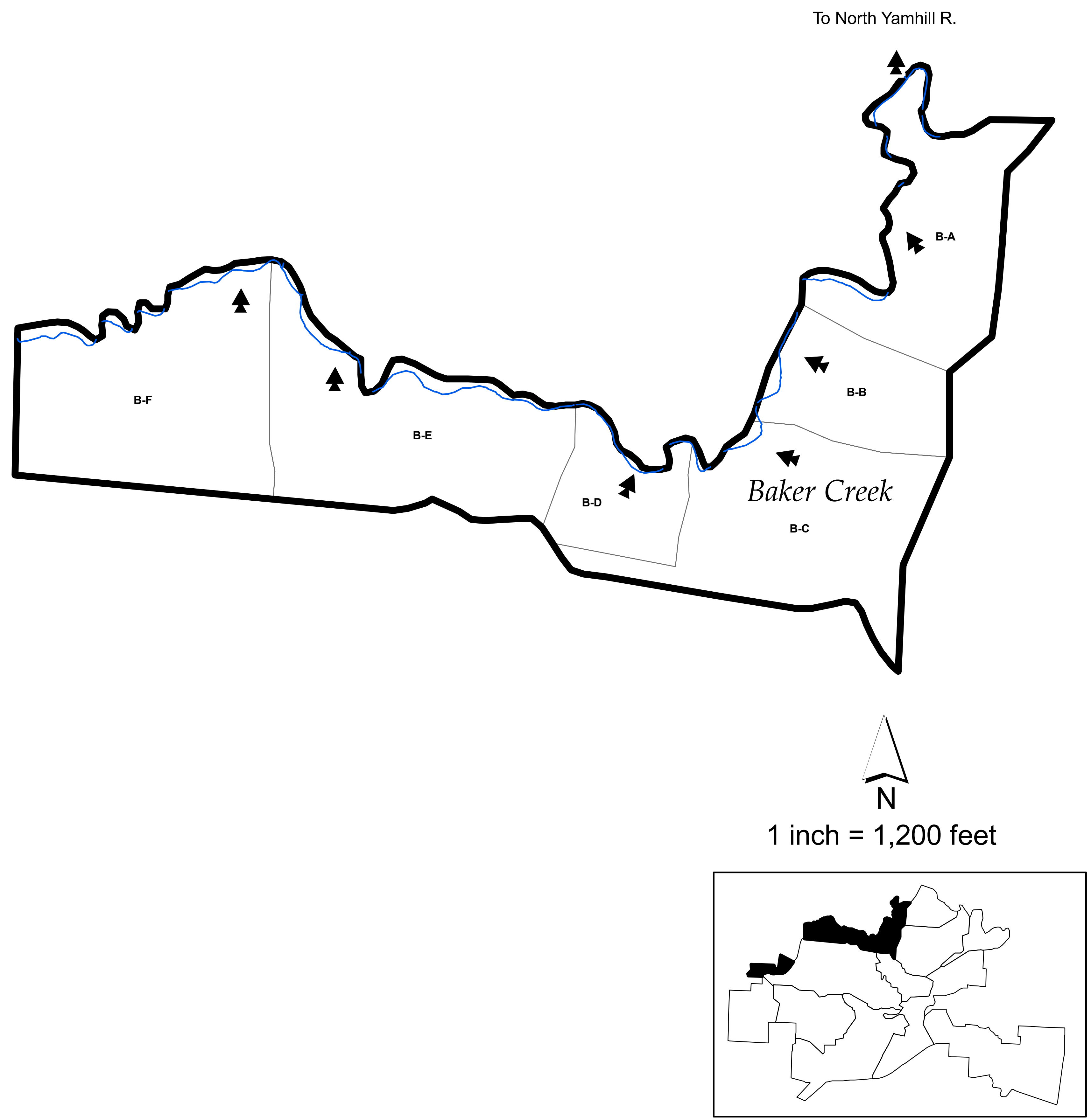
Date: 4/2/2009

Sub-Basin	Sub-Basin	Existing (Q10)	Future (Q10)
	(acres)	(cfs)	(cfs)
B-A	73.3	27	31
B-B	42.6	17	20
B-C	93.9	33	33
B-D	32.9	15	15
B-E	97.2	38	39
B-F	105.0	37	46
B-G	89.5	Local Drainage Only	

Note: For Cumulative Drainageway Flows, See Table 6-1



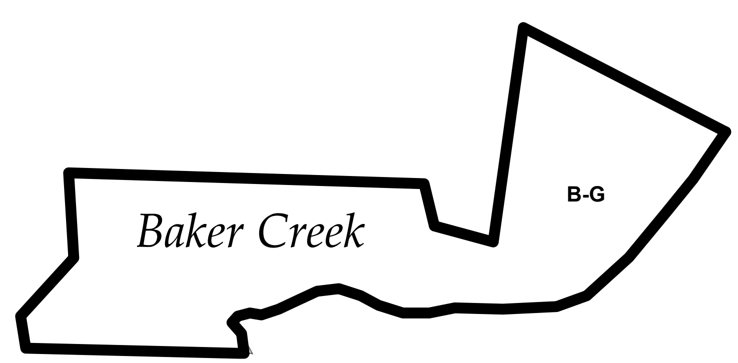


FIGURE 6-4

BAKER CREEK SUB-BASIN FLOWS

City of McMinnville
Stormwater Drainage Master Plan

Legend

- Creek\River
- *Sub-Basin Node with Direction of Flow*
- Major Basin
- Subbasins

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Date: 4/10/2009

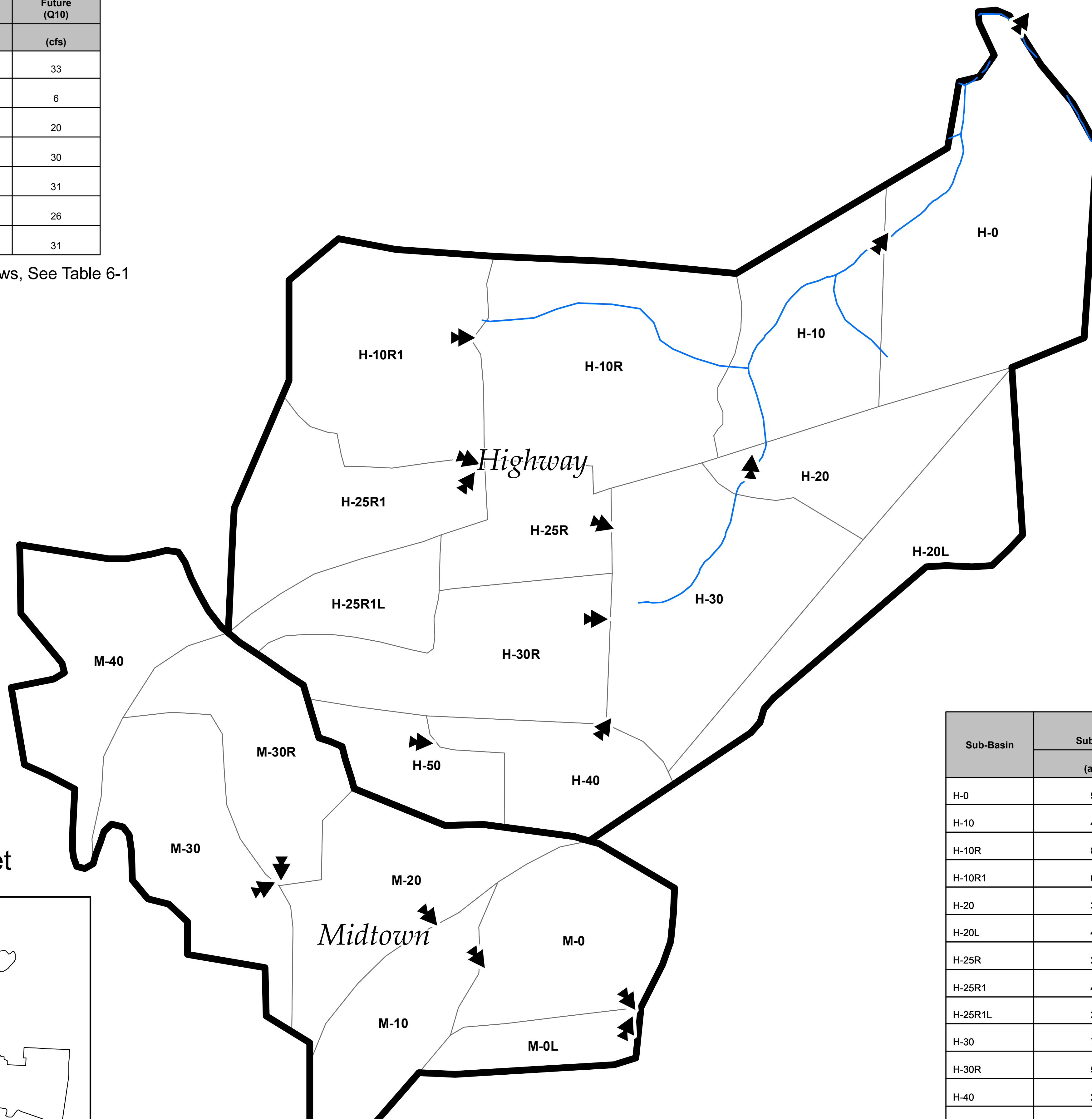
FIGURE 6-5

MIDTOWN & HIGHWAY SUB-BASIN FLOWS

City of McMinnville
Stormwater Drainage Master Plan

Sub-Basin	Sub-Basin (acres)	Existing (Q10) (cfs)	Future (Q10) (cfs)
M-0	46.5	33	33
M-0L	15.9	6	6
M-10	33.9	20	20
M-20	49.1	30	30
M-30	49.7	30	31
M-30R	41.9	26	26
M-40	50.6	31	31

Note: For Cumulative Drainageway Flows, See Table 6-1



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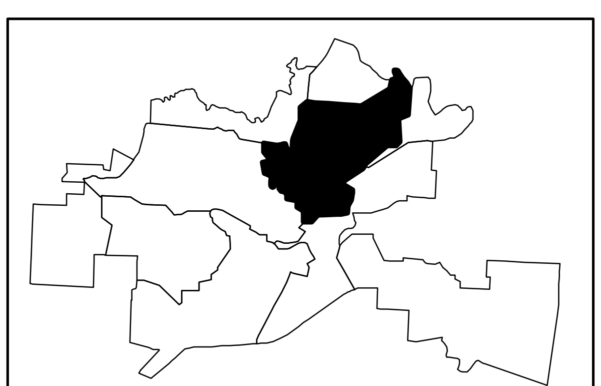
1 inch = 1,000 feet



Sub-Basin	Sub-Basin (acres)	Existing (Q10) (cfs)	Future (Q10) (cfs)
H-0	91.2	66	67
H-10	48.4	31	32
H-10R	80.7	40	40
H-10R1	63.1	32	32
H-20	32.4	24	24
H-20L	47.2	28	28
H-25R	27.0	20	20
H-25R1	45.5	29	29
H-25R1L	22.6	13	13
H-30	73.7	47	47
H-30R	54.6	28	28
H-40	28.7	17	17
H-50	23.2	13	13

Note: For Cumulative Drainageway Flows, See Table 6-1

Legend

Creek\River

Sub-Basin Node with Direction of Flow

Major Basin

Subbasins

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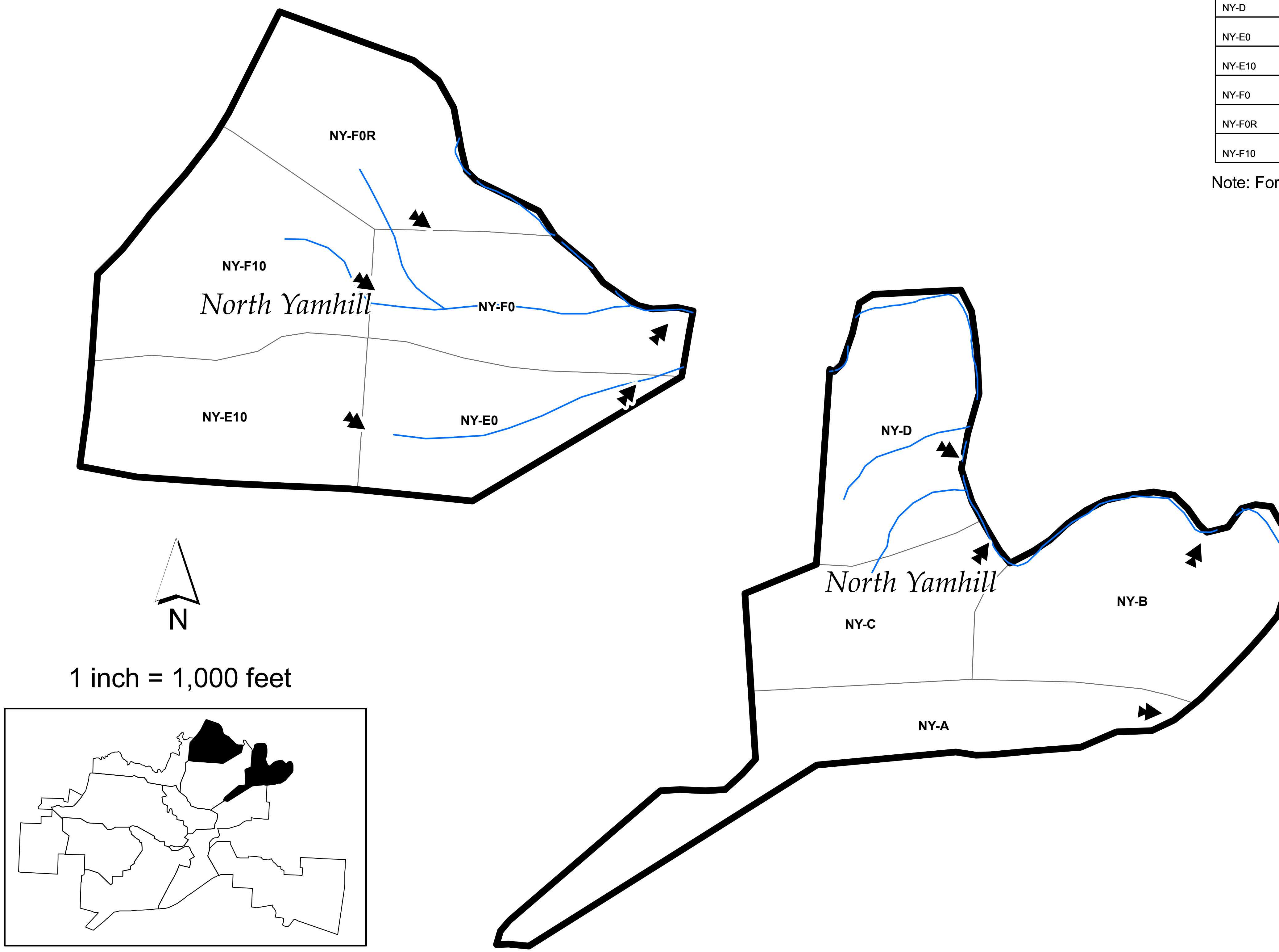
FIGURE 6-6

NORTH YAMHILL SUB-BASIN FLOWS

City of McMinnville Stormwater Drainage Master Plan

Sub-Basin	Sub-Basin (acres)	Existing (Q10) (cfs)	Future (Q10) (cfs)
NY-A	69.6	20	31
NY-B	77.9	26	36
NY-C	49.0	27	27
NY-D	59.2	16	16
NY-E0	49.9	16	19
NY-E10	59.7	17	22
NY-F0	56.3	24	25
NY-F0R	61.3	30	31
NY-F10	55.2	20	21

Note: For Cumulative Drainageway Flows, See Table 6-1



Legend

- Creek\River
- *Sub-Basin Node with Direction of Flow*
- Major Basin
- Subbasins

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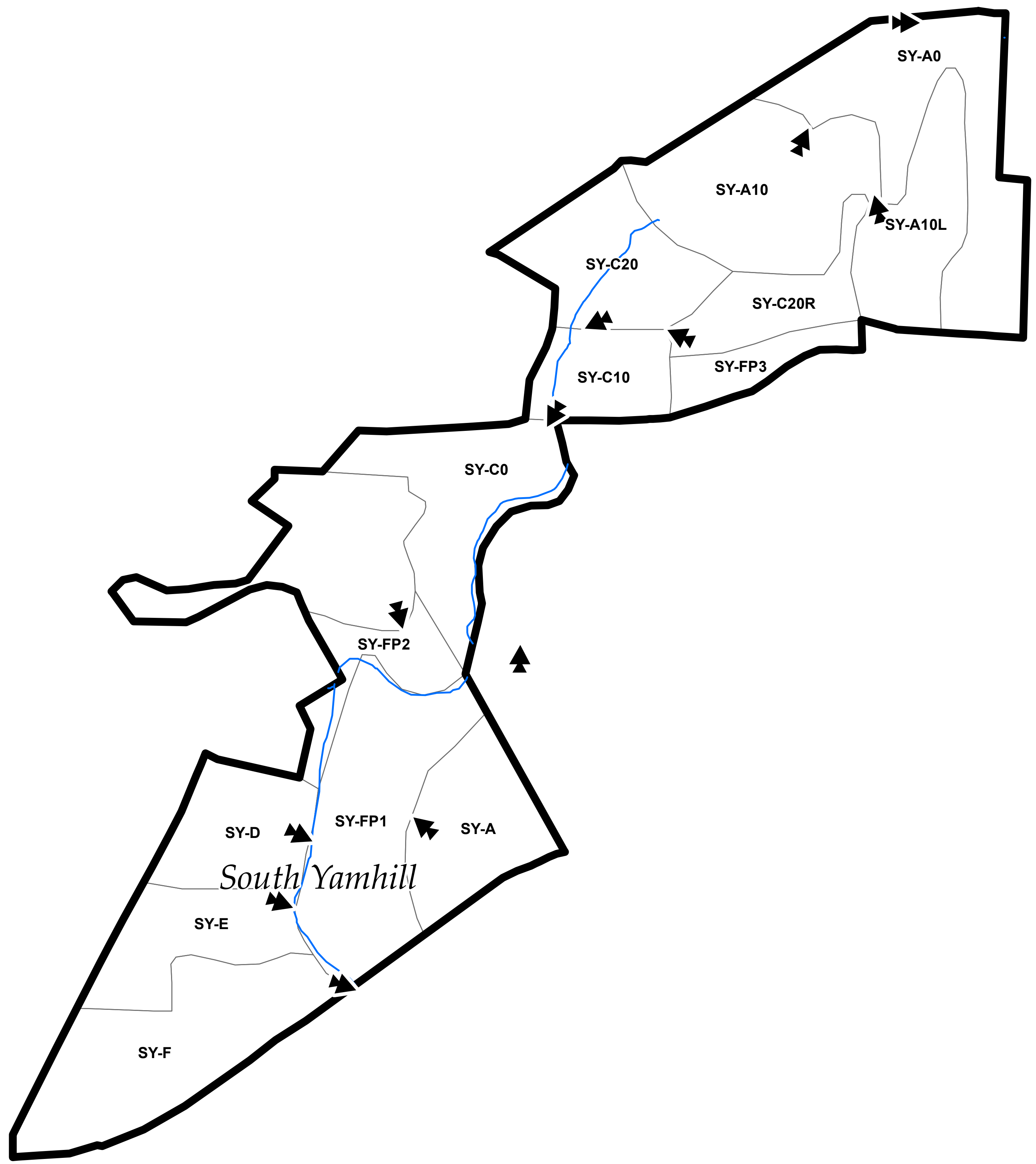
FIGURE 6-7

SOUTH YAMHILL SUB-BASIN FLOWS

City of McMinnville Stormwater Drainage Master Plan

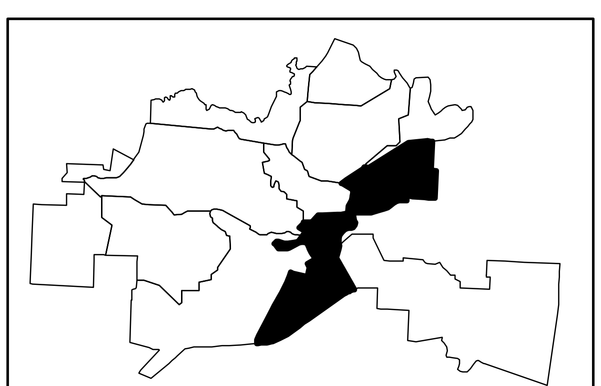
Sub-Basin	Sub-Basin (acres)	Existing (Q10) (cfs)	Future (Q10) (cfs)
SY-A0	93.6	54	54
SY-A10	84.1	62	62
SY-A10L	48.8	34	34
SY-C0	67.1	41	41
SY-C10	33.0	18	18
SY-C20	56.5	33	33
SY-C20R	32.6	19	19
SY-D	44.7	23	28
SY-E	46.0	20	21
SY-F	91.1	38	40
SY-CSS	66.3	Combined Sewer	
SY-FP1	87.8	Combined Sewer	
SY-FP2	27.7	Combined Sewer	
SY-FP3	20.7	Combined Sewer	
SY-A	51.6	Combined Sewer	

Note: For Cumulative Drainageway Flows, See Table 6-1



N

1 inch = 1,500 feet



Legend

- Creek\River
- *Sub-Basin Node with Direction of Flow*
- Major Basin
- Subbasins

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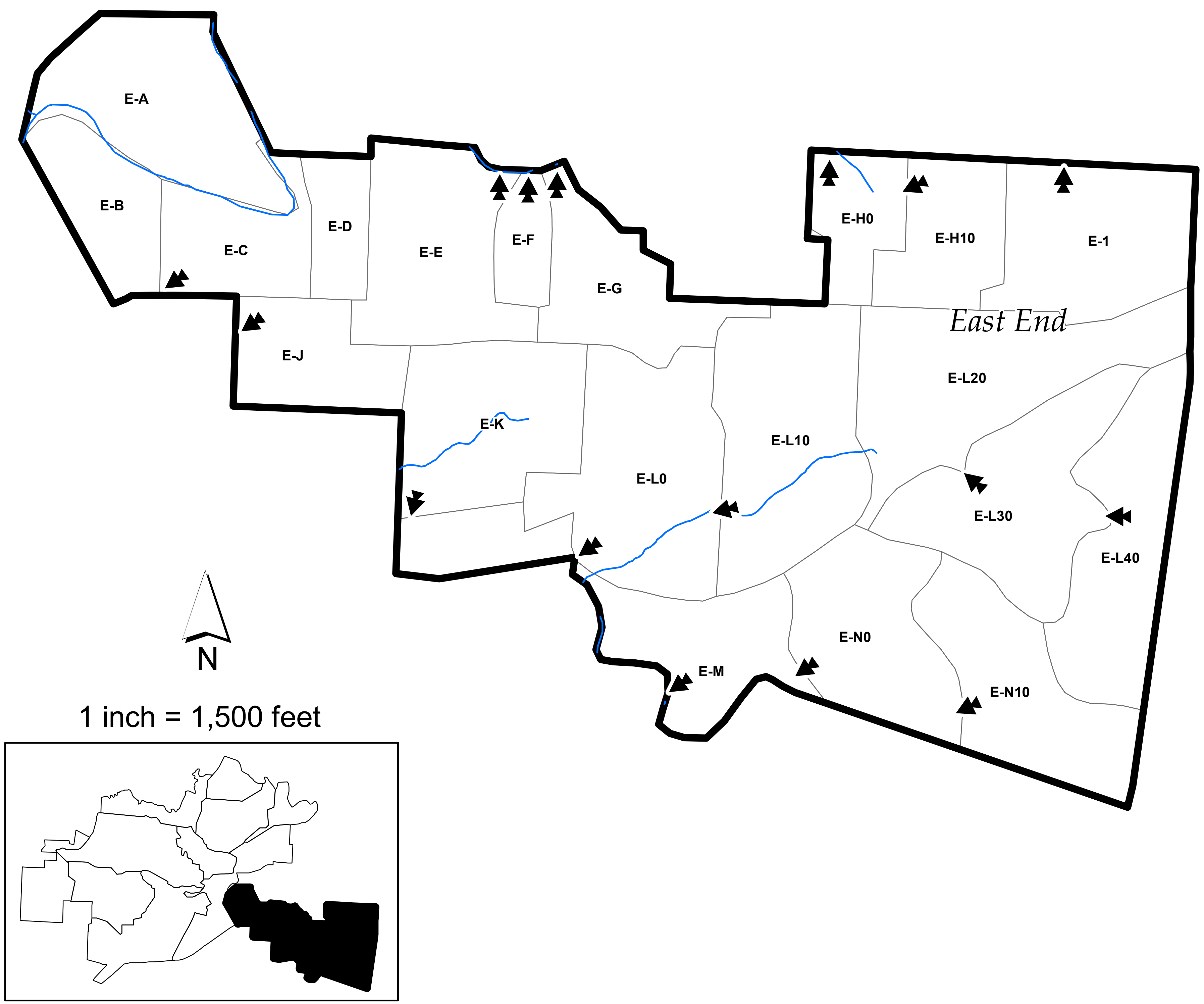

Sub-Basin	Sub-Basin	Existing (Q10)	Future (Q10)
	(acres)	(cfs)	(cfs)
E-A	93.6	30	35
E-B	47.1	18	19
E-C	49.8	27	29
E-D	26.9	13	15
E-E	87.0	63	66
E-F	21.1	11	13
E-G	62.8	33	35
E-H0	36.6	21	25
E-H10	51.0	13	13
E-H20	62.0	16	16
E-I	86.8	47	55
E-J	51.6	28	32
E-K	87.7	43	56
E-L0	111.0	49	67
E-L10	113.5	50	67
E-L20	114.6	68	70
E-L30	96.0	57	58
E-L40	89.1	45	52
E-M	65.7	41	41
E-N0	80.3	44	46
E-N10	83.6	49	50
E-O	30.9	Local Drainage Only	

Notes:
For Cumulative Drainageway Flows, See Table 6-1.
Sub-Basin E-H20 is outside the UGB and not shown.

FIGURE 6-8

EAST END SUB-BASIN FLOWS

City of McMinnville
Stormwater Drainage Master Plan

Legend

- Creek\River
- *Sub-Basin Node with Direction of Flow*
- Major Basin
- Subbasins

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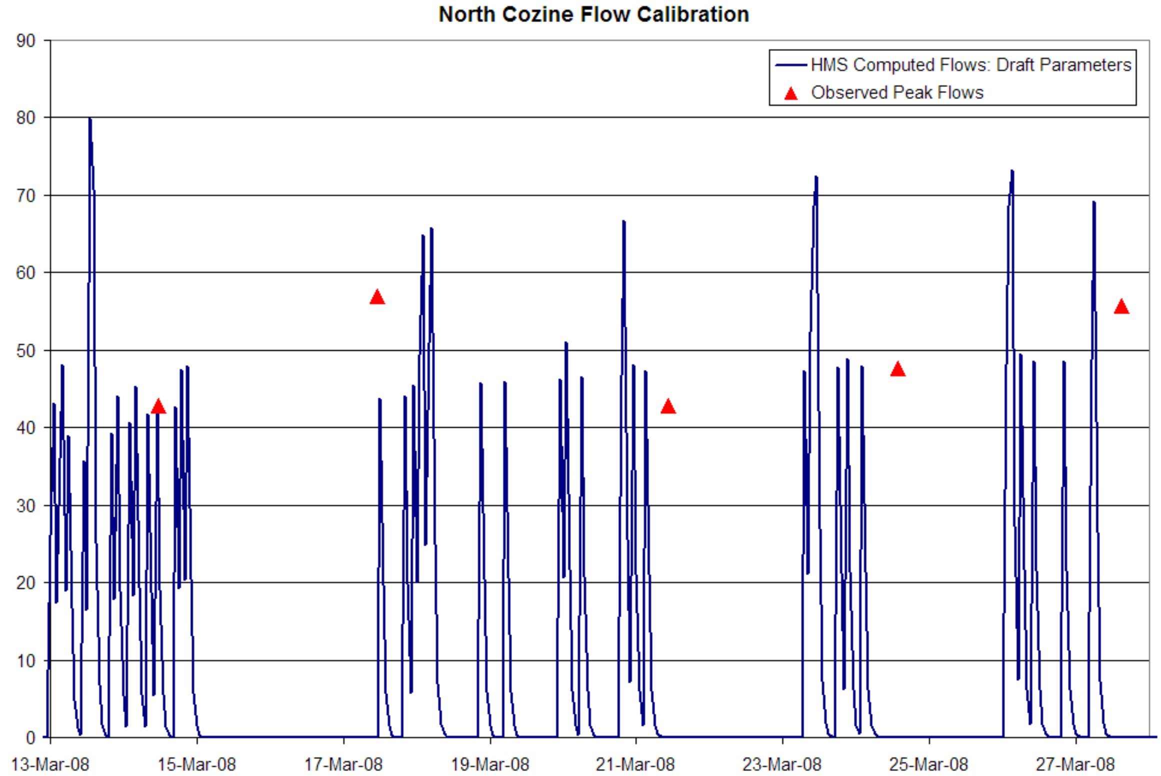
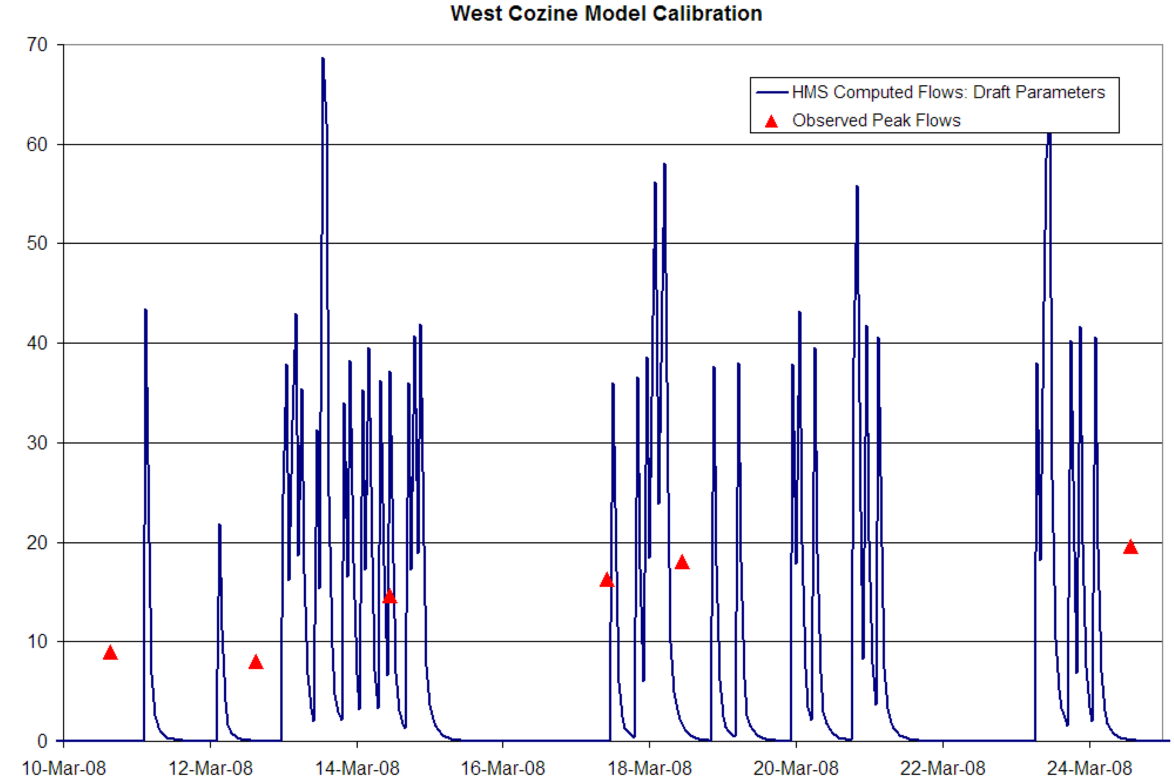


North Cozine Basin

Time	Measured Flow	Uncalibrated HEC-HMS Flows	% Flow Change Needed
3/14/2008 11:30	42.8	80	-87%
3/17/2008 11:00	57	48	16%
3/21/2008 10:30	42.8	48	-12%
3/24/2008 13:50	47.7	72	-51%
3/27/2008 14:50	55.7	73	-31%
		Average =	-33%

6.1.1.3 West Cozine Basin

The HMS model significantly over estimated peak flows. This is likely due to the presence of significant detention in West Cozine, which is not accounted for directly in the HEC-HMS model.



West Cozine Basin

Time	Measured Flow	Uncalibrated HMS Flows	% Flow Reduction Needed
3/10/08 15:30	9	24	167%
3/12/08 15:00	8	47	488%
3/14/08 11:00	15	75	414%
3/17/08 10:00	16	44	170%
3/18/08 10:30	18.10	60	231%
3/24/08 13:40	19.60	67	242%
3/27/08 15:10	26	67	163%
		Average =	268%

The goal of the model calibration is to adjust the modeled flows to match the average residual observed during the flow monitoring period. Peak flows were reduced by adjusting two critical hydrologic parameters: reducing the EIA and increasing the Lag Time (Lt). These factors were adjusted uniformly for the entire basin using a calibration factor, a simple multiplier. Once the hydrologic parameters were adjusted such that the necessary reduction in peak flows was accomplished, the calibration factors were applied to other basins with similar characteristics (Impervious Area and Curve Number).

Since the Midtown Basin showed a reasonable match with observed flows, no adjustment was made to the hydrologic parameters. Midtown is a highly urbanized basin that appears to experience relatively large peak flows. Both the Highway and South Yamhill basins have similar impervious area percentages and curve numbers so no further adjustment was made to the hydrologic parameters in these basins.

In North Cozine, the target reduction was 33 percent, which required doubling the Lag Time and reducing the effective impervious area estimates by 50 percent. These adjustment factors were then applied to Baker and North Yamhill because they have similar characteristics.

The characteristics of Cozine Creek are in the middle of Midtown (High Density), and North Cozine (Medium Density). Therefore, the target flow reduction percentage was set to 17 percent, the average between the two.

Hydrologic parameters were not adjusted in West Cozine since the sustainability of existing detention facilities is uncertain. As detention facilities age and become less effective, peak flows will likely increase. However, modeled peak flows were reduced by a factor of 2.5 (approximately the average needed flow reduction to match measured values) to assess current problem areas for capital improvement planning in the West Cozine basin. Any identified facilities requiring improvements in this basin were then sized using the unadjusted model flows. Ignoring detention (usually only effective to the 10-year event in the best case) in sizing downstream facilities is a common approach.

In addition to the calibration adjustments described above, the impervious area for the East End airport sub-basins (E-L30, E-L40, E-N0, and E-N10) was also reduced from 80 to 15 percent based on the aerial photo. The land use based approach for assigning impervious area does not hold true in this case since the airport is not typical industrial land.

Once the hydrologic parameters were adjusted, the model scenarios were all recomputed. The summary table for West Cozine Creek in Appendix C shows the resulting reduction in peak flows by basin.

6.2 Peak Cumulative Flows

Hydrographs from each sub-basin were routed and combined using the HEC-HMS computer program. The purpose was to estimate the peak in-stream flows resulting from all sub-basins within the upstream watershed contributing to the point of interest. For the major basins, the flow routing from each sub-basin is shown on Figures 6-1 through 6-8. Each diagram shows a major basin with its sub-basins, sub-basin code names, total upstream watershed area that drains through the sub-basin, and total drainageway (nodal) flows for the 10-year storm event under both existing and future development conditions. For the major open channel drainageways, which must be evaluated for events greater than 10 years, the peak 10-, 25-, 50-, and 100-year flows were similarly computed. The results are presented in Table 6-1, Peak Drainageway Flows.

TABLE 6-1
Peak Drainageway Flows
City of McMinnville Storm Drainage Master Plan

Routed Flow	Cumulative Upstream Area (acres)	Existing Flows (cfs)				Future Flows (cfs)			
		10 yr	25 yr	50 yr	100 yr	10 yr	25 yr	50 yr	100 yr
Cozine Creek Reach									
C-R-90L-80	33	234	273	323	374	234	273	323	374
C-R-80-70	2,897	357	415	489	564	359	417	491	566
C-R-70-60	3,147	371	430	507	584	373	432	509	586
C-R-60-50	3,412	401	463	545	628	403	466	552	644
C-R-50-40	3,441	403	466	549	633	406	469	558	652
C-R-40-30	3,543	414	478	570	669	420	485	589	688
C-R-30-20	3,731	440	504	622	728	460	525	642	748
C-R-20-10	3,793	457	520	646	754	478	542	666	775
C-R-10-0	3,825	463	525	654	764	483	547	674	784
C-0 (END)	3,863	470	532	663	775	490	554	684	796
West Cozine Creek									
W-R-30-20	271	138	159	185	211	139	159	185	211
W-R-20-10	575	266	304	352	403	268	306	354	404
W-R-10-0	647	301	344	398	453	302	345	400	455
W-0 (END)	719	327	374	434	495	330	378	438	498
North Cozine Creek									
N-R-30-20	694	238	275	324	373	253	291	339	388
N-R-20-10	780	263	306	360	415	277	319	374	428
N-R-10-0	981	328	382	450	519	342	396	463	532
N-0 (END)	1,125	381	445	527	610	393	454	531	612

cfs = cubic feet per second.

6.3 Partial Sub-basin Flows

For minor reaches within a sub-basin, such as a storm drain that contributes to the main drainageway, an easy method to estimate peak flow is needed. The smaller the catchment area, the smaller the lag time and the higher the flows assuming all other factors remain equal. Therefore, partial sub-basin flow can only be estimated as a non-linear function of sub-basin area. To estimate flows for catchment areas that are less than a sub-basin in size, use the following method:

1. For the point of interest, find the appropriate sub-basin by referring to Figures 6-1 through 6-8, as appropriate.
2. For the sub-basin and storm frequency of interest, find the peak sub-basin flow by referring to Figures 6-1 through 6-8, as appropriate.
3. Estimate the area the minor drainageway serves as a percentage of the total sub-basin area.
4. Refer to Figure 3-1, Computing Flows in Minor Reaches. Using the percentage of sub-basin area drained, find the percentage of sub-basin flow.
5. Multiply the total sub-basin peak flow determined in Step 2 above by the percentage of sub-basin flow determined in Step 4.

6.4 River Water Surface Elevations

The water surface elevations for events of various frequencies have been established for the South and North Forks of the Yamhill River and for Baker Creek as part of the Federal Emergency Management Agency's (FEMA's) Flood Insurance Study (FIS) Program. The water surface elevations, which were used as starting water surface elevations for creeks discharging into the Yamhill River, are shown in Table 6-2.

TABLE 6-2
South Yamhill Backwater Elevations at Cozine Creek
City of McMinnville Storm Drainage Master Plan

Recurrence Interval	Water Surface Elevation (NGVD 29)
10-year	113.5
25-year	115.0
50-year	117.5
100-year	118.8

NGVD = National Geodetic Vertical Datum.

Based on model results for the Cozine Creek Basin and confirmed by observation of flood events, the elevation of Cozine Creek is affected by the backwater of the South Yamhill River upstream as far as Fellows Street.