1400 Lakehurst Court
Suite 100
Dublin, Ohio 43016

Technical Memorandum

Prepared for: Mid-Ohio Regional Planning Commission

Project Title: Sustaining Scioto

Project No.: 144491

Technical Memorandum No. 2

Subject: Upper Scioto River Watershed, Water Inventory

Date: May 13, 2014

To: David Rutter, Project Manager, Mid-Ohio Regional Planning Commission

From: Kristin Knight, PE, Deputy Project Manager, Brown and Caldwell

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Section 1: Project Background

The Mid-Ohio Regional Planning Commission together with partners the City of Columbus Department of Public Utilities, Del-Co Water Company, Inc., the U.S. Geological Survey (USGS) and the Ohio Water Development Authority have initiated a study to model the effects of climate change on water supply in the Upper Scioto River Basin. The primary objective for this project is the development of an adaptive management plan for the region, a plan that will ensure a resilient water supply system well in to the future. This project, named Sustaining Scioto, is a two-phased project.

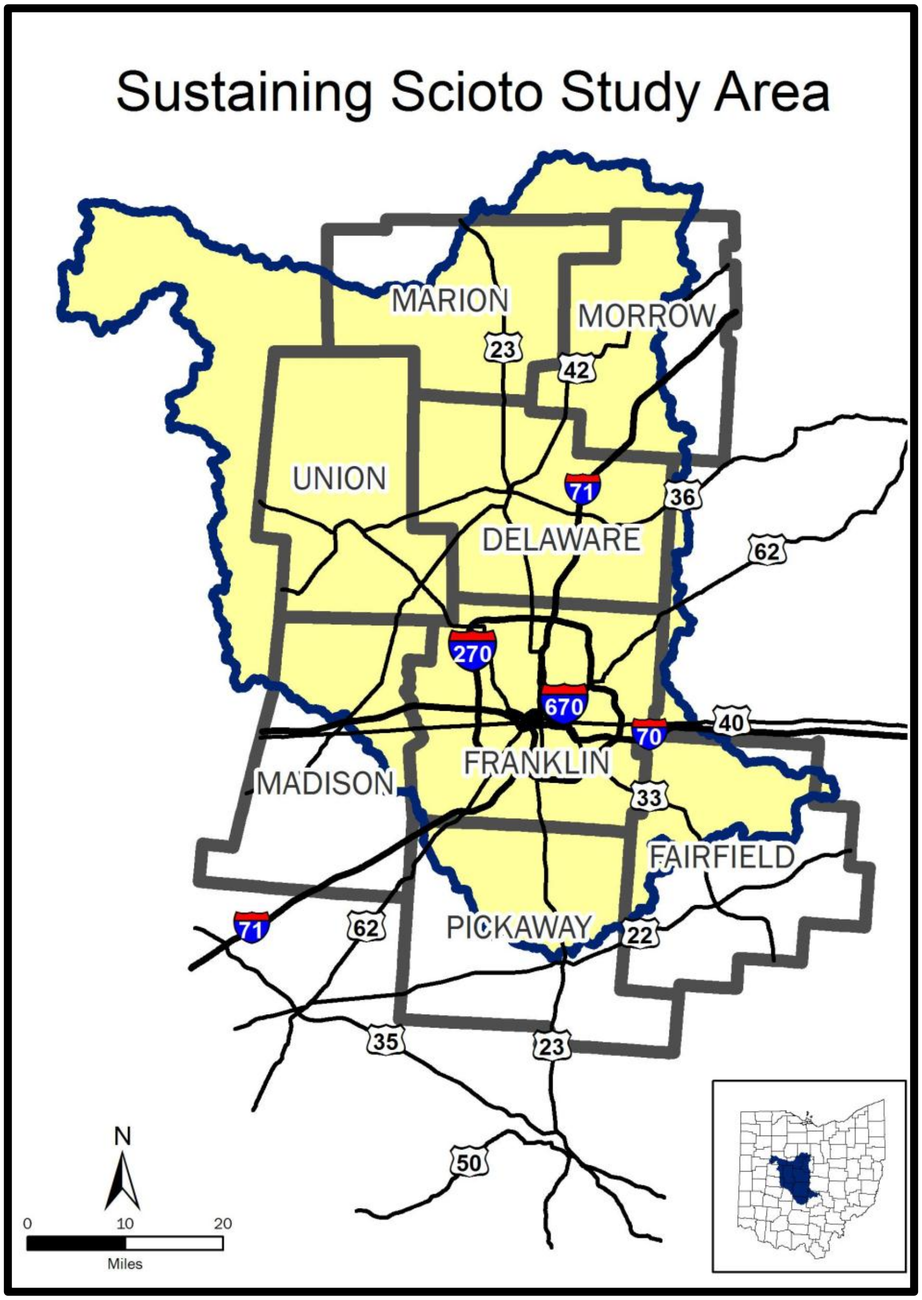
The first phase of the project involves the development of a computer model for the prediction of the impacts of projected climatologic conditions on the water resources of the basin through the year 2090, also referred to as build-out. The USGS developed the watershed model and has calibrated and validated the results using historical gaging station data. Model outputs reflect the flow volumes in the Scioto River, with a range of scenarios reflecting projected changes to climatological conditions. Model input for historical conditions included input of existing withdrawals and discharges to the Scioto from public utilities, agriculture and industry. For future conditions, the USGS will run the model with projected future water demands, build-out land use and a range of climate (rainfall and temperature) projections.

The second phase of the project involves development of future water use projections, evaluation of the water budget and evaluation of the vulnerability of water supply sources and infrastructure based on the USGS model results. One of the first tasks involves evaluation of the future development within the region and the associated water demand projections based on population growth, commercial and industrial development. A water budget for the region will be prepared based on these demands that will assess the current water system inputs and outputs currently and into the future to determine potential system risks and provide the framework for future planning. Finally, using the results of the model and the water inventory, the project team, along with a Stakeholder Advisory Committee, will develop an adaptive management plan for the region that will provide utilities, developers, agriculture and industry in the region with an understanding of the risks imposed by climate change. This plan will also serve as a guide for future investment and planning for water resource management.

1.1 Project Location

Sustaining Scioto encompasses the Upper Scioto River watershed from its headwaters in northern Ohio to just north of Circleville, in the south. The project includes the counties of Franklin, Delaware, Pickaway, Union, Marion, Morrow, Madison, Champaign, Logan, Crawford and Hardin. Figure 1.1 shows a map of the project area. The project area includes the Scioto River, Big Walnut Creek and the Olentangy River as well Griggs, O’Shaughnessy, Alum Creek and Hoover Reservoirs and Delaware Lake.

Figure 1-1
Sustaining Scioto Study Area



1.2 Purpose of Water Inventory

A water inventory provides an estimation of the overall availability of water within a watershed, documenting the amount of water coming into and leaving the hydrologic system. These inventories can have varying levels of detail from very high level accountings of water inflows and outflows in a region to highly detailed hydrologic simulations within a watershed. The purpose of the inventory is to provide an understanding of the total water availability and the changes to that balance with projected development or other changes within the watershed. For this project, the inventory allows for evaluation of the potential change to water availability within the watershed related to land development, population growth and climate change.

Due to the large planning horizon for this project (through 2090), the water inventory was performed at a high level thereby providing a large scale analysis of water inflows (precipitation and wastewater treatment plant discharges) and outflows (water treatment plant withdrawals and evaporation). By performing this analysis for current conditions and future conditions in 2035 and 2075, the potential changes in water availability within the watershed due to changing weather patterns in conjunction with projected land development were assessed.

This task provides an overview of potential comprehensive impacts to water availability within the Upper Scioto River watershed. It should be noted that at this higher level scale, it is most important to look at the overall trends and changes to the balance from what is currently experienced in the watershed. This analysis does not include evaluation of all the minor inflows and losses from the watershed and should not be used as a quantitative estimate of actual water availability.

Section 2: Upper Scioto River Watershed Water Inventory

The Upper Scioto River watershed water inventory was developed using historical and projected climate data for precipitation and temperature which were downscaled from large scale Global Climate Models (GCMs). The water withdrawals and discharges used in the analyses were taken from the Water Use Projection task.

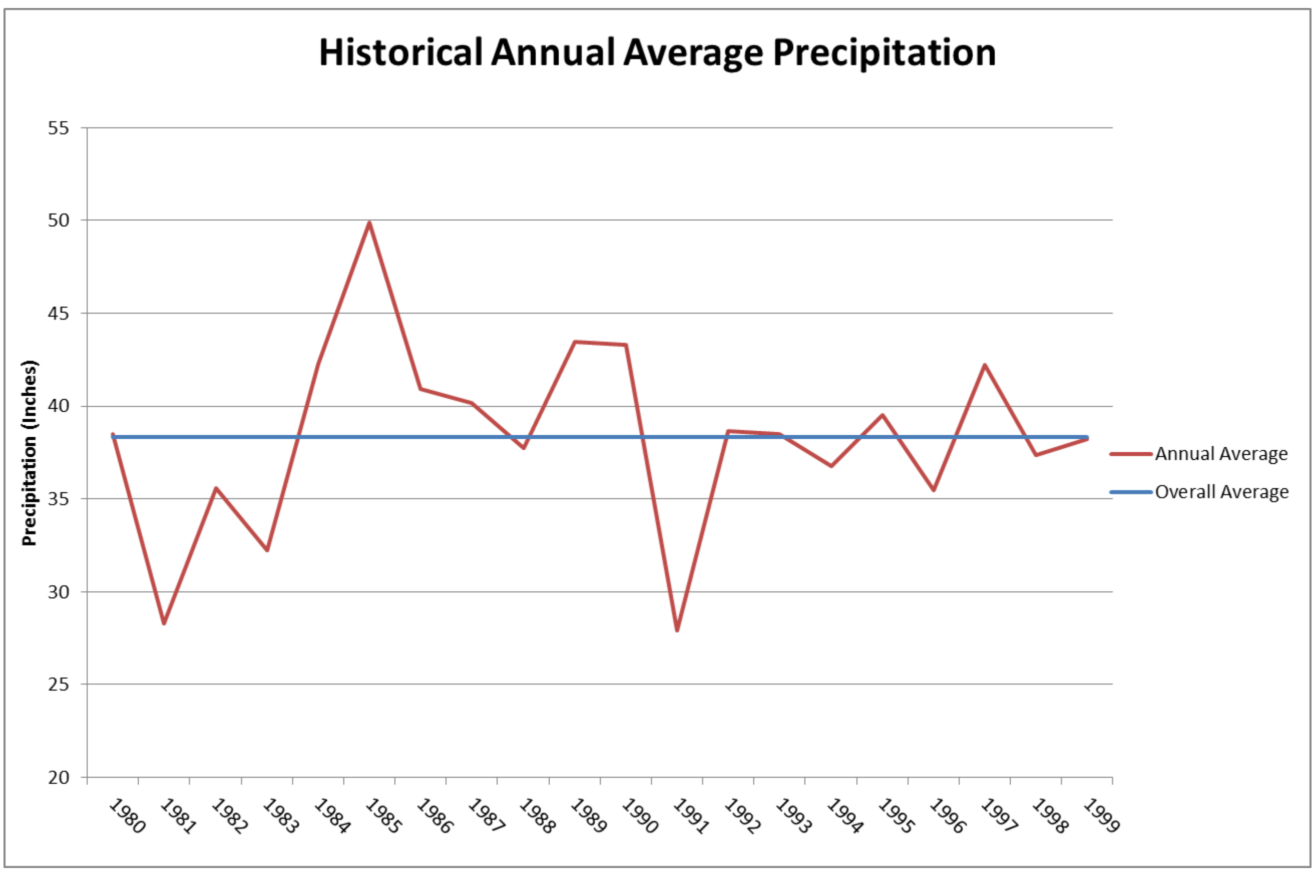
2.1 Climate Data

Two types of climate data were used in the development of the water inventory. Historical data was used to establish the baseline conditions within the watershed over the 20 year period from 1980 to 1999. The climate data for the future scenarios was provided by the four global climate model data sets that were used as part of the development of the watershed model. Each of these climate model data sets has a high emission scenario and a medium emission scenario, so there are eight total data sets for potential future conditions due to climate change.

2.1.1 Historical Climate Data

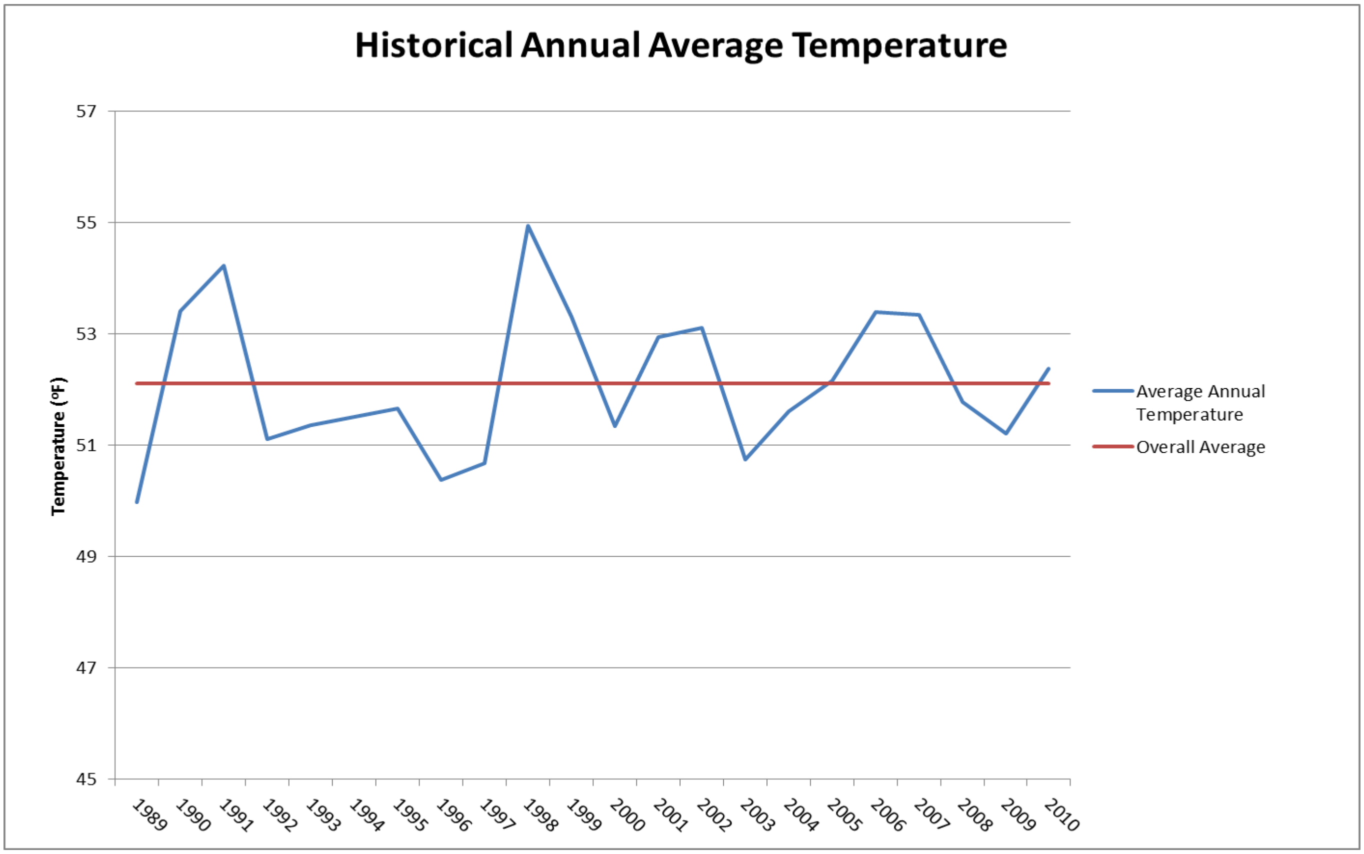
Historical average annual precipitation for the Upper Scioto River watershed is shown in Figure 2-1. The graph shows that the overall average annual precipitation for the watershed is 38 inches.

Figure 2-1



Historical Average Temperature is shown in Figure 2-2. The overall annual average temperature within the watershed is 52 °F.

Figure 2-2



2.1.2 Future Climate Data

Figure 2-3 shows the predicted annual average precipitation for the high emission scenarios. Figure 2-4 shows the predicted annual average precipitation for the medium emission scenarios. While it is difficult to identify a trend in the projected precipitation, there does appear to be an overall increase in total precipitation as indicated in Figure 2-5. This figure reflects the mean rainfall over the entire simulation period from each model superimposed on the historical precipitation data. Six of the climate models predict higher average precipitation in the future, while two of the models predict less future precipitation.

Figure 2-3

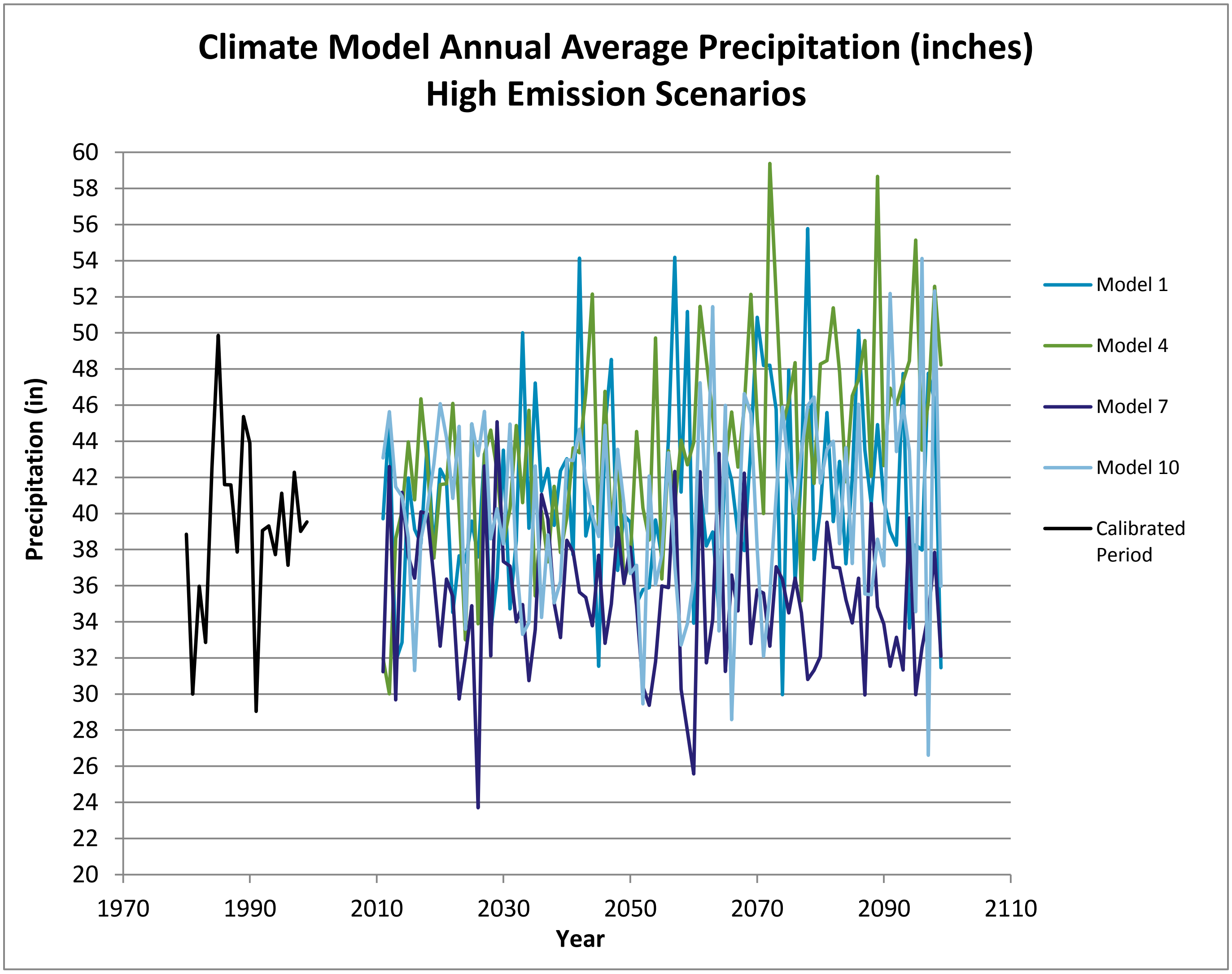


Figure 2-4

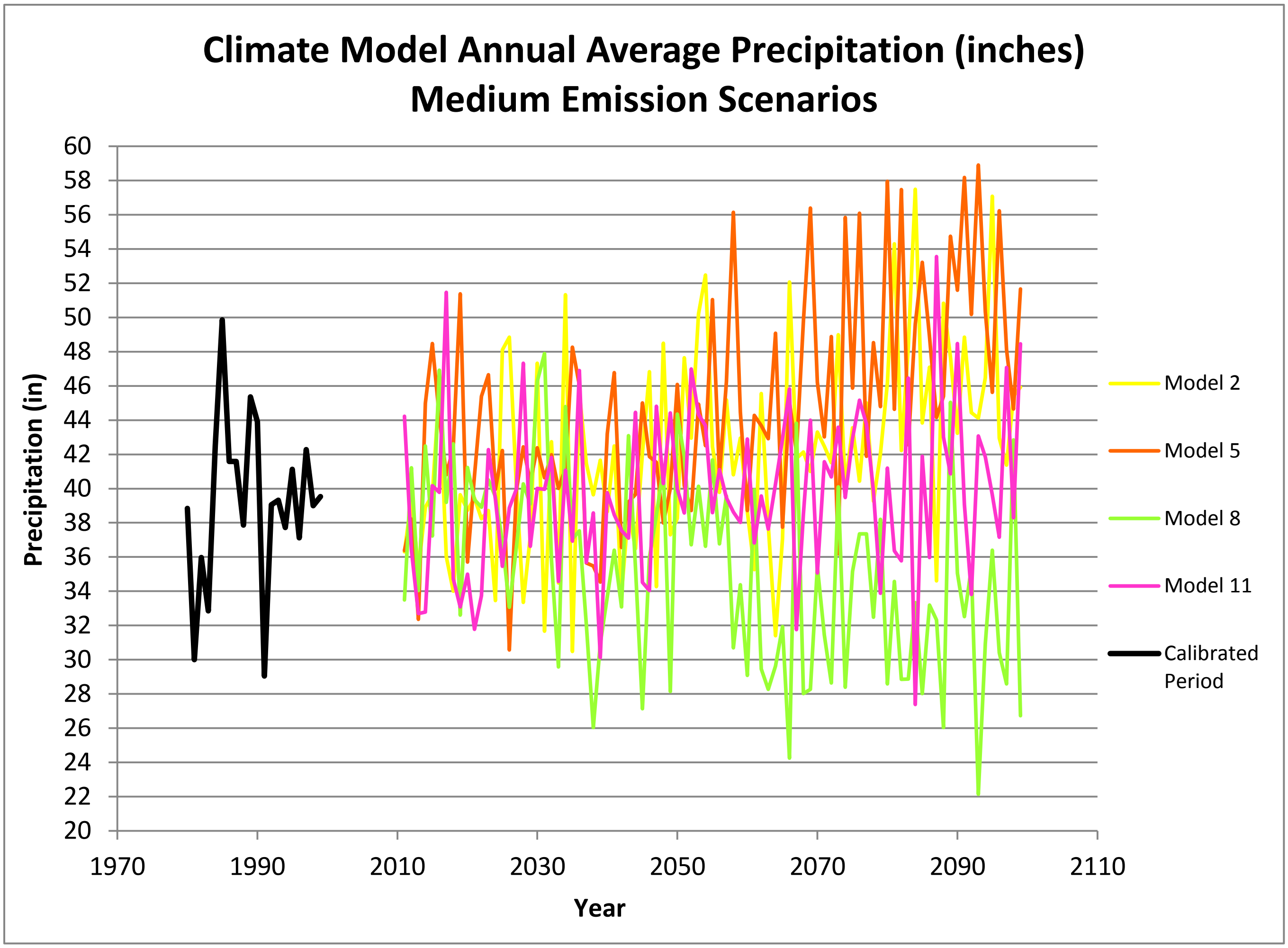

Climate Model Annual Average Precipitation (inches)
Medium Emission Scenarios
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
Precipitation (in)
1970
1990
2010
2030
2050
2070
2090
2110
Year
Model 2
Model 5
Model 8
Model 11
Calibrated Period

Figure 2-5

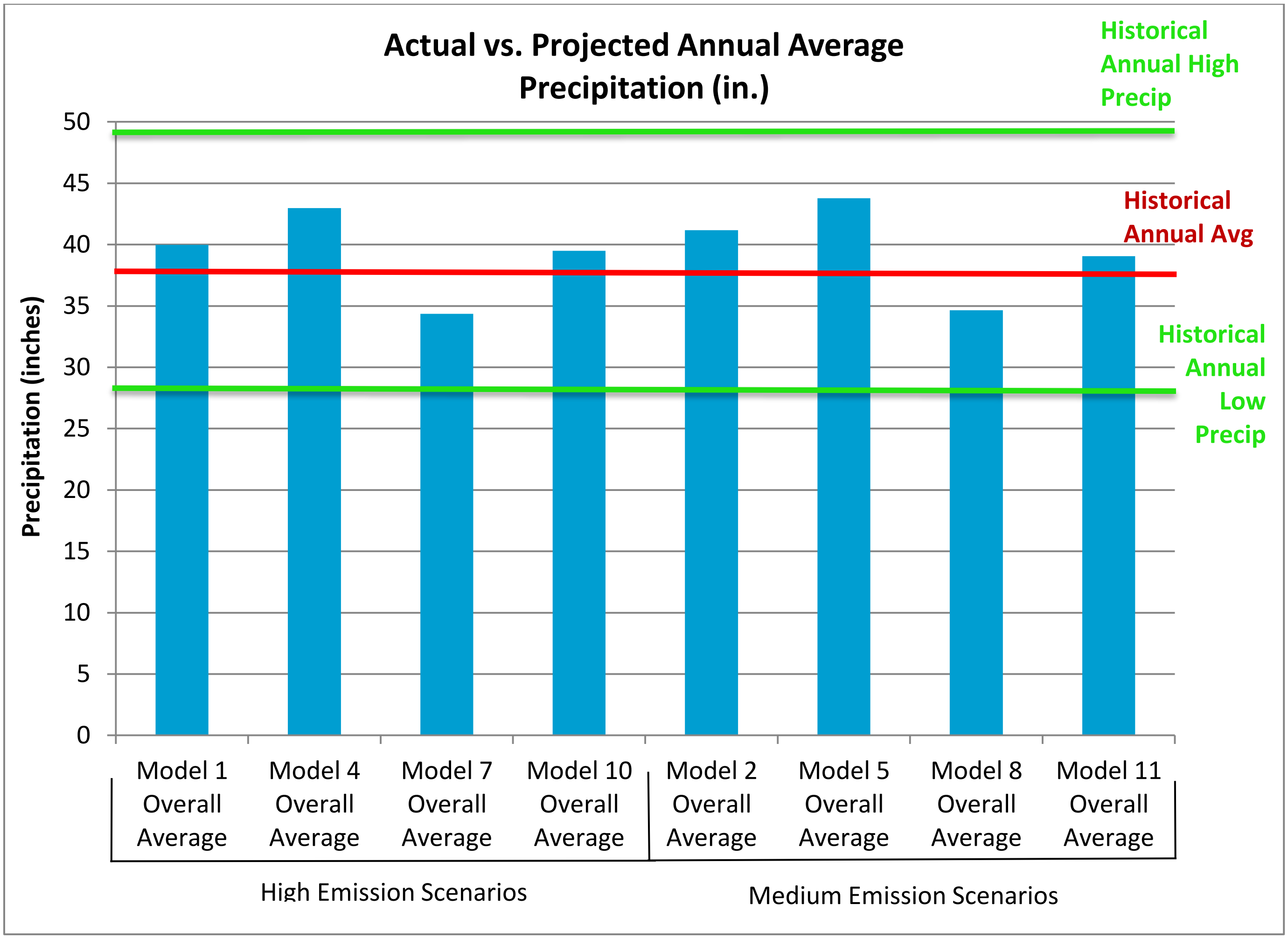

Actual vs. Projected Annual Average Precipitation (in.)
Historical Annual High Precip
Historical Annual Avg
Historical Annual Low Precip
Precipitation (inches)
50
45
40
35
30
25
20
15
10
5
0
Model 1 Overall Average
Model 4 Overall Average
Model 7 Overall Average
Model 10 Overall Average
Model 2 Overall Average
Model 5 Overall Average
Model 8 Overall Average
Model 11 Overall Average
High Emission Scenarios
Medium Emission Scenarios

Figure 2-5 shows the predicted annual average temperature for the high emission models. Figure 2-6 shows the predicted annual average temperature for the medium emission models. Figure 2-7 reflects the mean temperature over the entire simulation period from each model superimposed on the historical temperature data. All of the climate models predict a significant increase in the future average temperature.

Figure 2-5

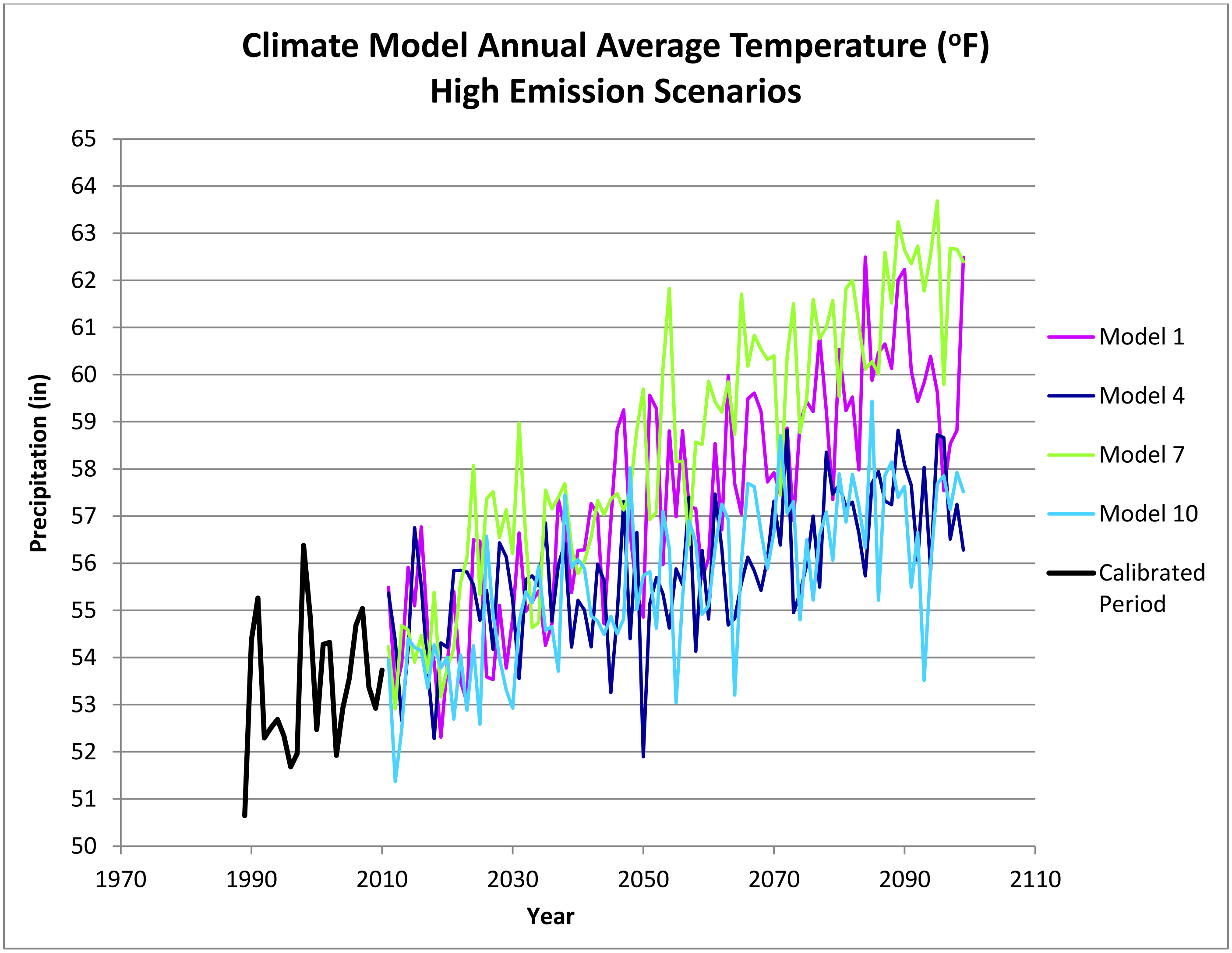
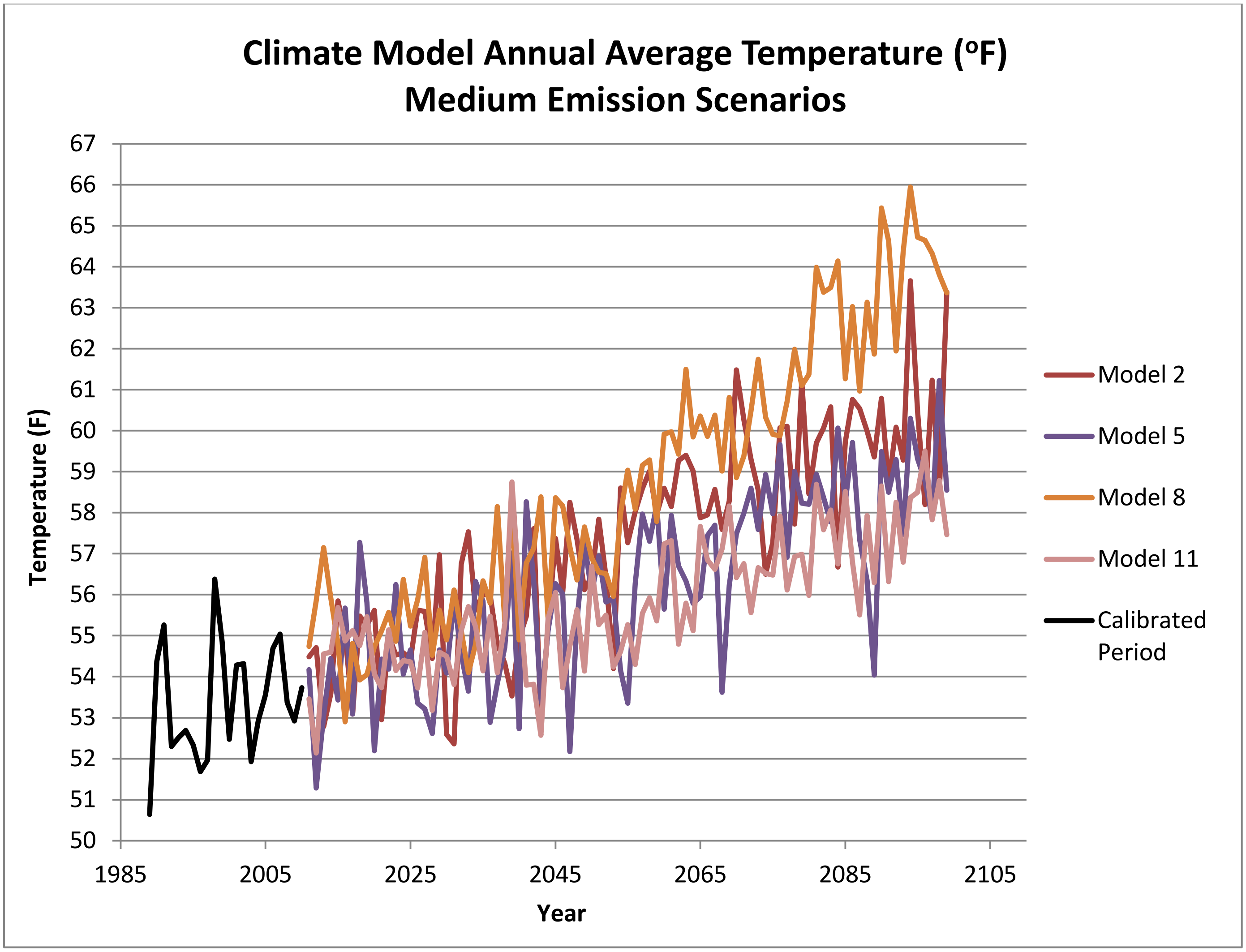
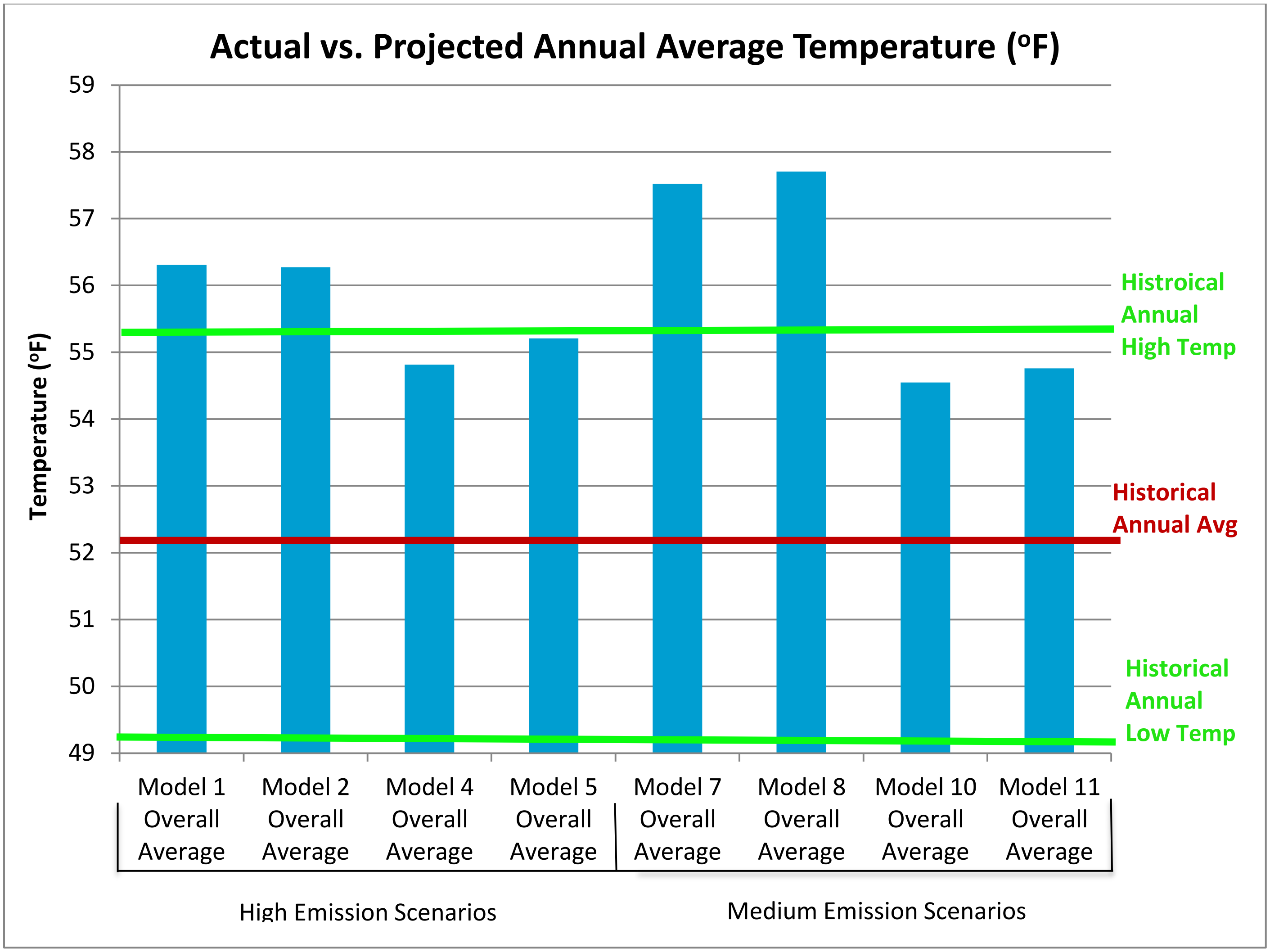


Figure 2-6



Climate Model Annual Average Temperature (°F)
Medium Emission Scenarios
Temperature (F)
67
66
65
64
63
62
61
60
59
58
57
56
55
54
53
52
51
50
1985
2005
2025
2045
2065
2085
2105
Year
Model 2
Model 5
Model 8
Model 11
Calibrated Period

Figure 2-7



2.2 Water Inventory

The water inventory estimates the amount of water that flows into and out of a watershed or basin. If the area being evaluated includes the headwaters of the primary body of water then precipitation is the primary water input for the inventory. This is the case for the water inventories developed for the Upper Scioto River watershed. The other significant water inputs for the system are the discharges from wastewater treatment systems. Because many of the water utilities within the watershed use groundwater as a supply source, the amount of water discharged to watershed from the wastewater treatment facilities can be greater than the amount of surface water withdrawn by the water treatment facilities.

Water withdrawals within the watershed come from two sources. The first is withdrawals for public water supplies. This information was determined in the Water Use Projections task for current water demands, demands in 2035 and demands in 2075. The other source of water withdrawal or loss is potential evaporation. Potential evaporation measures the amount of water returned to the atmosphere through evaporation from water bodies, plants and soils based on climatic conditions. This loss is heavily dependent on temperature and will increase with rising temperatures.

Nine separate water inventories were developed as part of this task. A historical water inventory was developed to gain an understanding of the current balance of water availability within the region. Future water inventories were developed for each of the future climate data sets at years 2035 and 2075, each accounting for the effects of climate change, growth and development within the region.

2.2.1 Historical Water Inventory

The historical water inventory was developed using historical precipitation, temperature and water demand data. Table 2-1 shows the calculated water balance based on the historical data.

Table 2-1

Upper Scioto River Watershed Water Inventory - Current

Average Annual Inflow	Average Annual Precipitation	Wastewater Treatment Plant Discharges	Total Inflow
Million Gallons	2,143,874	69,459	2,213,333
Average Annual Losses	**Evaporation**	**Withdrawals**	**Total Losses**
Million Gallons	1,658,413	61,981	1,720,393
Water Inventory/Balance = Total Inflow - Total Losses			
Net Balance - 2,213,333 - 1,720,393 = 492,940 Million Gallons			

The historical water inventory indicates that there is currently a surplus of approximately 493,000 million gallons of water within the Upper Scioto River watershed.

2.2.2 Future Water Inventories – 2035 and 2075

The same calculation process was repeated for each of the future climate data sets at years 2035 and 2075. As indicated in the tables and figure below, while there is a significant variability in the projected balance with the different climate models, five out of eight indicate reduced water availability in both 2035 and 2075. It should be noted that several of the models indicate there will be increased water availability. This balance is significantly impacted by the projected increased water demand and water discharges from the water and wastewater treatment plants as indicated in Tables 2-2 and 2-3.

Table 2-2

Upper Scioto River Watershed Water Inventory - 2035

Average Annual Inflow (Million Gallons)								
	Model 1	Model 2	Model 4	Model 5	Model 7	Model 8	Model 10	Model 11
Precipitation	2,571,917	1,647,871	1,927,933	2,451,828	1,853,344	2,092,732	2,347,636	2,052,175
Discharges	105,530	105,530	105,530	105,530	105,530	105,530	105,530	105,530
Total Inflow	**2,677,447**	**1,753,401**	**2,033,464**	**2,557,358**	**1,958,874**	**2,198,262**	**2,453,167**	**2,157,705**
Average Annual Losses (Million Gallons)								
	Model 1	Model 2	Model 4	Model 5	Model 7	Model 8	Model 10	Model 11
Evaporation	1,780,136	1,764,380	1,766,066	1,766,583	1,857,259	1,822,294	1,754,026	1,765,043
Withdrawals	69,994	69,994	69,994	69,994	69,994	69,994	69,994	69,994
Total Losses	**1,850,129**	**1,834,374**	**1,836,060**	**1,836,577**	**1,927,253**	**1,892,287**	**1,824,020**	**1,835,037**
Net Balance	**827,318**	**-80,973**	**197,404**	**720,781**	**31,621**	**305,974**	**629,147**	**322,668**

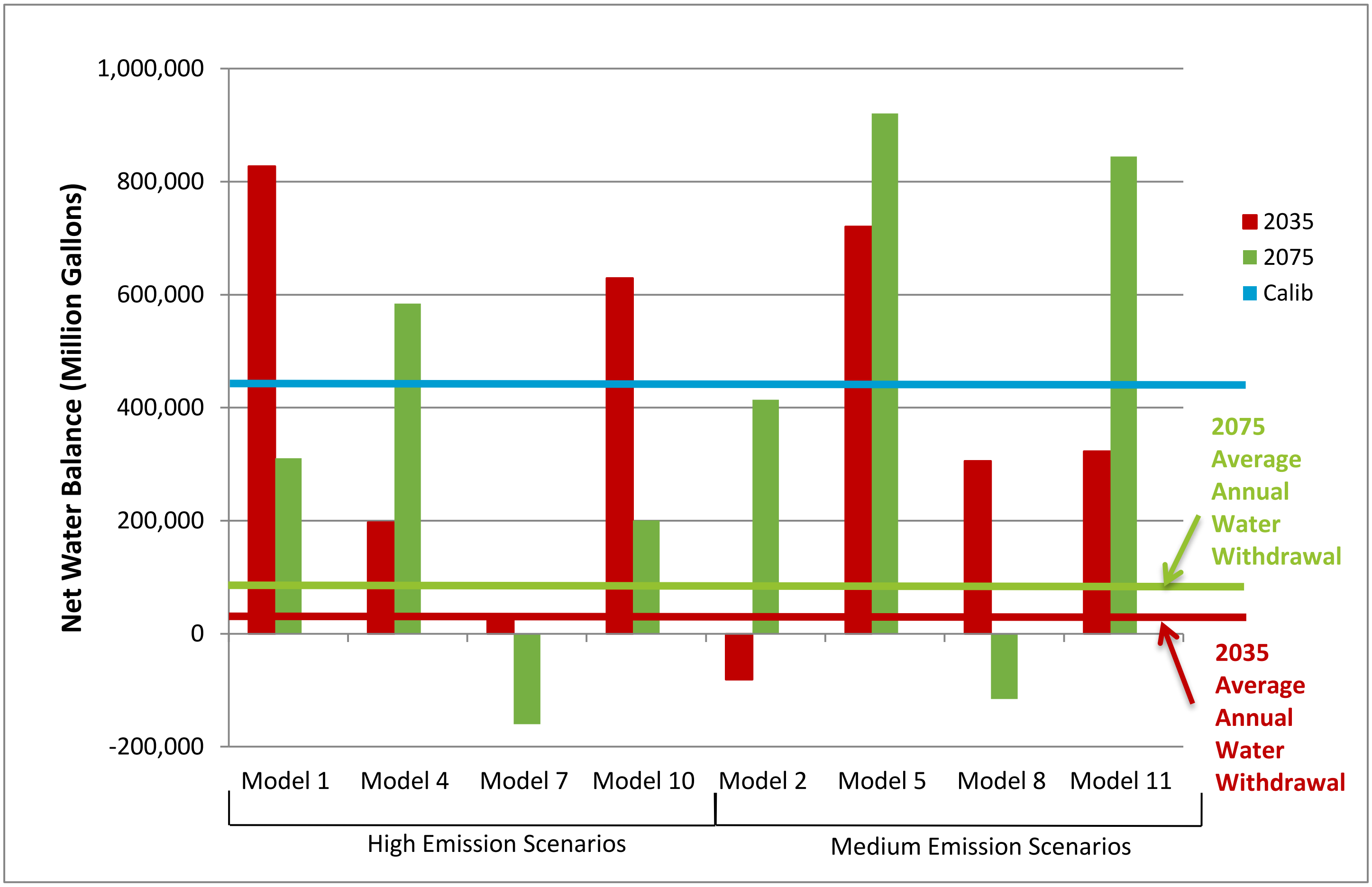
Table 2-3

Upper Scioto River Watershed Water Inventory - 2075

Average Annual Inflow (Million Gallons)								
	Model 1	Model 2	Model 4	Model 5	Model 7	Model 8	Model 10	Model 11
Precipitation	2,229,251	2,341,584	2,392,503	2,806,999	1,871,926	1,959,369	2,041,457	2,677,267
Discharges	177,737	177,737	177,737	177,737	177,737	177,737	177,737	177,737
Total Inflow	**2,406,988**	**2,519,322**	**2,570,241**	**2,984,737**	**2,049,663**	**2,137,107**	**2,219,194**	**2,855,004**
Average Annual Losses (Million Gallons)								
	Model 1	Model 2	Model 4	Model 5	Model 7	Model 8	Model 10	Model 11
Evaporation	1,965,303	1,974,149	1,855,301	1,933,255	2,078,802	2,121,913	1,888,020	1,879,627
Withdrawals	130,888	130,888	130,888	130,888	130,888	130,888	130,888	130,888
Total Losses	**2,096,191**	**2,105,037**	**1,986,189**	**2,064,143**	**2,209,690**	**2,252,801**	**2,018,908**	**2,010,515**
Net Balance	**310,797**	**414,285**	**584,052**	**920,594**	**-160,027**	**-115,694**	**200,286**	**844,489**

Figure 2-7 shows the net water balance for each of the climate models during the specified years compared with the historical net water balance and the projected municipal water demands for 2035 and 2075.

Figure 2-7



Section 3: Conclusions

As indicated in Figure 2-7, there is a significant variability in the projected water balance with the different climate models. Several of the models indicate that the projected water demand in the watershed may be close to or exceed the overall capacity of the basin in the future with the projected growth in population and water demand and the projected changes to climate. It is important to note that this inventory calculation was developed to provide only an overview of potential comprehensive impacts to water availability within the watershed. The inventory was conducted to allow for evaluation of the overall trends and changes to the balance from what is currently experienced in the watershed. This analysis does not include evaluation of all the minor inflows and losses from the basin and should not be used to as a quantitative estimate of actual water availability.

While five out of the eight models indicate reduced water availability in both 2035 and 2075, several of the models indicate there will be increased water availability. The balance is significantly impacted by the projected increased water demand and water discharges from the water and wastewater treatment plants. In some portions of the Upper Scioto River Watershed, increased demands associated with population growth are projected to be met from the groundwater supply. If this shift in water use to groundwater is not realized as the region develops, there would be further increases in water demand that are not reflected in this analysis. Also, as noted above, this higher level inventory accounts only for municipal water use and does not reflect the impact that increased irrigation associated with temperature increase may have on the overall supply.

It is recommended that a more detailed water balance model be developed in the future as the population grows and water demands approach the levels that have been projected in this planning level estimate. This more detailed modeling will allow for the region to more carefully balance growth with the available water supply.