

**D.0 APPENDIX D: SELECT MODEL SETUP AND RESULTS**

**D.1 SELECT Assumptions and Setup**

SELECT estimated potential *E. coli* load resulting from cattle, deer, feral hogs, pets, malfunctioning OWTS, and Waste-Water Treatment Plants. The default fecal production rates are the highest from the range of values provided in the EPA Protocol for Developing Pathogen TMDLs (USEPA, 2001) for all *E. coli* sources in the Lake Granbury Watershed (Table D-1). Default values for *E. coli* concentrations were used for all sources except malfunctioning OWTS due to the stakeholder resolutions on raw sewage effluent. Additionally, stakeholders resolved using a Fecal coliform to *E. coli* conversion of 0.7 based on local data observations.

**Table D-1 Calculation of *E. coli* Loads from Source Populations.**

Source	Calculation
Cattle	$E.coli = \#Cattle * 10 * 10^{10} cfu / day * 0.7$
Deer	$E.coli = \#Deer * 3.5 * 10^8 cfu / day * 0.7$
Feral Hogs	$E.coli = \#Feralhogs * 1.1 * 10^{10} cfu / day * 0.7$
Dogs	$E.coli = \#Households * \frac{0.8dogs}{Household} * 5 * 10^9 cfu / day * 0.7$
Malfunctioning OWTS	$E.coli = \#OWTSs * MalfunctionRate * \frac{9.554x10^6 cfu}{100mL} * \frac{200gal}{household / day} * \frac{3785.4mL}{gal} * 0.7 * 0.133$
WWTP	$E.coli = PermittedMGD * \frac{126cfu}{100mL} * \frac{10^6 gal}{MGD} * \frac{3785.4mL}{gal}$

Livestock

All livestock populations are determined from the 2007 National Agricultural Statistics Service (NASS) inventory on a per county basis. The cattle populations for Hood and Parker counties were 30,265 and 62,793 cattle, respectively. The cattle population was distributed uniformly on grasslands and pasture/hay since cattle graze mainly on these land uses.

Wildlife

SELECT attempts to account for wildlife contributions by distributing population estimates across suitable habitats as determined by consultation with wildlife experts. The first step in calculating wildlife pollutant loading is to identify the types of wildlife most likely contributing the most significant amounts of pollution and ignore the sources that only minimally contribute. This was achieved by consulting wildlife experts such as the Texas Parks and Wildlife Department (TPWD) and thorough literature review. It is also important to identify the land use classifications wildlife prefer/need for survival, along with population estimates. Many agencies such as the TPWD have published studies that address these issues. Currently, SELECT provides

the option to evaluate pollutant loading of *E. coli* from deer, feral hogs, and two other generic sources.

The population density of 13.25 deer/1000 acre is estimated from the Lockwood (2000) report. This report was a study the Texas Parks and Wildlife Department (TPWD) performed to track white tail deer populations. The deer population density was determined as the average of Resource Management Unit (RMU) 22 and RMU 24 for the Lake Granbury Watershed. It was assumed that deer roam in forests and shrubland. The model also assumes the deer need continuous suitable habitat of at least 20 acres. Urban areas, as defined in the shapefile from the 2000 US Census, were removed from the suitable habitat.

A regional population density of 4 hogs/km<sup>2</sup> (Teague, 2007) results in an estimated feral hog population of 4,166 hogs in the entire Lake Granbury Watershed. This population was redistributed within a 100 m buffer of the streams and restricted to undeveloped land use classifications.

### On-site Wastewater Treatment Systems (OWTSSs)

Another need for bacteria load assessment is an improved understanding of when OWTSSs malfunction, how much these systems contribute to contamination, and how to reasonably predict such occurrences. For evaluating the potential *E. coli* loading from malfunctioning OWTSSs a new approach different from Teague (2007) was developed. Clark et al. (2001) indicated that the age of OWTS, soil condition, and vicinity to water bodies have the greatest influence on contamination due to OWTSs. Methods for developing a sewage pollution risk assessment have been developed and were used as a guideline (Kenway and Irvine, 2001). Combining this methodology for OWTS risk assessment with soil landscape mapping can assess the individual system contribution to the cumulative risk of sewage pollution (Chapman et al., 2004). The primary function of SELECT is to provide a total potential *E. coli* loading available on the land surface before fate and transport mechanisms are incorporated. Therefore, the distance component when predicting contribution from malfunctioning OWTSSs is not included in the load assessment.

This method was developed based on the age of subdivisions and the OWTS absorption field limitation ratings (slight, moderate, and severe) provided with National Resource Conservation Service (NRCS) SSURGO soils data (USDA-NRCS, 2004). The user inputs the appropriate OWTS shapefile and indicates the 'fields' within the attribute table containing the number of permits and the average estimated age of the subdivision/OWTSs in each polygon. The number of systems contributing to potential is determined from the number of permitted homes on OWTSs multiplied by the expected percent malfunction. The percent malfunction is a reclassification of the OWTS suitability rating for a given area. The suitability rating is calculated as:

$$\text{SuitabilityRating} = 0.7 \times \text{SoilRate} + 0.3 \times \text{AgeRate} \quad (3.1)$$

The program creates an age rating for the OWTS shapefile (Table D-2), and a soil rating based on the SSURGO soil limitation ratings of severely limited (3), somewhat limited (2), and slightly

limited (1). The NRCS limitation ratings are based on geophysical factors such as soil classification, depth to bedrock, and slope (Table D-3). The soil file with the suitability rating is intersected with the age rate and then weighted with 70% to soil rate and 30% to the age rating to create a new OWTS malfunction index. This weighting scheme is based on the assumption that soil treatment capability has the greatest role in contribution, followed by malfunction due to limited maintenance (related to age of system) (Lesikar, 2007). Areas missing soil or age information are assigned index ratings of -99. In this case the higher the suitability rating, the less effluent the system can treat. A malfunction index based on the suitability rating is converted to a raster file and then reclassified into percent malfunctioning (contributing to load potential) (Table D-4). After determining the number of homes contributing, a flow rate (gal / household × day), effluent rate (cfu/100 mL), and necessary conversion factors are applied to estimate the potential *E. coli* loading in cfu/day.

OWTS information was obtained from county permit records (Hood County Appraisal District). The assumption of 200 gal/household-day is based on the adopted stakeholder resolutions. SSURGO soil shapefiles for each county and the associated soil properties tables were obtained from the NRCS Soil Datamart. In addition, after further discussion and comparisons with cove modeling results it was decided to incorporate a correction factor for the likeliness for a given system to fail on a given day. It is assumed that a higher loading (which would lead to overflow of the system) occurs approximately four times every month so on a given day each system has a 4/30 or 13.3% chance of overflow.

**Table D-2 Age Rating for Subdivisions in Lake Granbury Watershed to Calculate OWTS Index.**

<b>Age (years)</b>	<b>Age Rate</b>
0 – 15	1
16 – 30	2
> 30	3
No Data	-99

**Table D-3 Interpretative Soil Properties and Limitation Classes for Septic Tank Soil Absorption Suitability (Source: SCS, 1986).**

Interpretive Soil Property	Limitation Class		
	Slight	Moderate	Severe
Total Subsidence (cm)	--	--	>60
Flooding	None	Rare	Common
Bedrock Depth (m)	> 1.8	1-1.8	< 1
Cemented Pan Depth (m)	> 1.8	1-1.8	< 1
Free Water Occurrence (m)	> 1.8	1-1.8	< 1
Saturated Hydraulic Conductivity (µm/s)			
Minimum 0.6 to 1.5 m <sup>a</sup>	10-40	4-10	< 4
Maximum 0.6 to 1 m <sup>a</sup>			> 40
Slope (Pct)	< 8	8-15	> 15
Fragments > 75 mm <sup>b</sup>	< 25	25-50	> 50
Downslope Movement			<sup>c</sup>
Ice Melt Pitting			<sup>c</sup>
Permafrost			<sup>d</sup>

<sup>a</sup>0.6 to 1.5 m pertains to percolation rate; 0.6 to 1 m pertains to filtration capacity

<sup>b</sup>Weighted average to 1 m.

<sup>c</sup>Rate severe if occurs.

<sup>d</sup>Rate severe if occurs above a variable critical depth (see discussion of the interpretive soil property).

**Table D-4 OWTS Index Reclassification to Percent Malfunction used in determining OWTS Malfunction Rates in Lake Granbury Watershed.**

Index	Percent Malfunction
< 0	8
0 - 1.5	5
1.5 - 2.5	10
2.5 – 3	15

Pets

Generally, dogs are the primary pet allowed to defecate outside the home and most often the defecated waste is not cleaned up. Cats and other pets are primarily kept in homes and waste disposed of directly to solid waste management so these contributions will be neglected. The assumption of a constant 0.8 dogs per home for Texas (AVMA, 2002) is an adjustable model parameter included in SELECT. The program creates a raster that represents the number of homes from the census block demographics table joined to the census block shapefile. Again the program applies the fecal production rate and then aggregates the potential load to zones of interest. Census block shapefiles are needed for each county. The associated census block demographics table for the state of Texas is indicated in the GUI as well as the appropriate field for the number of homes in each census block.

## Wastewater Treatment Plants (WWTPs)

To assess point sources SELECT evaluates the contribution from Wastewater Treatment Plants (WWTPs). Within the GUI, the user indicates the shapefile with the permitted outfall locations ensuring unrelated outfalls (i.e. cooling plants or any other non-pathogenic discharges) removed. The file should include permitted discharges in the units of millions of gallons per day (MGD) as a field within the shapefile. The default (adjustable within the GUI) value of 126 cfu/100 mL effluent standard is assumed. The loading is calculated by simply multiplying the effluent by the discharge and applying conversion factors to determine the loading in cfu/day. For this study, wastewater outfall locations were obtained from TCEQ GIS files. The permitted flows were obtained from the EPA Envirofacts Data Warehouse (USEPA, 2006).

Once all individual source inputs are selected and fed into the model a summation from all sources is carried out. Thus, potential loading for the Lake Granbury watershed was spatially distributed.

## **D.2 SELECT Results**

### **D.2.1 Large Lake Granbury watershed**

Potential *E. coli* loadings from livestock, wildlife, and domestic sources in the Lake Granbury Watershed were calculated by SELECT. The loadings from the individual sources were combined and aggregated on a subwatershed basis and then divided by the area of the subwatersheds to produce the area weighted potential loading (Figure D.1). The potential loading component of SELECT can help identify source contributions spatially distributed across the watershed. However, this is only a daily snapshot of the amount of *E. coli* potentially present in the watershed. The Pollutant Connectivity Factor (PCF) applied weighting to important fate and transport factors such as runoff capabilities and travel distance to provide helpful information to determine whether *E. coli* from various sources potentially contaminate the waterbodies. For the Lake Granbury Watershed, PCF analyses was based on applying multiple weighting schemes (Table D-5) and then ranking the subwatersheds (Figure D.3) for potential water quality problems due to bacteria.

**Table D-5 Weighting Scheme for Sensitivity Analyses of Pollutant, Runoff, and Distance Indicators for determining the Pollutant Connectivity Factor (PCF).**

<b>Trial Number</b>	<b><math>W_p</math></b>	<b><math>W_r</math></b>	<b><math>W_d</math></b>
1	5	3	2
2	5	2	3
3	4	4	2
4	4	3	3
5	4	2	4
6	3	5	2
7	3	4	3
8	3	3	4
9	3	2	5
10	2	5	3
11	2	4	4
12	2	3	5
13	3.33	3.33	3.33

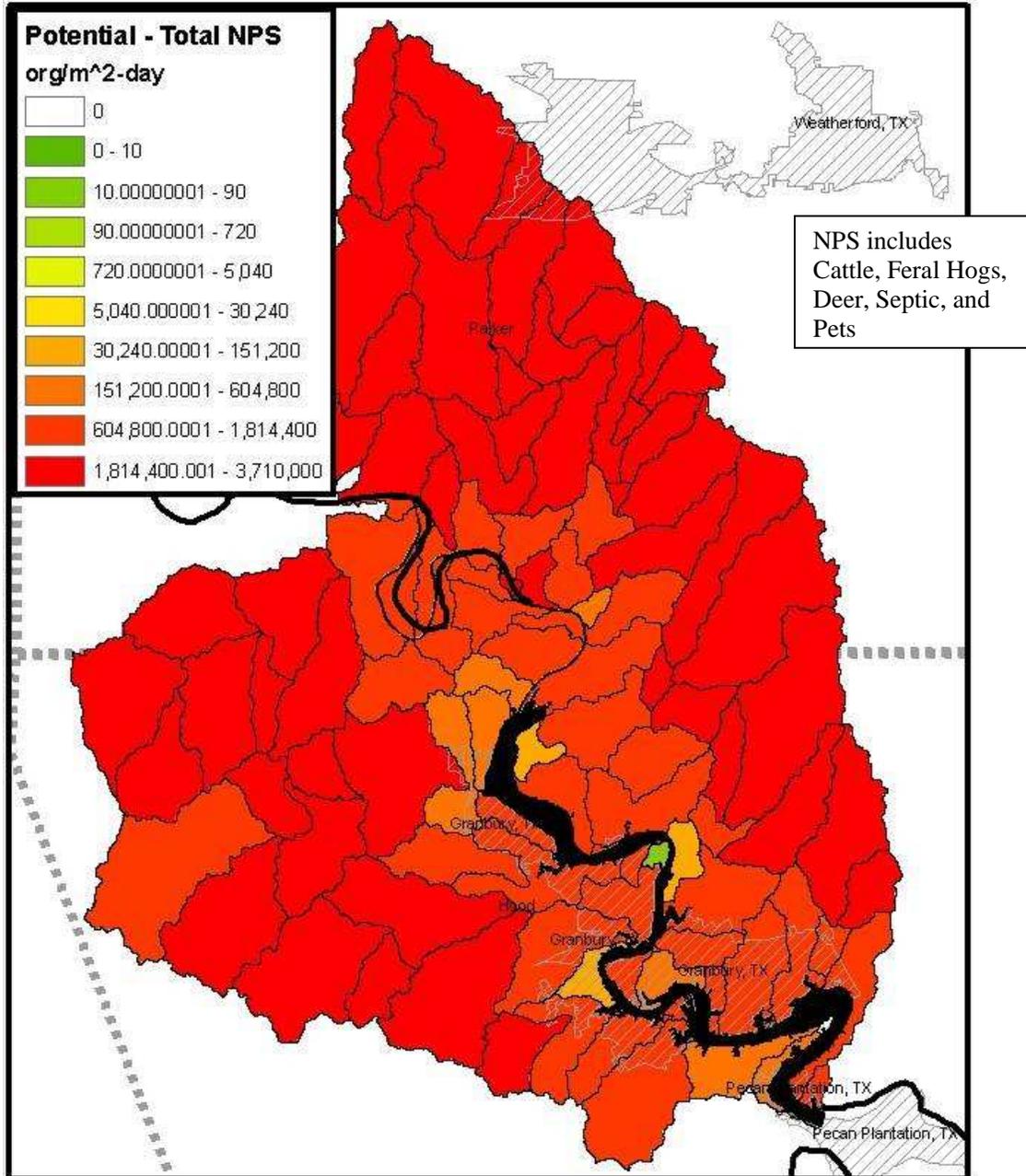


Figure D.1 Total Potential Non-Point Source (NPS) *E. coli* Load from All Sources in Lake Granbury Watershed.

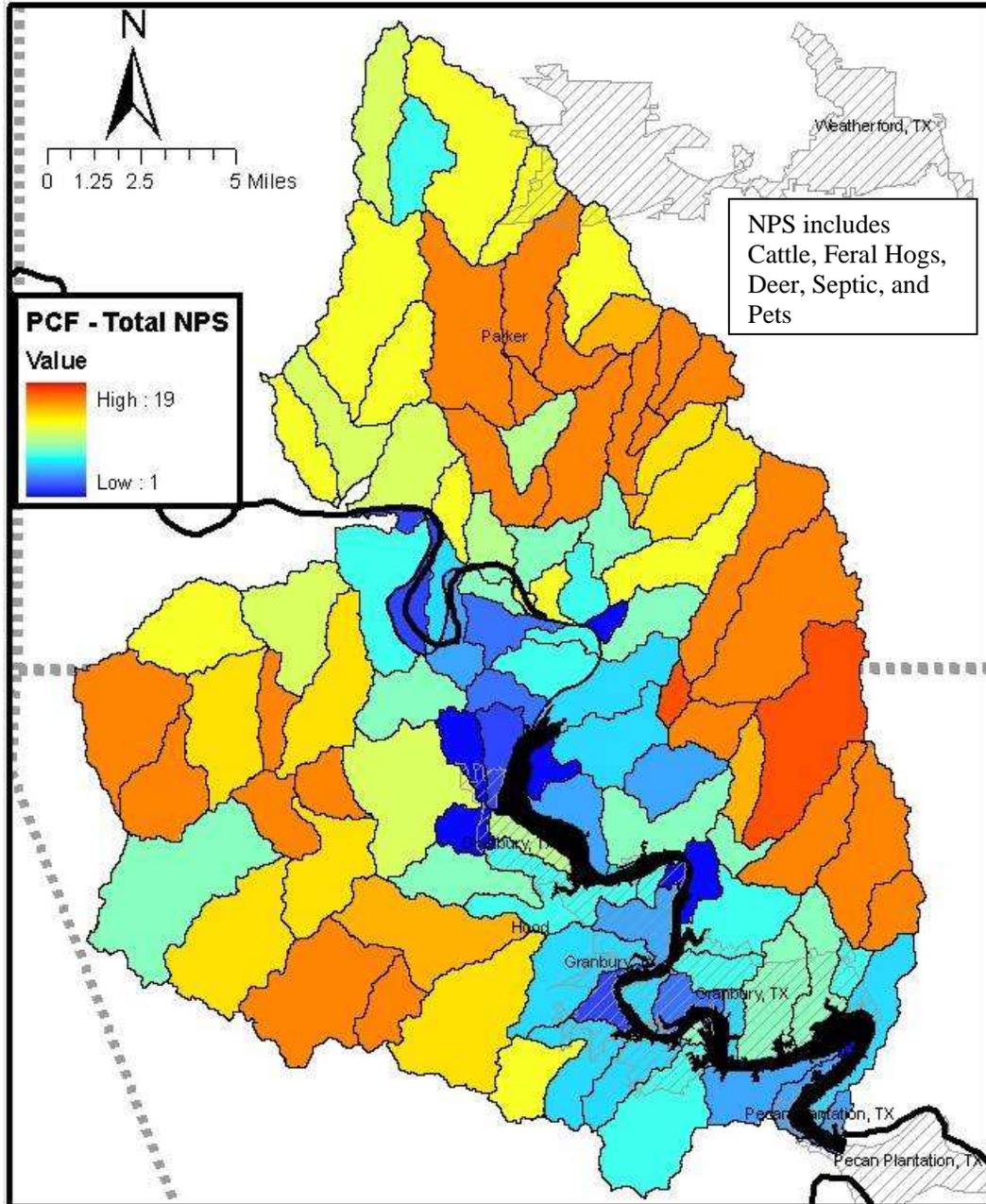
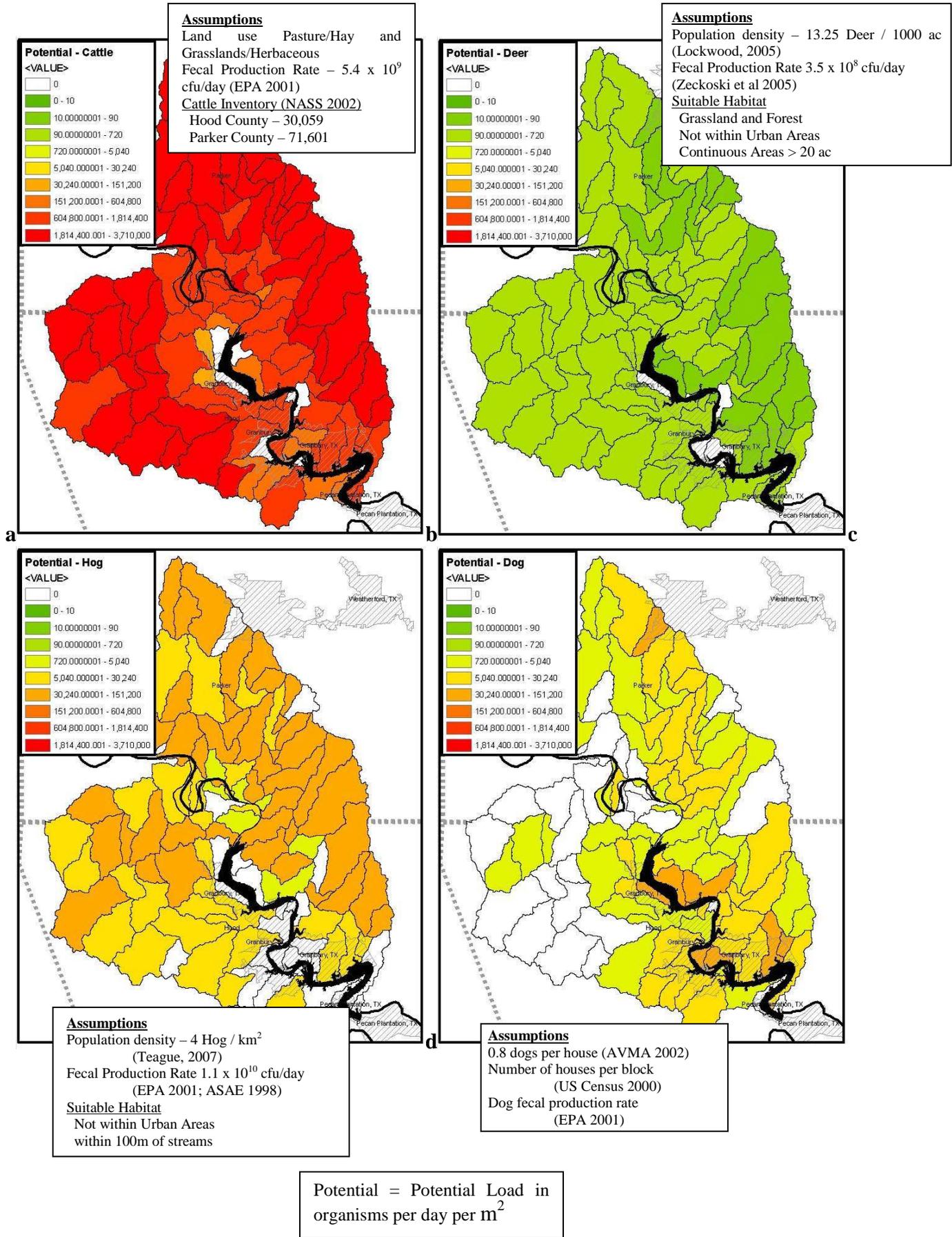
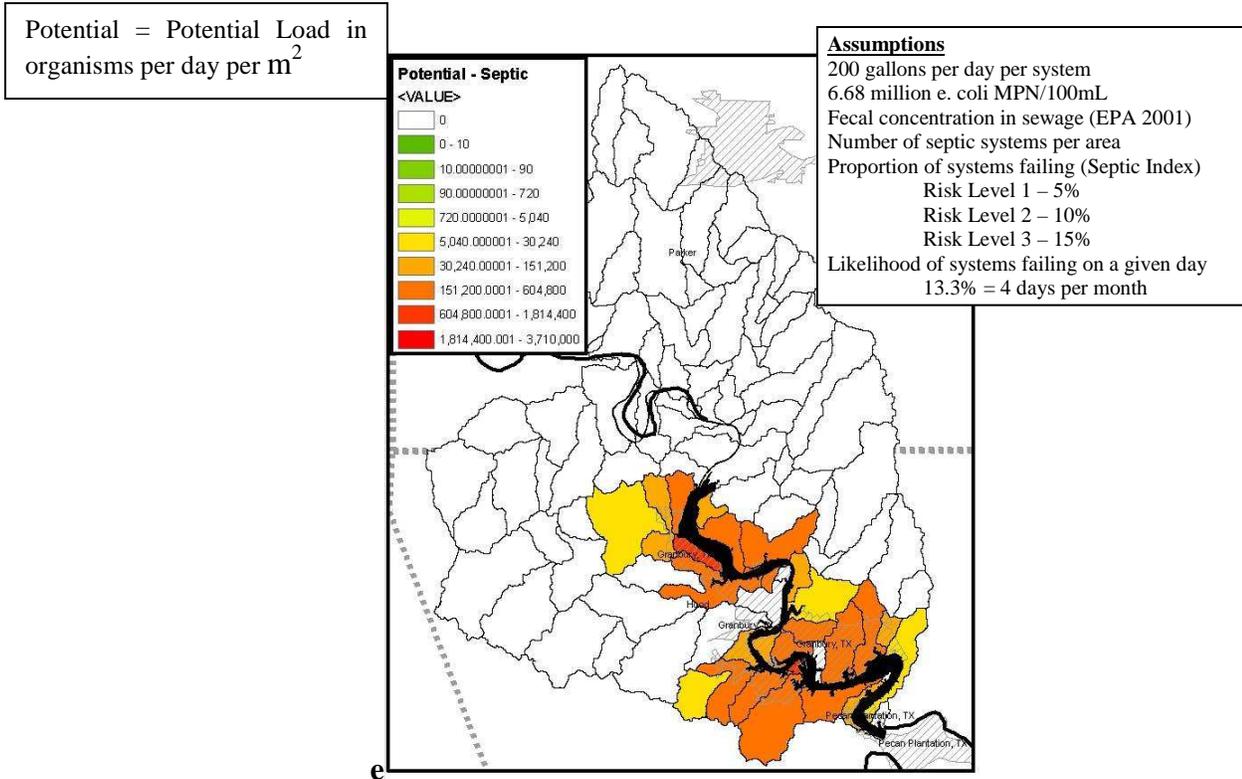


Figure D.2 Pollutant Connectivity Factor for Total Non-Point Source (NPS) *E. coli* Potential Load Determined by Ranked Subwatersheds Averaged over Multiple Weighting Scenarios.

**Daily Potential *E. coli* Loading in Lake Granbury Watershed**

The potential *E. coli* loading can be broken into two classes for analyses; non-point and point sources.





**Figure D.3 Area Weighted Potential *E. coli* Load (organisms/day-m<sup>2</sup>) in Lake Granbury Watershed Resulting from Various Non-Point Sources: a) Cattle, b) Deer, c) Feral Hogs, d) Pets , and e) On-site Wastewater Treatment Systems (OWTS)**

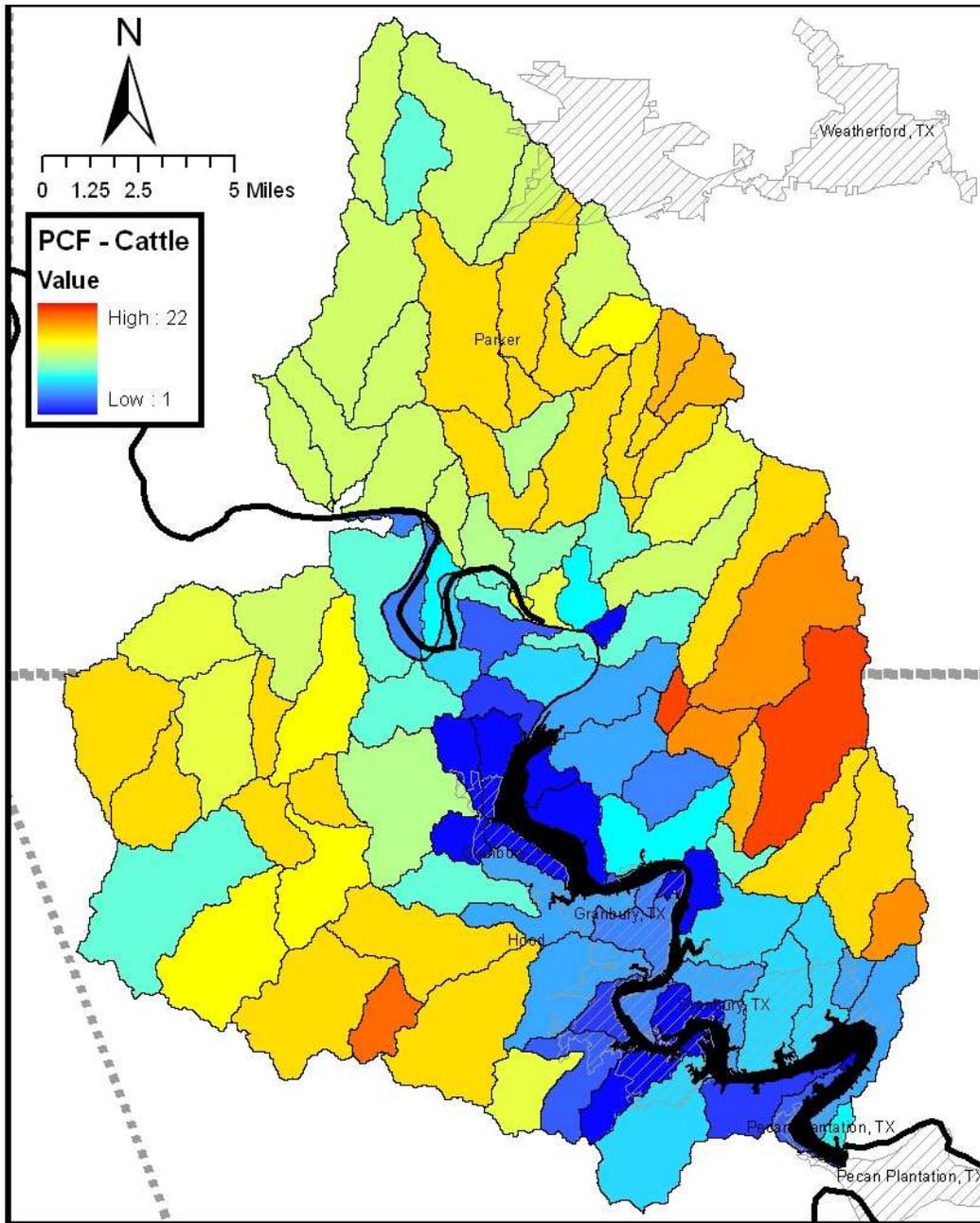


Figure D.4 Ranked PCF for Area Weighted Cattle Potential *E. coli* Loading

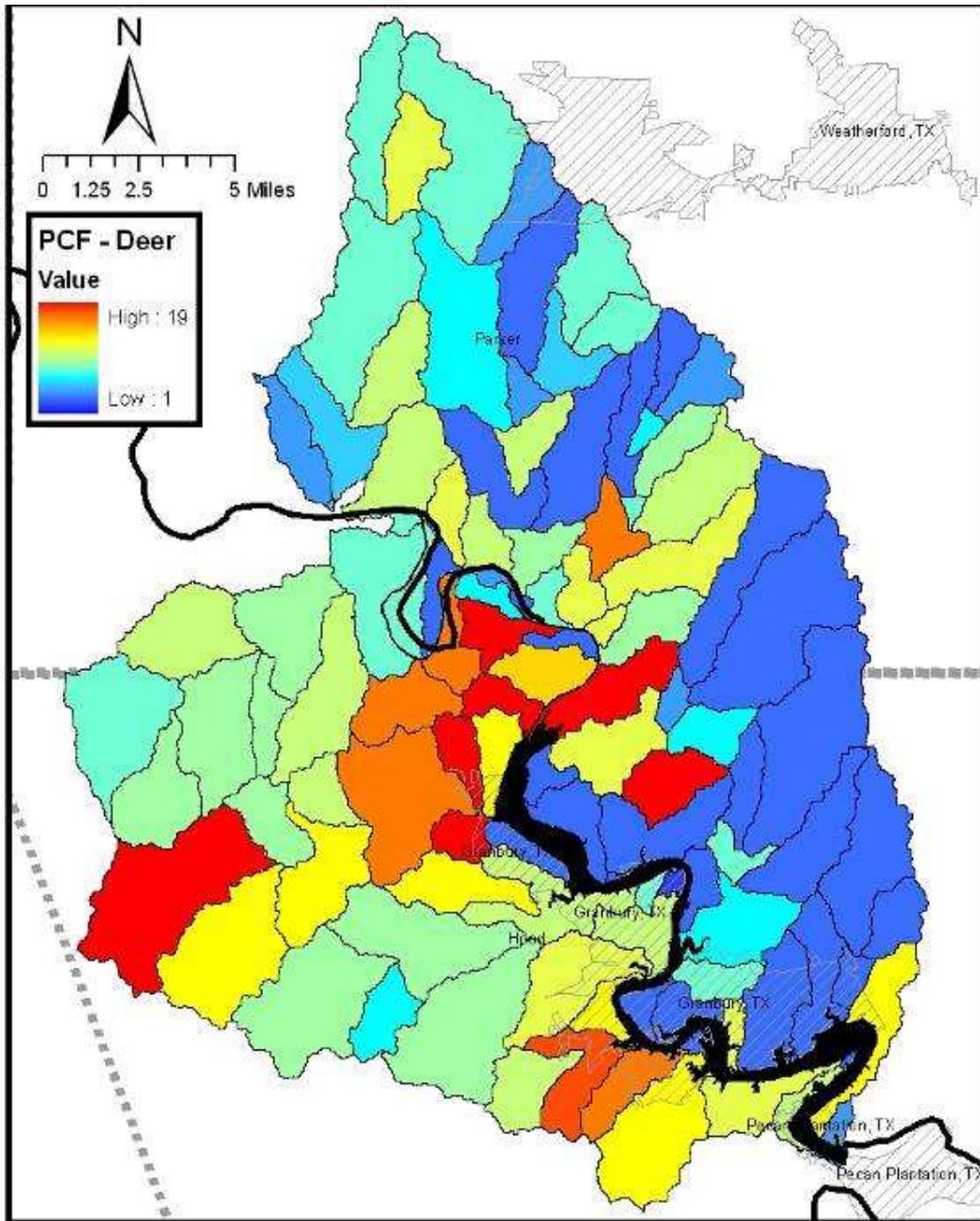


Figure D.5 Ranked PCF for Area Weighted Deer Potential *E. coli* Loading

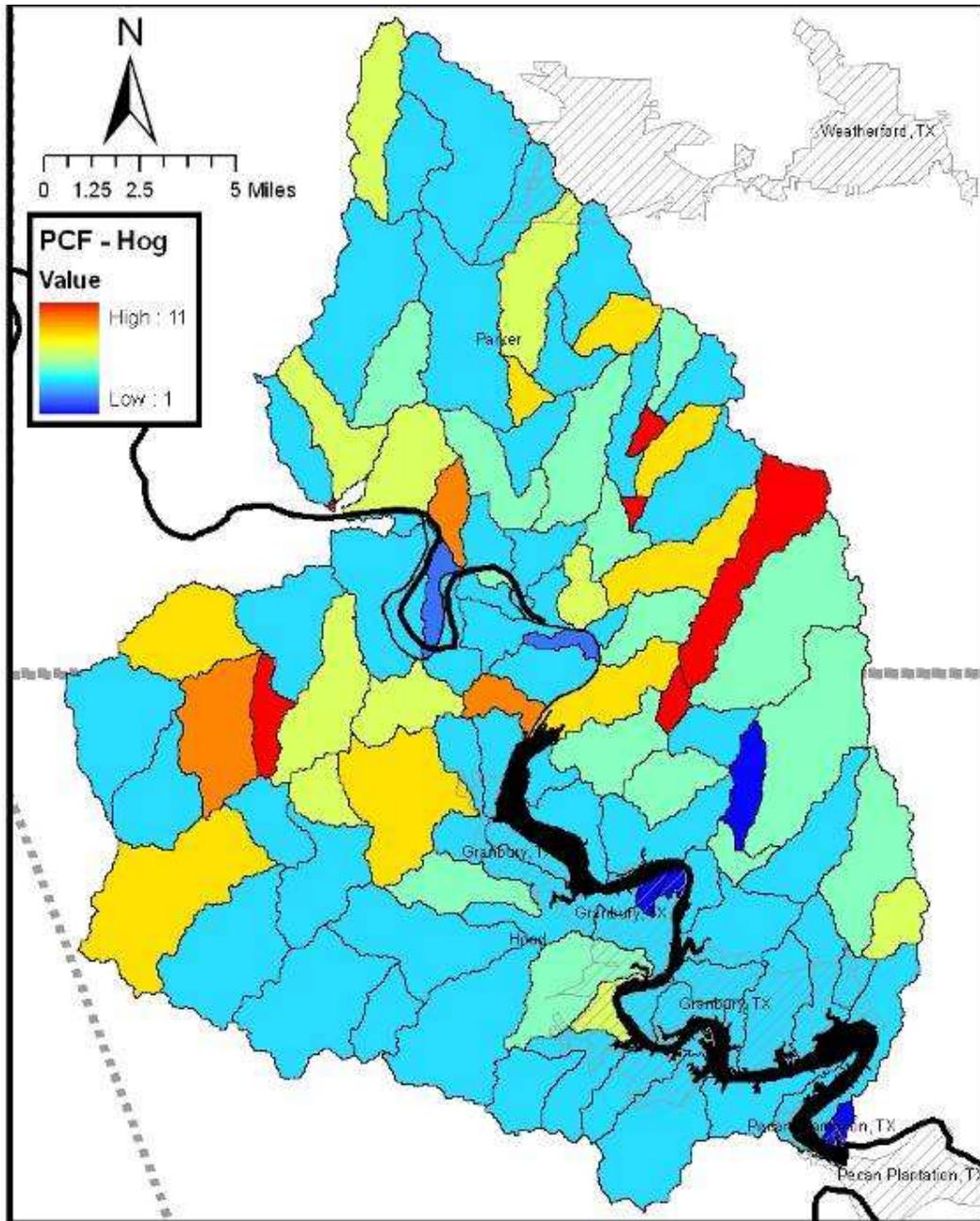


Figure D.6 Ranked PCF for Area Weighted Feral Hog Potential *E. coli* Loading

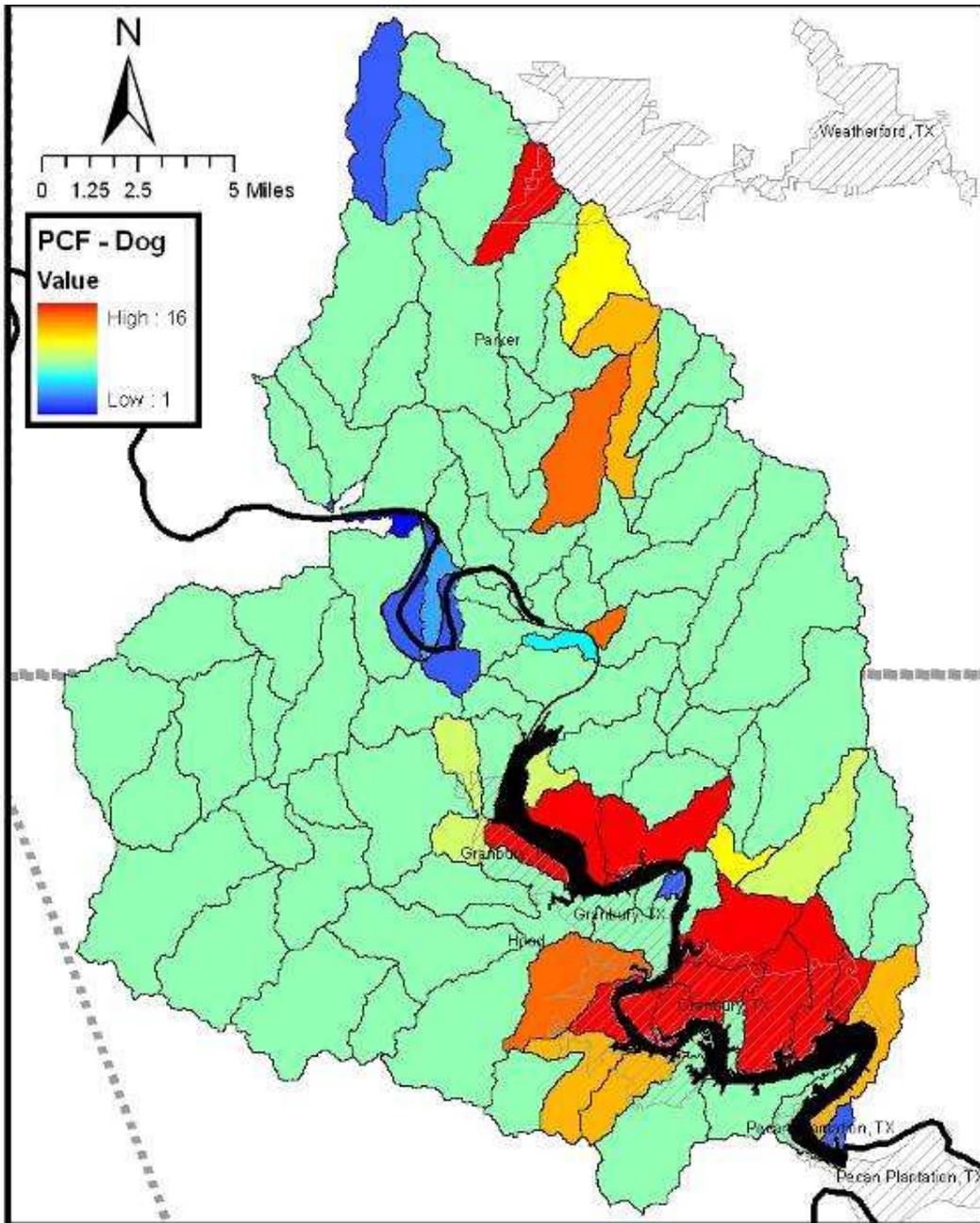


Figure D.7 Ranked PCF for Area Weighted Dog Potential *E. coli* Loading

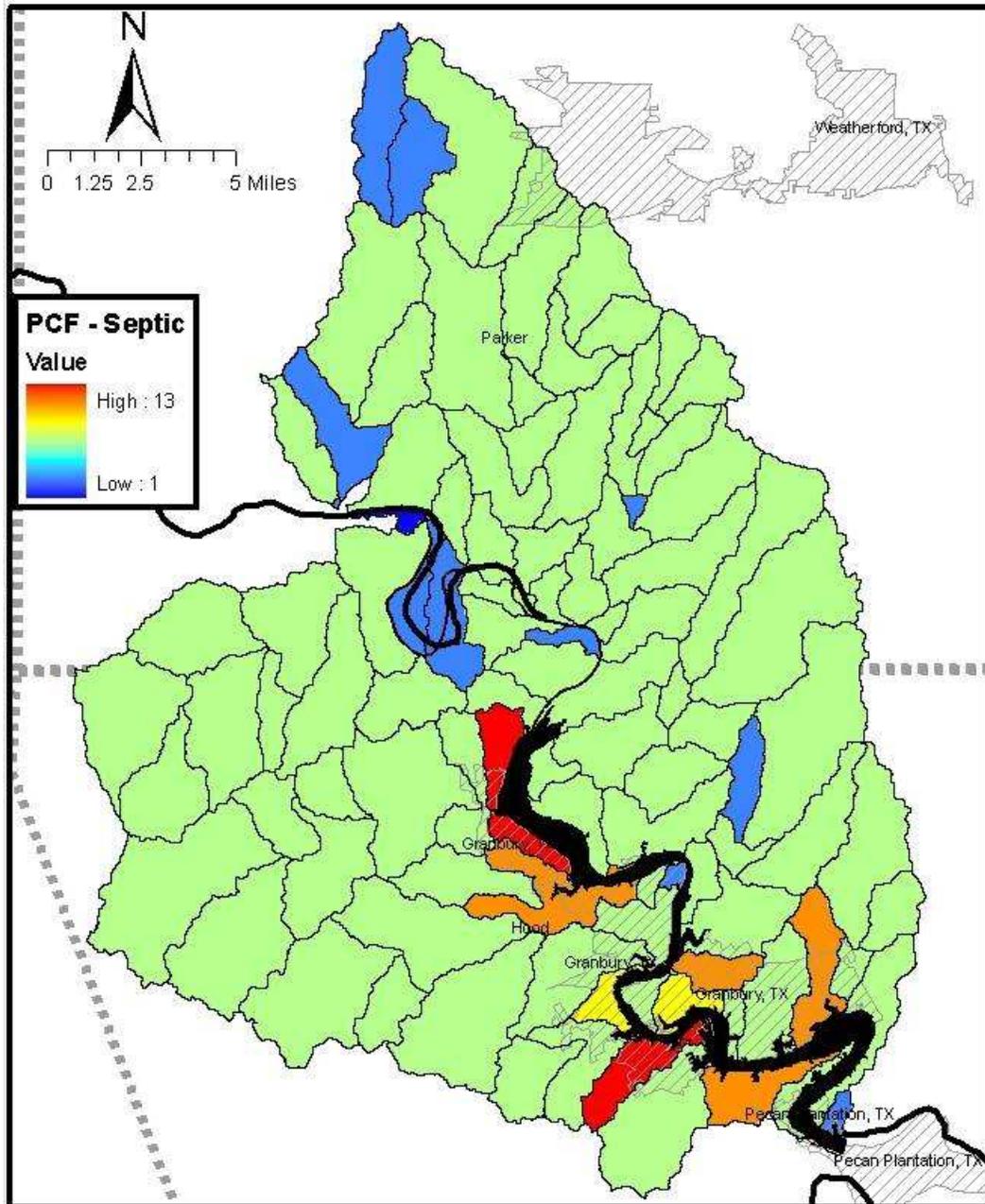


Figure D.8 Ranked PCF for Area Weighted Septic Potential *E. coli* Loading

#### Non-Point Sources

High potential *E. coli* load resulting from cattle (Figure D.3a) occurs in the northern-most subwatersheds as well as in subwatersheds on the Eastern side of the watershed near the Hood and Parker County lines. These subwatersheds have a landscape dominated by grasslands with a mixture of pasture/hay. The watersheds closest to Caddo Lake have lower loads mainly due to higher human population. During a runoff event the highest ranked PCF ‘hot spots’ are the most likely to significantly contribute to contamination in the waterbodies. The subwatersheds with high potential loads and closest to the lake were determined to be the highest ranked, by PCF, areas likely to be contributing to contamination in the waterbodies (Figure D.4). The highest

average PCF ranking occurs in the eastern portion of the basin near the Hood and Parker County lines about 5 miles away from Lake Granbury.

The highest potential *E. coli* loading resulting from deer (Figure D.3b) can be seen in the northern and western portions of the watershed where human population is less dense and large areas of contiguous forested lands are found. The second highest group of potential loading tends to have significant amounts of forests but these areas are more scattered and broken up by streams and intermixed with open range and grass lands. The southern half of the watershed generally has lower potential loads resulting from deer mainly due to the influence of higher human populations. When these loads are compared with the PCF ranking (Figure D.5), it is evident the most influence from deer can be found in the subwatersheds just north of Lake Granbury and in the far Western portions of the basin with the least influence in the southeast portions of the basin.

The areas with high feral hog potential are similarly characterized as with the deer population except the feral hogs are distributed in more areas of the watershed and concentrated along stream corridors. The feral hog *E. coli* potential is insignificant in the urban areas along Lake Granbury and in the southern portion of the watershed due to the highly developed land classifications in these regions. This is further emphasized in the PCF ranking for feral hogs (Figure D.6).

Potential *E. coli* loading resulting from malfunctioning OWTSs (Figure D.3c) was calculated for Hood County only where descriptive permit data was gathered to create a spatial subdivision OWTS file by the Brazos River Authority from the Hood County Appraisal District. This information has not been gathered for Parker County. This does not pose a significant problem since the northern portion of the watershed in Parker County is much further from the waterbodies of concern. In addition, the only areas with significant populations are on the northeastern edge of the watershed where the populations are quite dense and most likely on combined sewer networks. Subwatersheds located across the main section of Lake Granbury on the eastern shoreline have the highest potential *E. coli* loads resulting from malfunctioning OWTSs (Figure D.8). These areas are characterized by significant developed, low intensity landuse classification which generally includes single-family housing units, as well as significantly developed, medium and high intensity, land use which includes single-family housing units with higher percent impervious land cover and areas where people reside or work in high numbers. The second highest potential loading group is located west of the lake and characterized by residential development scattered amongst undeveloped grasslands, forests, and pastures.

The potential *E. coli* loading resulting from pets (Figure D.3d) is highest in the northern-most portion of the watershed, along the southeastern edge, and in subwatersheds around Lake Granbury. This is explained by significant low and medium intensity developments within these subwatersheds and the direct relationship between household densities and pet density. These are popular residential areas because of the lake in the southern portion of the watershed and the close proximity to the Fort Worth metropolitan area in the northeast.

### Point Sources

There are seven wastewater treatment plant facilities operating within the watershed (Figure D.9). These facilities contribute large amounts of treated effluents and could impact the environment if improper/inefficient treatment of wastewater were to occur. When localities are considering consolidating on-site wastewater treatment systems into municipal sewage systems, the local officials should take into account the amount of pollutants, such as *E. coli* and nutrients, that would be discharged as a direct point source (with virtually zero travel time or attenuation) if maintained improperly.

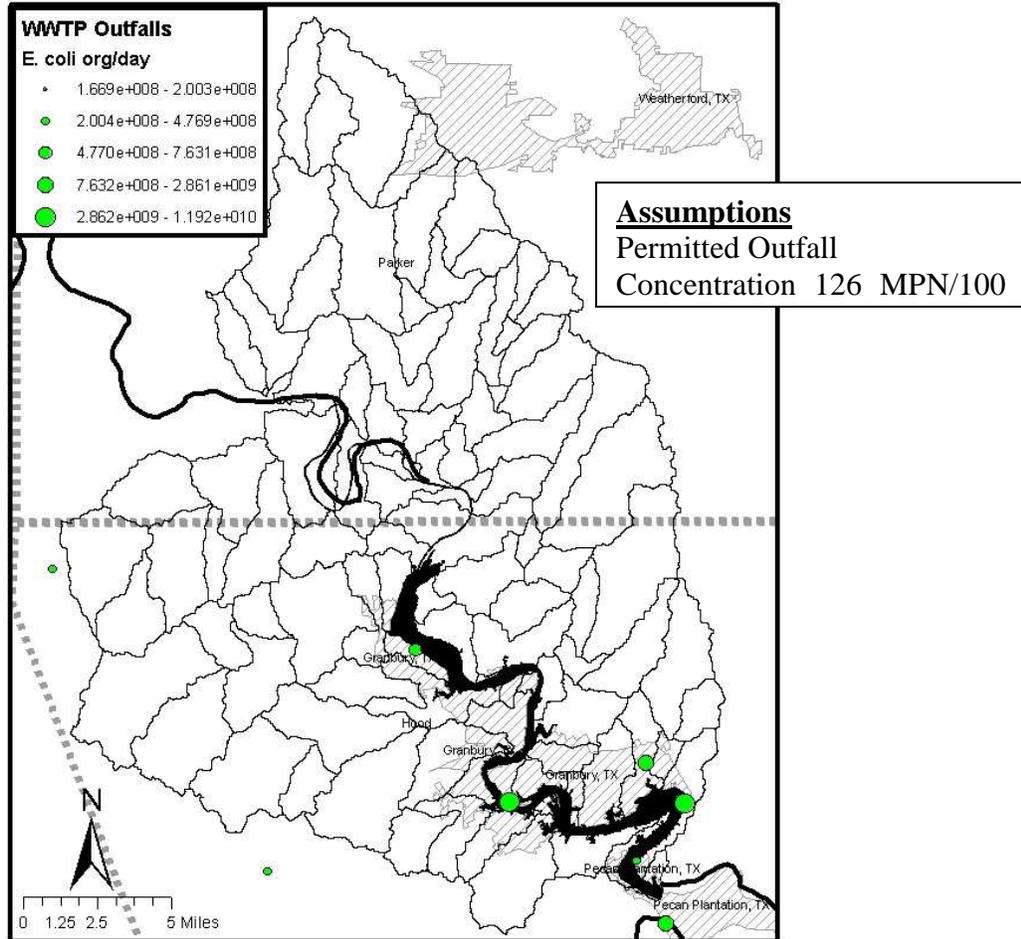


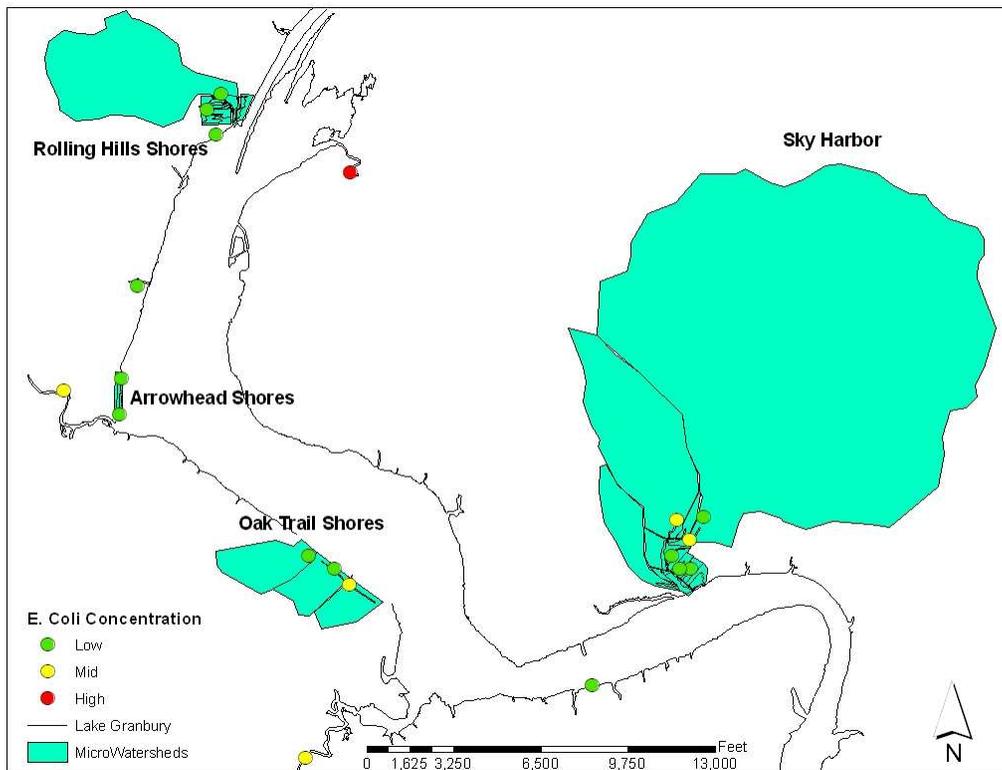
Figure D.9 Potential *E. coli* Loading from Wastewater Treatment Plants.

Combined Loading from All Sources

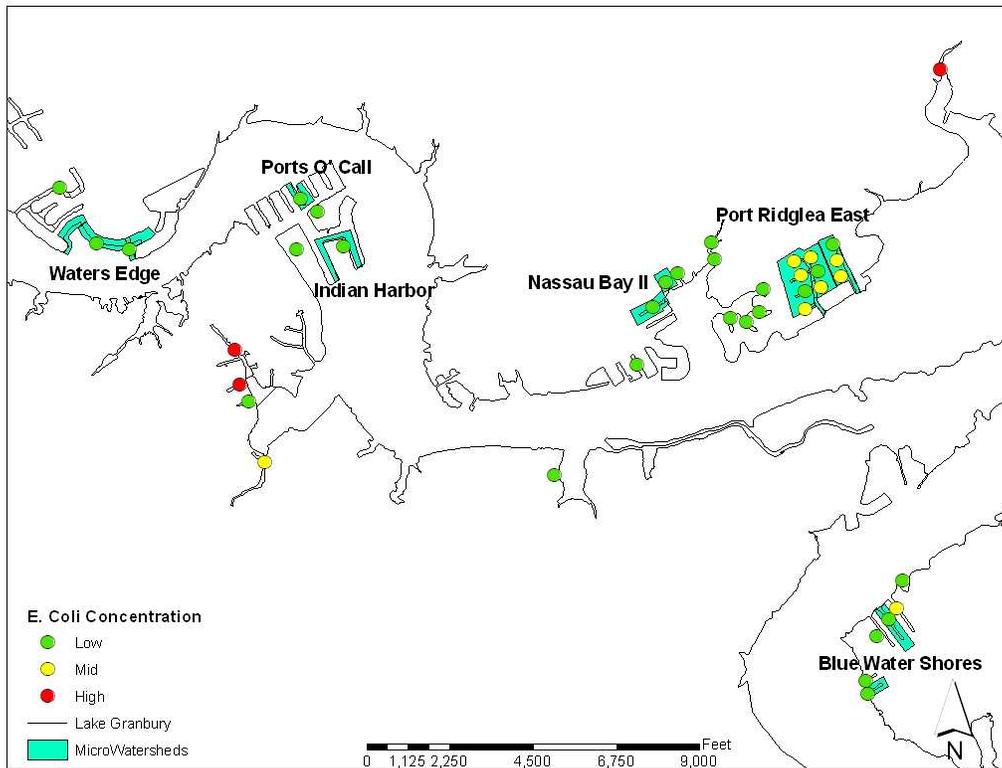
The SELECT results including the PCF analysis indicate that across the entire watershed cattle is the largest contributor to *E. coli* loading followed by deer, pets, OWTS, and then WWTPs (Figure D.3 through Figure D.9). Comparing the SELECT results with actual *E. coli* concentrations measured at water quality monitoring stations indicates that malfunctioning OWTS are potentially a major concern followed by pets. Currently, bacterial water quality is not monitored where SELECT predicts high potential *E. coli* loads in the broader Lake Granbury Watershed (Figure D.3 through Figure D.8).

## D.2.2 Modeling Results for Micro-watersheds of Priority Areas

Potential *E. coli* loadings for Micro-watersheds (Figure D.10 and Figure D.11) in Lake Granbury subdivisions were calculated by SELECT following the same assumptions as in the larger Lake Granbury Watershed analyses. Bacteria loads from livestock (cattle), wildlife (deer and feral hogs) and domestic sources (septic systems and other OWTs and pets) were calculated individually and combined and aggregated on micro-watershed basis. The potential loading component of SELECT can help identify source contributions spatially distributed across the watershed. However, this is only a snapshot of the amount of *E. coli* present in the area. The Pollutant Connectivity Factor (PCF) applied weighting to important fate and transport factors such as runoff capabilities and travel distance to provide qualitative information to determine whether *E. coli* from various sources potentially contaminate the waterbodies. It should be noted that PCF is comparative only with the particular source of interest and is not meant for comparative use between sources as magnitude of potential bacterial loading is normalized in each case individually. The difference in magnitudes will be similar to those seen in the larger watersheds potential loading.



**Figure D.10 Lake Granbury Micro-watersheds (Northern Portion of Lake)**



**Figure D.11 Lake Granbury Micro-watersheds (Southern Portion of Lake)**

#### Non-Point Sources

Only non-point sources were evaluated for the micro-watershed modeling since the WWTP point sources will be identical to those described previously in the large watershed modeling section of this report.

High potential *E. coli* load resulting from cattle Figure D.13 occurs in the microwatersheds around the Sky Harbor subdivision (Figure D.10). These micro-watersheds have a relatively larger landscape dominated by grasslands with a mixture of pasture/hay. The other small micro-watersheds have negligible cattle loads mainly due to the urban landscape and high population. During a runoff event the highest ranked PCF ‘hot spots’ are the most likely to significantly contribute to contamination in the waterbodies. The highest average PCF ranking was in Sky Harbor subdivision (Figure D.12).

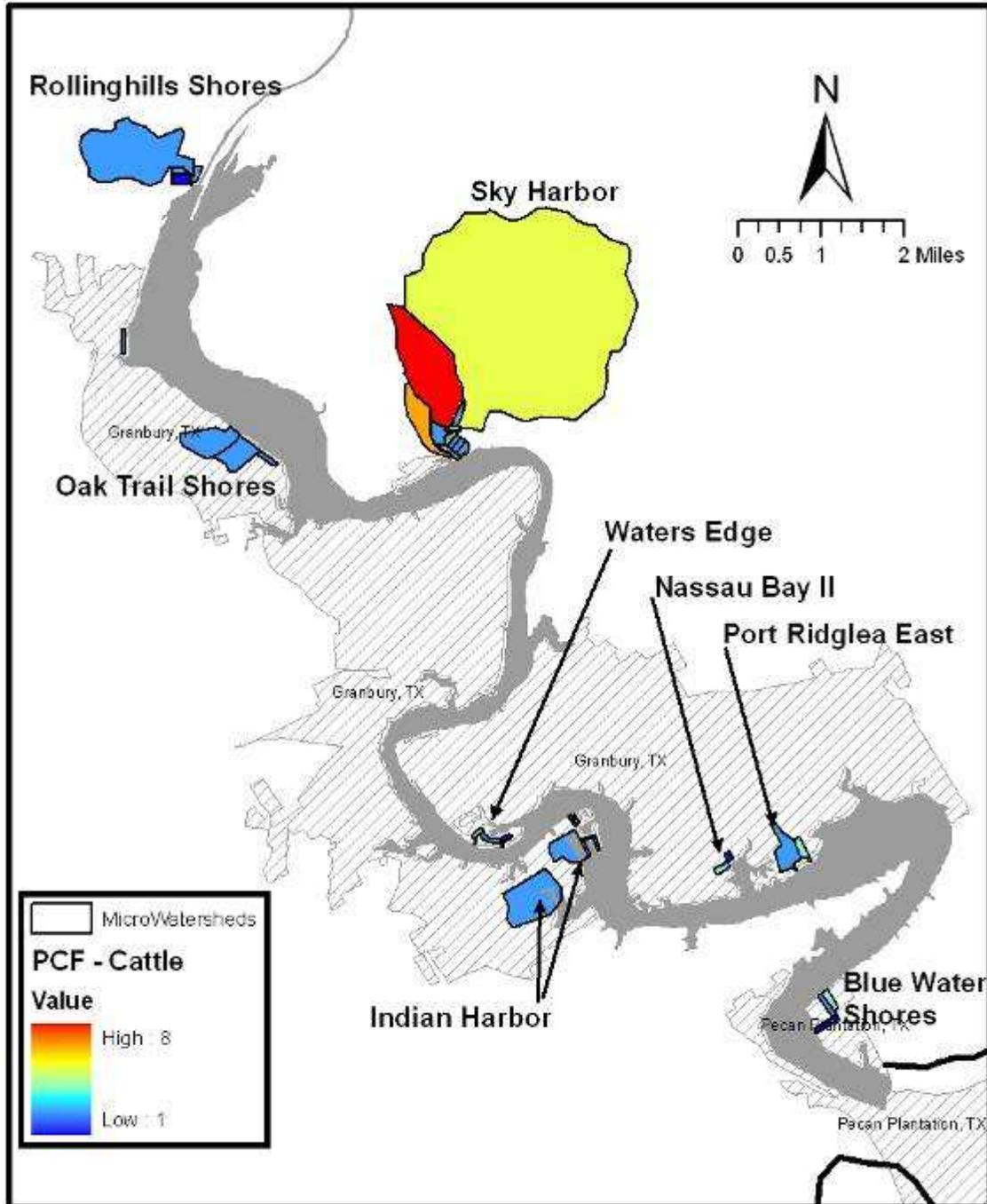


Figure D.12 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Cattle

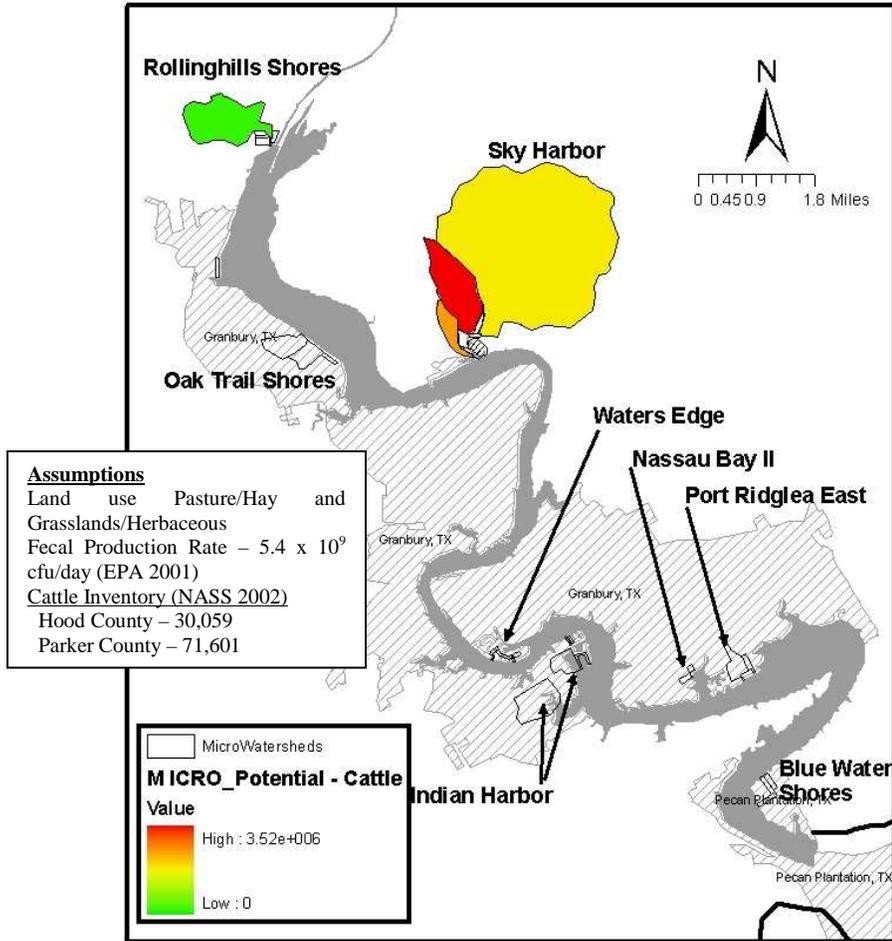


Figure D.13 Area Weighted Potential E. coli Loading from Cattle

The highest potential *E. coli* loading resulting from deer (Figure D.14 and Figure D.15) can be seen in the Rolling Hills Shores micro-watershed where human population is less dense and forest landuse is the dominant landscape. The small watersheds around urban subdivisions have lower potential loads resulting from deer mainly due to the influence of higher human populations. When these loads are compared with the PCF ranking, Rolling Hills Shores was among the areas of high concern. Following Rolling Hills Shores for concern due to deer contributions are the micro-watersheds around the Sky Harbor subdivision which is also characterized by less development and some forested areas.

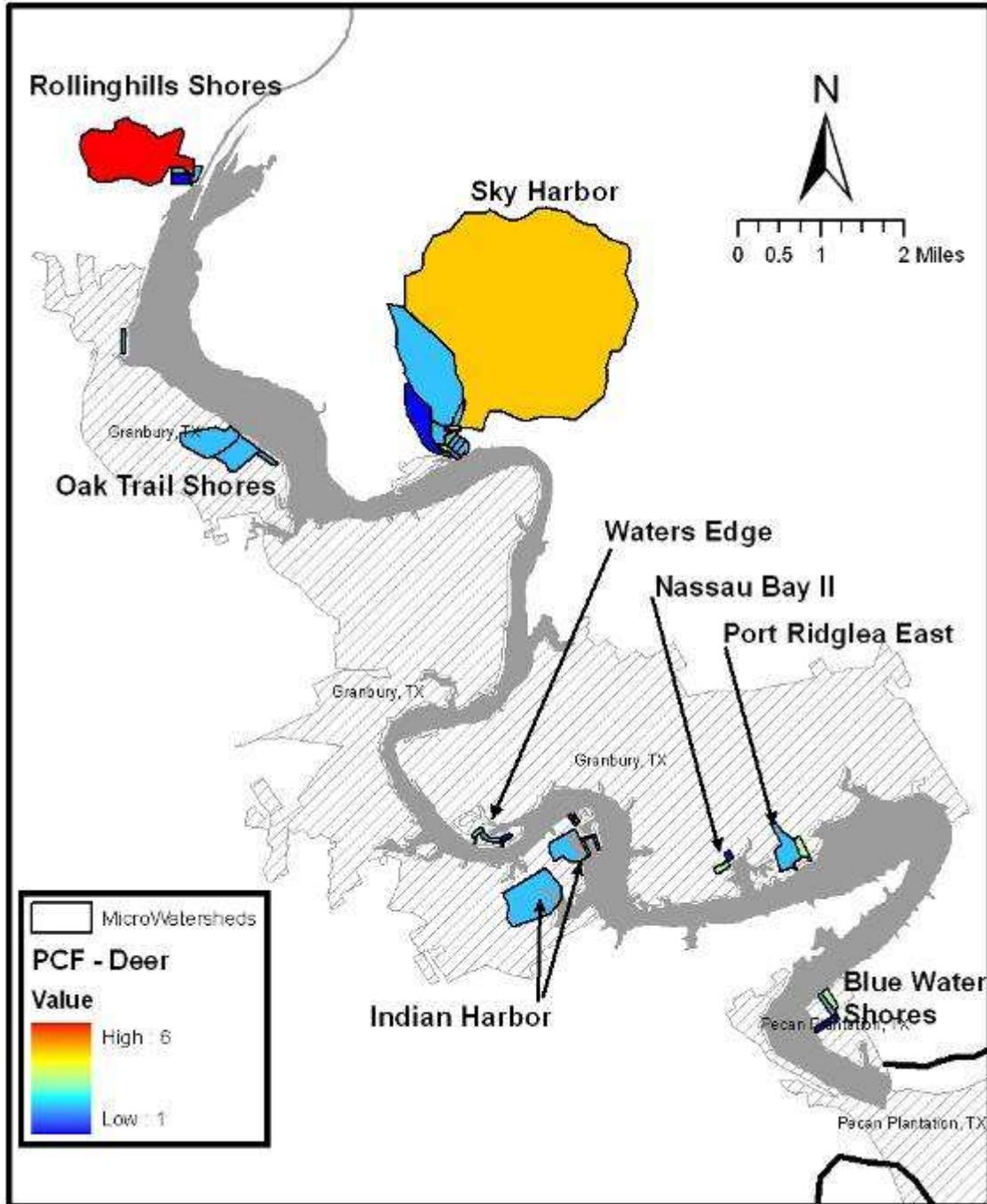


Figure D.14 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Deer

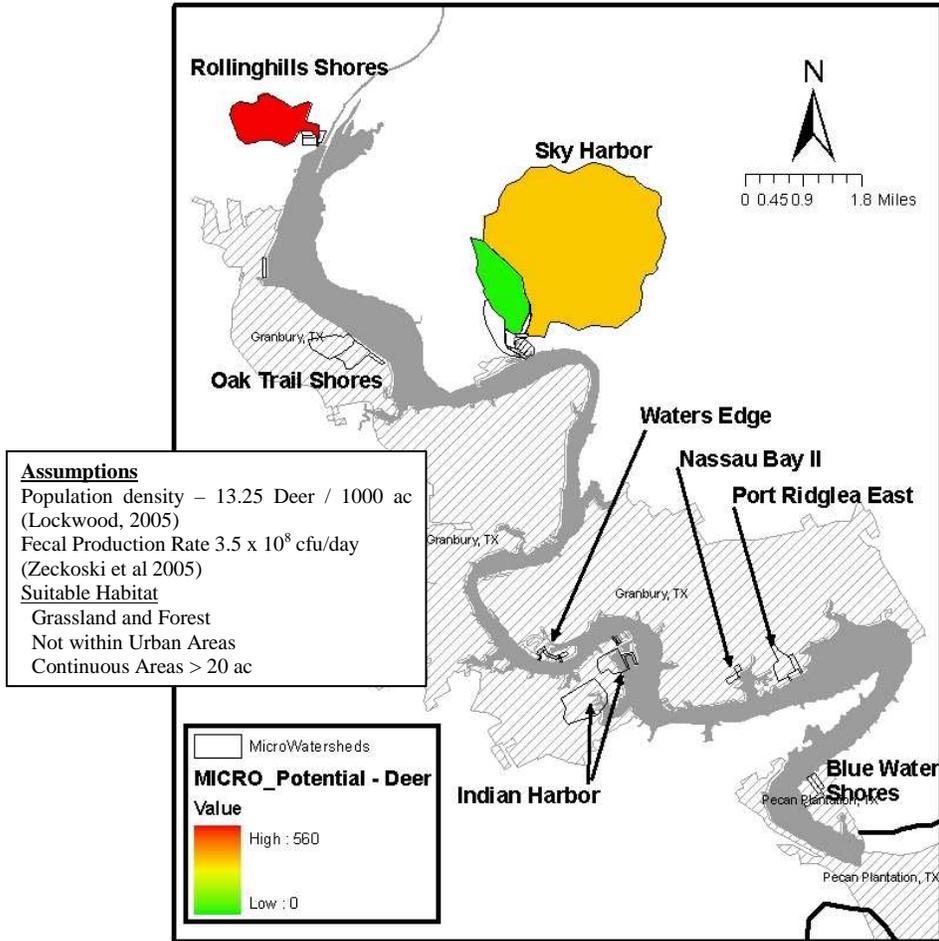


Figure D.15 Area Weighted Potential *E. coli* Loading from Deer

Potential *E. coli* loading from feral hogs (Figure D.16 and Figure D.17) would most likely be contributed in Sky Harbor but is very unlikely due to the high human population and relative closeness to higher human populated areas. Overall, for these subdivisions feral hogs have very low potential *E. coli* load contributions.

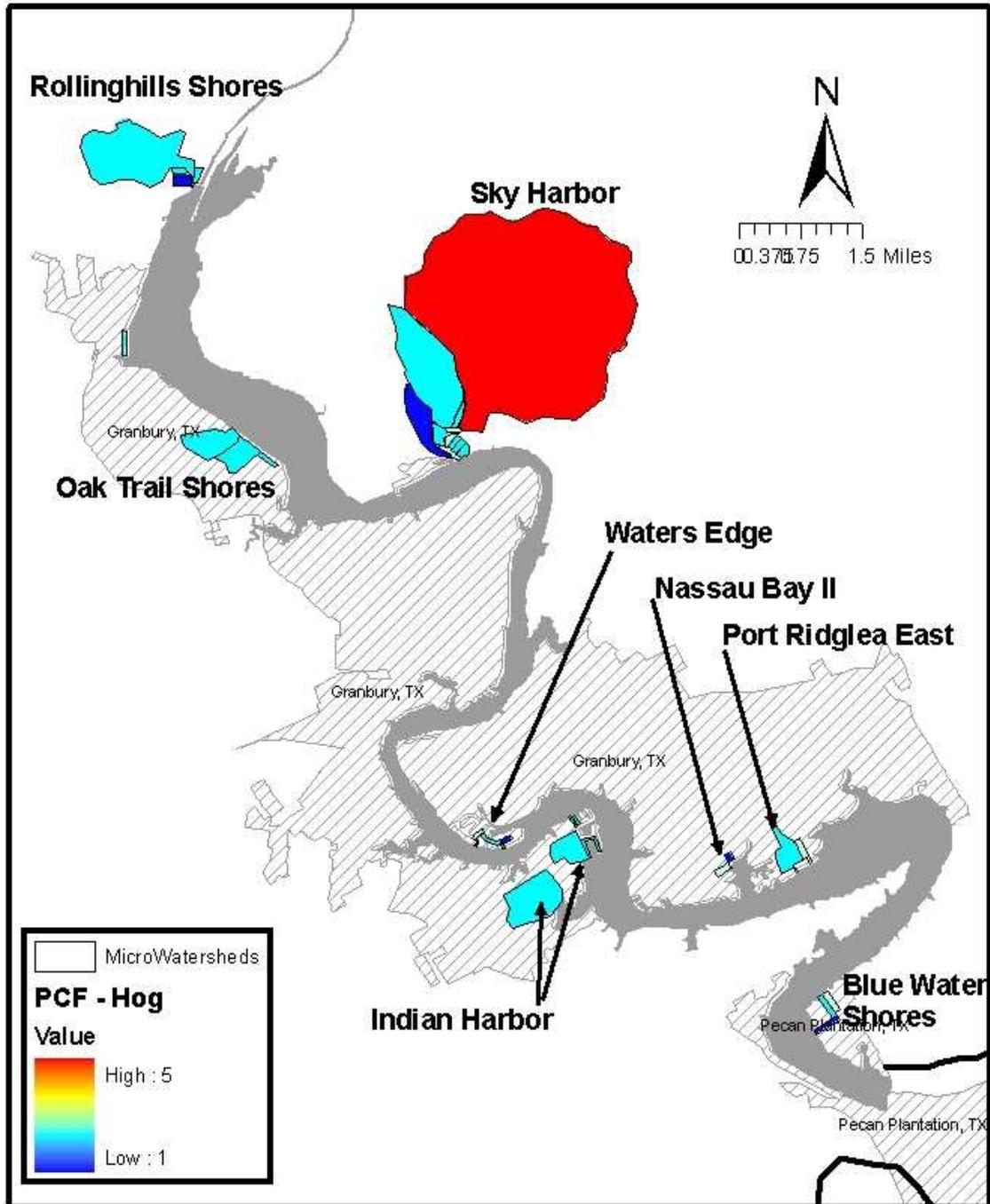


Figure D.16 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Feral Hogs

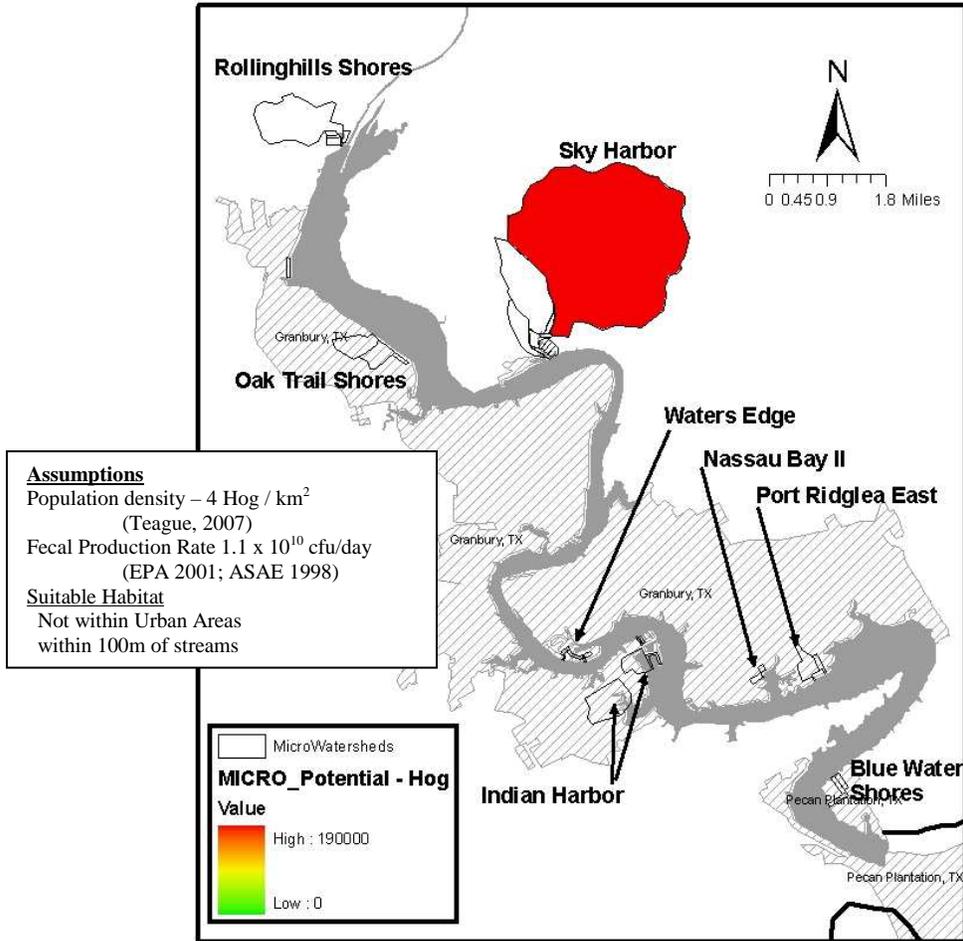


Figure D.17 Area Weighted Potential *E. coli* Loading from Feral Hogs

Potential *E. coli* loading resulting from malfunctioning septic systems (Figure D.17) was highest around small micro-watershed areas at Oak Trail shores, Ports O' Call, Indian Harbor and Port Ridglea East. These micro-watersheds were characterized by significant developed, high intensity landuse classification which generally included single-family housing units with higher percent impervious land cover and areas where people reside or work in high numbers. The areas potentially contributing significant *E. coli* loadings resulting from malfunctioning OWTs a high PCF ranking of three to ten (Figure D.18).

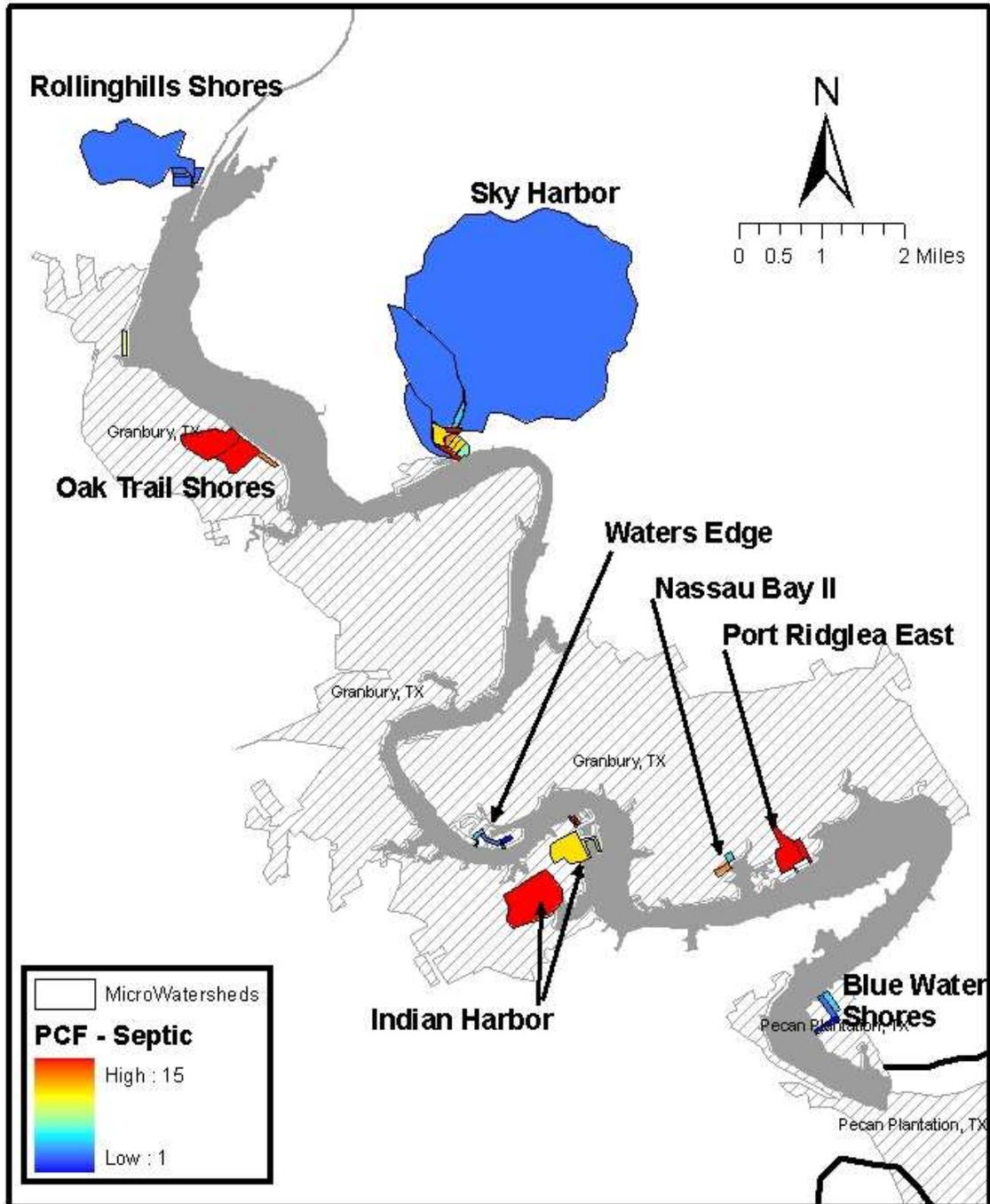


Figure D.18 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Malfunctioning Septic Systems

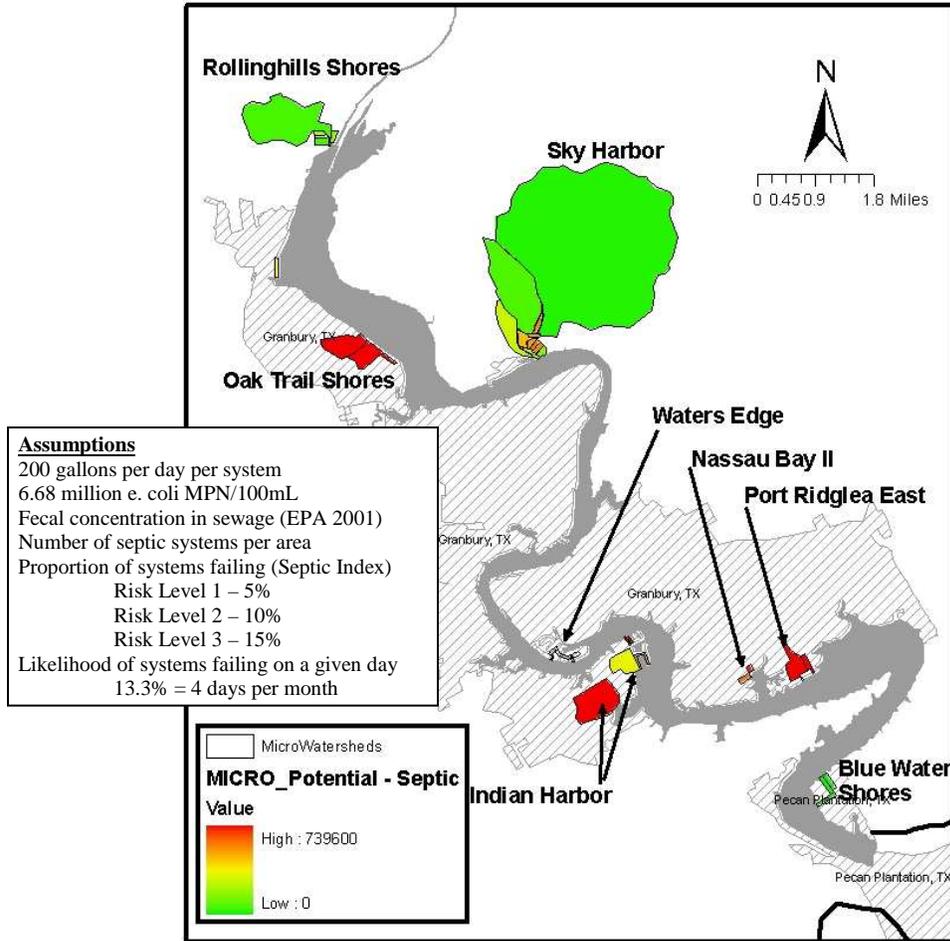


Figure D.19 Area Weighted Potential *E. coli* Loading from Malfunctioning Septic Systems

The potential *E. coli* loading resulting from pets (Figure D.21) is highest in micro-watersheds at Oak Trail Shores and Sky Harbor. Also it should be noted that there is some loading in all of the subdivisions. This is explained by housing developments within these subdivisions. These are popular residential areas because of the lake in the southern portion of the watershed. The micro-watersheds with highest potential *E. coli* load resulting from pets are ranked using the average PCF over several weighting schemes as high (Figure D.21).

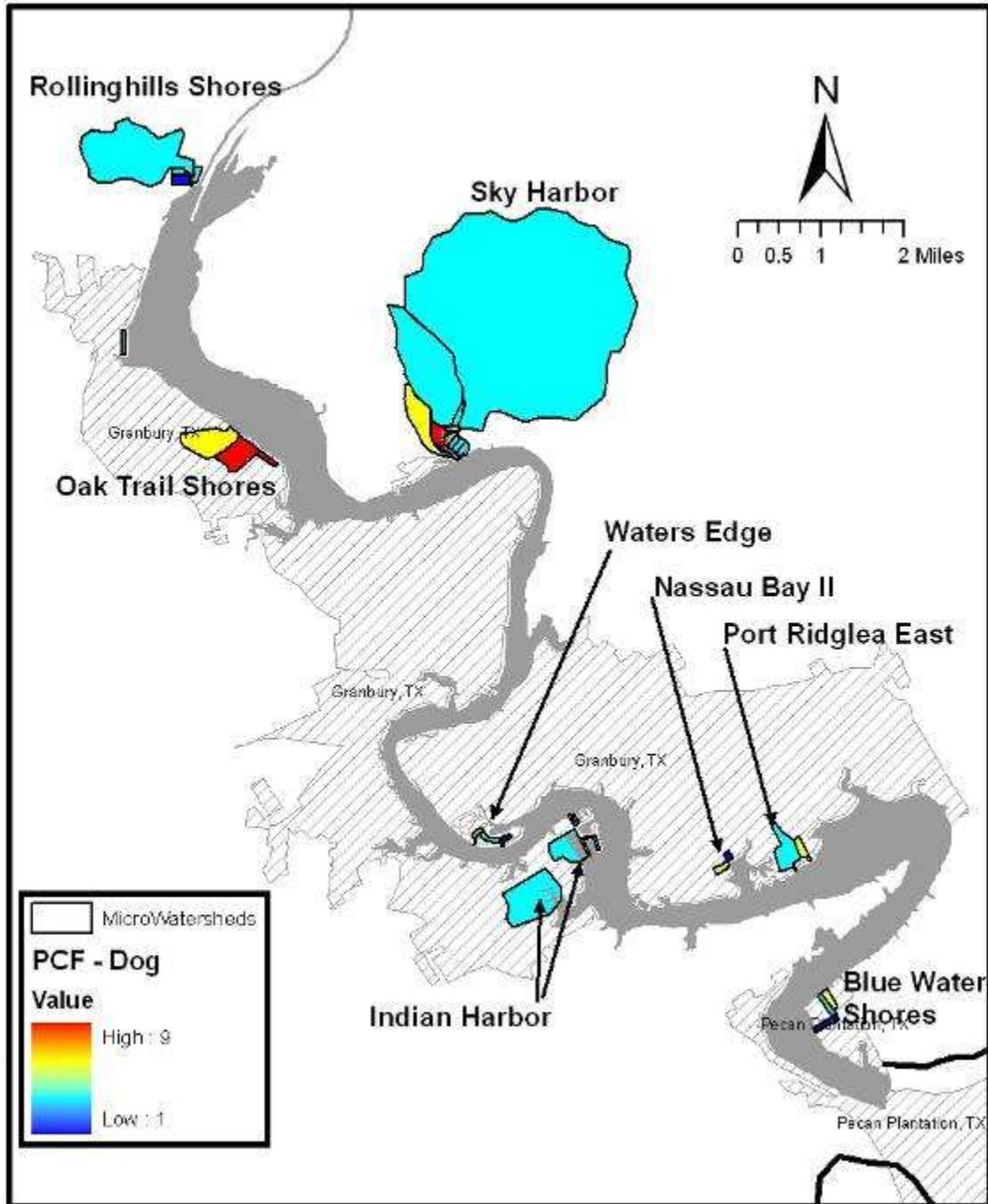


Figure D.20 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Dogs

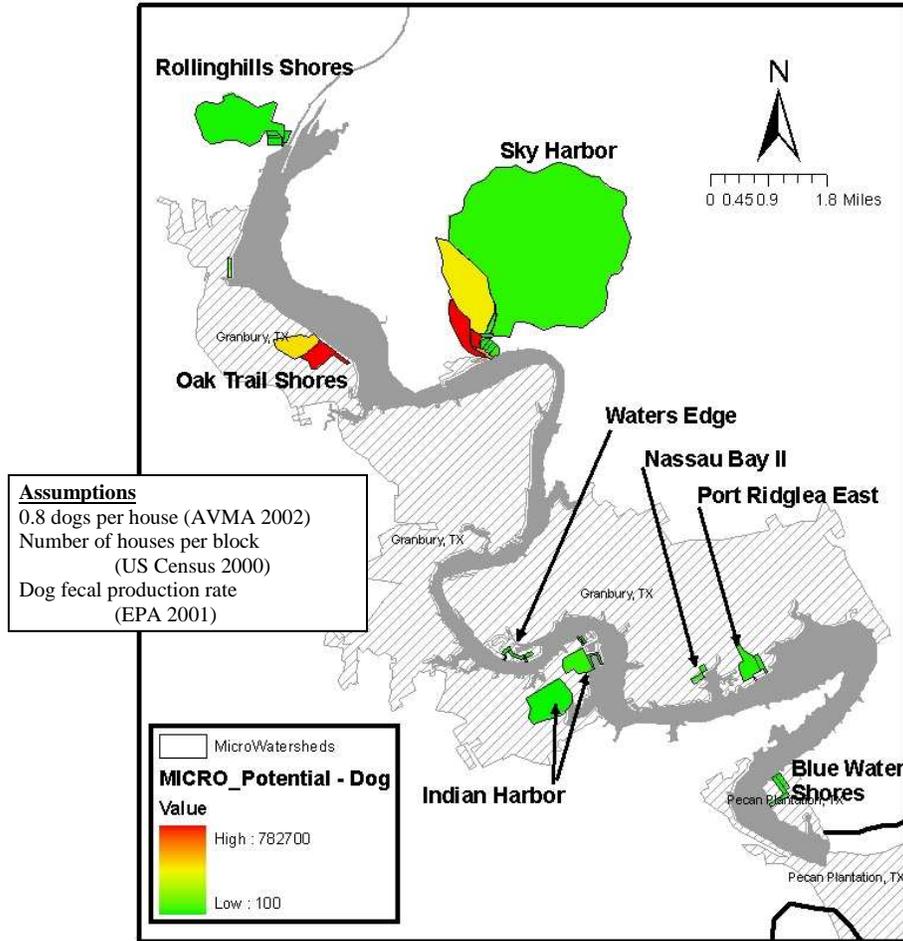


Figure D.21 Area Weighted Potential *E. coli* Loading from Dogs

#### Combined Loading from All Non-Point Sources

The highest total non-point source *E. coli* loads (Figure D.23) occur in micro-watersheds around Sky Harbor and Rolling Hills Shores. These subdivision watersheds have land uses appropriate for cattle and deer. Hence, it can be concluded that major *E. coli* contributors in these micro-watersheds are cattle and deer. It should also be pointed out that all of the microwatersheds had similar total potential loadings per area even though the source composition is slightly different for each micro-watershed.

The SELECT results including the PCF analysis of the microwatersheds indicates the highest concern for contributing *E. coli* to the waterbodies is in Sky Harbor and portions of Port Ridglea East (Figure D.22). For Sky Harbor BMP efforts should focus on controlling wildlife and livestock access to waterways. In Port Ridglea East either more education about maintaining properly functioning OWTSs or the consolidation into municipal sewage collection system are options to be considered due to the high possibility of malfunctioning OWTS contributions.

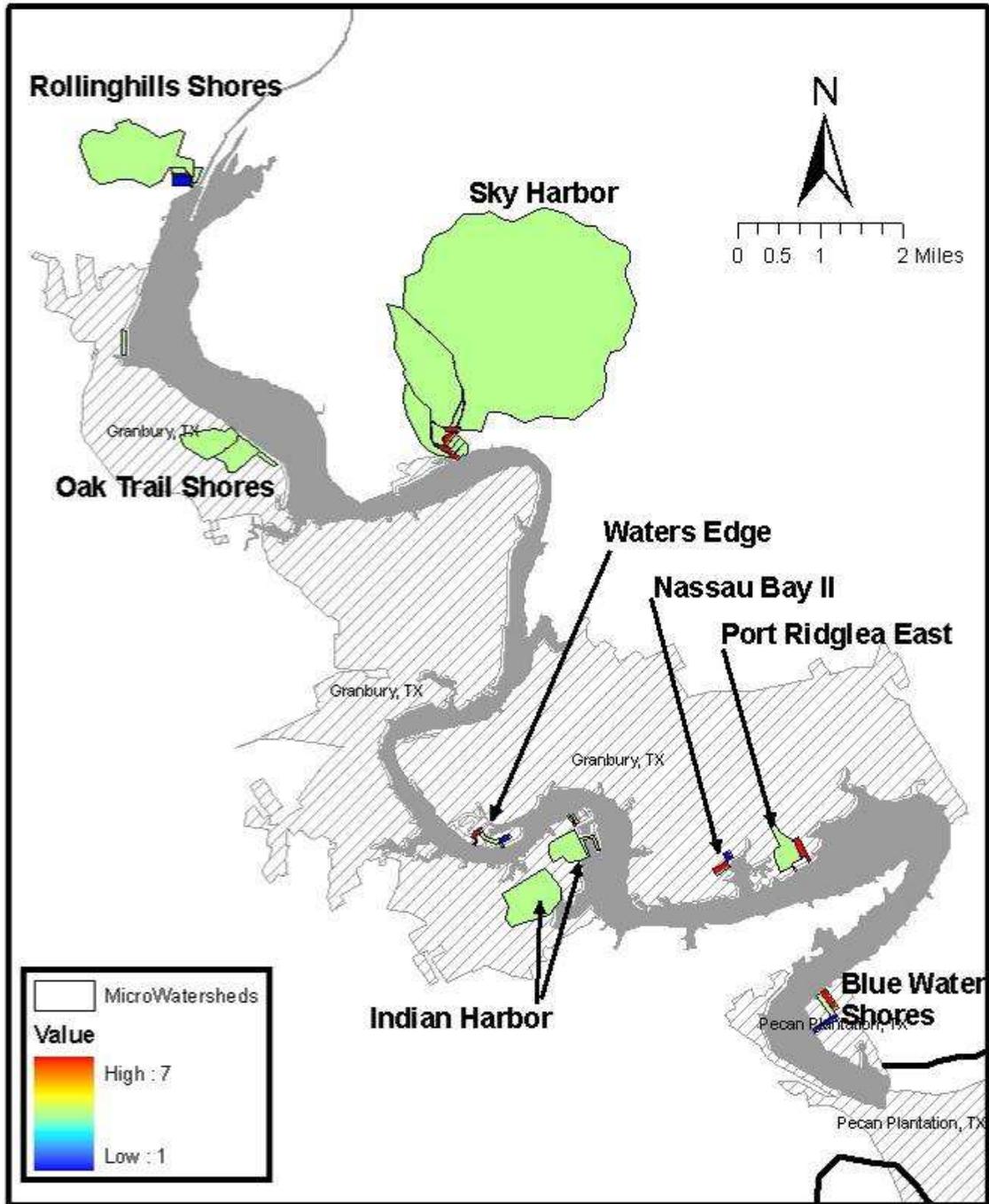


Figure D.22 PCF Ranking of Microwatersheds from Area Weighted Potential E. coli Loading from Non-point Sources

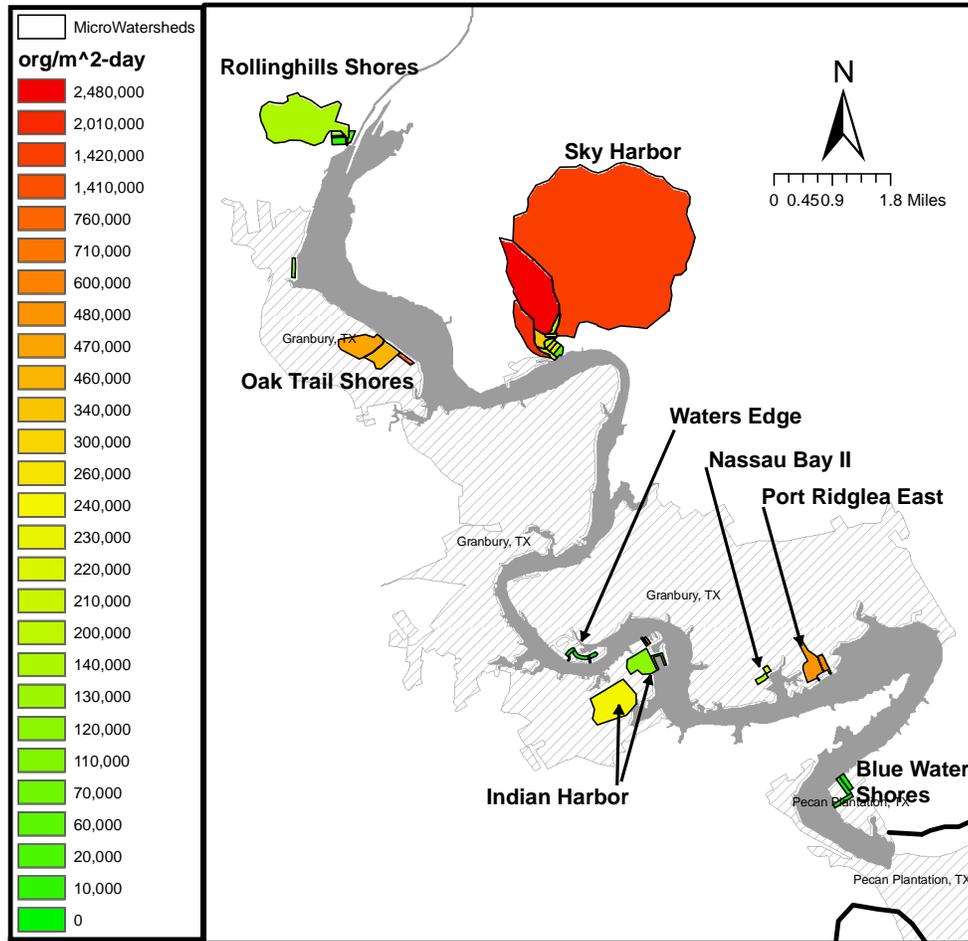


Figure D.23 Area Weighted Potential *E. coli* Loading from Non-point Sources

### Point Sources

There are five wastewater treatment plant facilities operating within the greater Lake Granbury watershed (Figure D.9). The highest *E. coli* loading occurs upstream of the Blue Water Shores watershed followed by the Waters Edge watershed. These facilities contribute large amounts of treated effluents and could impact the environment if improper/inefficient treatment of wastewater were to occur. When localities are considering consolidating on-site wastewater treatment systems into municipal sewage systems, the local officials should take into account the amount of pollutants, such as *E. coli* and nutrients, that would be discharged as a direct point source (with virtually zero travel time or attenuation) if municipal systems are managed improperly.

### D.3 Watershed Modeling Summary

The Spatially Explicit Load Enrichment Calculation Tool (SELECT) was developed and automated to characterize the production of pathogens from various pollutant sources across a watershed. SELECT was applied to the greater Lake Granbury Watershed in Texas as well as for the micro-watersheds of particular subdivisions along the lake.

When potential *E. coli* loads simulated by SELECT are combined with the PCF module, decision makers can identify *E. coli* sources and areas of potential concern in a watershed. This will ultimately help decision makers choose cost effective BMPs to alleviate contamination issues in an impaired watershed. Once BMPs have been chosen, PCF analysis can be performed in order to determine the spatially explicit locations to implement source specific BMPs. The PCF results can also be used to determine the locations for water quality monitoring. Ideally, these locations should be in potential *E. coli* contributing areas and in areas where BMPs have been implemented to measure the success of the *E. coli* load reductions.

It is very possible that the water quality data will indicate a different scenario than the simulated loads using SELECT. In this case a more thorough investigation is imperative. It will be necessary to apply a more specific hydrologic simulation model to investigate pollutant loads reaching the lake waterbodies and canals.

#### D.4 Watershed Modeling References

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