Water Quality Modeling
Lake Granbury

Espey Consultants, Inc.

December 3, 2008

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Presentation Outline

- Review Model Inputs and Resolutions
- Current E. coli status (through October 2008)
- Methods to evaluate potential sources
- Cove modeling (in-water lake modeling)
  - 10 cove and canal sites
- Watershed modeling (on-ground modeling)
  - Land Use modifications
  - SELECT modeling
    - Area-wide analysis
    - Microwatershed analysis
- Wrap-up → Watershed + Cove + BST

Modeling Resolutions

- Ratio of E. Coli to Fecal Coliform 0.7:1
- Raw sewage E. Coli count 6.68 million MPN/100mL
- Non-point source (NPS) concentration in urban runoff: Fecal coliform count 16,048 MPN/100mL
- Residential wastewater generation 200 gpd/house
- Site-specific dispersion values 0.02 to 0.18 m/s2
- Bacteria decay rate 0.2/day at 15`C
  - Medium summer temperature 28`C
  - Temperature correction, K = K1* Θ ^ (T – T1)
    - Θ = 1.07 (Thomann and Mueller 1987) (decay rate = 0.5 @ 28`C)

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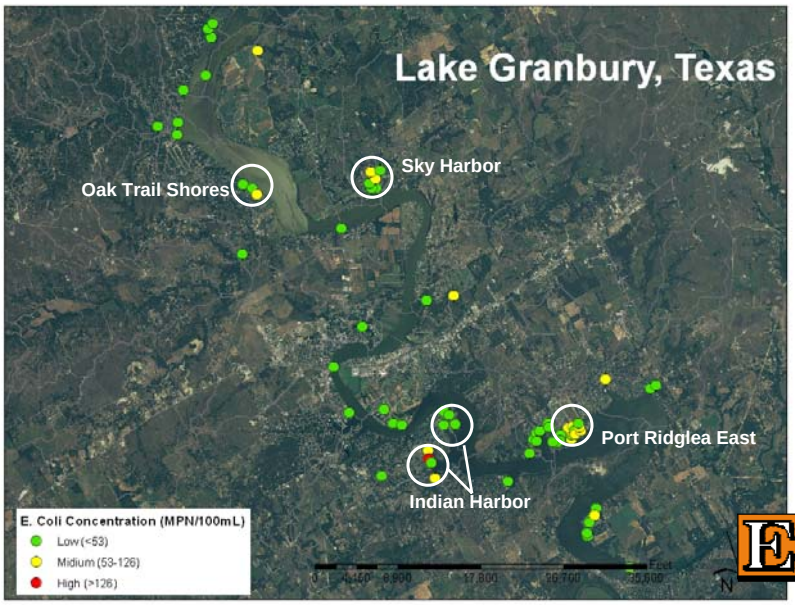
Status – Monitoring

E. Coli Monitoring through October 2008



Source evaluation:
Cove + Watershed + BST

Source Evaluation

- Monitoring Data
- Predictive Tools
  - Cove Modeling
  - Watershed Modeling
  - Models can be used to evaluate solutions
    - Load reductions through BMPs
- Confirmatory or Diagnostic Tool
  - Bacterial Source Tracking (BST)

Source Evaluation

- Sources evaluated in each approach

PREDICTIVE TOOLS		
Cove	**Watershed**	**BST**
Septic/Direct Discharge	Septic	Human
Non Point Source	Dog WWTP Cattle Deer Hogs	Wildlife Cattle Other livestock
Main Lake		

Note: Non Point Source = Urban runoff related to rainfalls

Source Evaluation

- Cove Modeling - In-water, cove and canal modeling
- Best opportunity to evaluate models with monitoring data
- Inputs
  - Localized Watershed drainage area
  - Canal geometry and site-specific dispersion
  - Rainfall
  - Point-source concentration (Septic)
- Assumptions and Literature Values
  - Non-point source loading (Urban runoff)
  - Point-source loading (Septic)
  - Decay rates
- Outputs
  - E. Coli concentration in a water body
- BST can be used as to evaluate these results

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Source Evaluation

- Watershed Modeling
- Potential Loads are hypothetical
- Inputs
  - Population density
  - Land Use
  - Watersheds
- Assumptions and Literature Values
  - Bacteria production
  - Spatial distribution
  - Sources
- Outputs
  - Potential bacteria count on the ground
  - Comparison of watersheds based on potential bacteria
- BST can be used as to evaluate these results

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Most likely potential sources

Subdivision	Most likely potential sources		
	Lake	Watershed	BST
Rolling Hills Shores			
Arrowhead Shores			
Oak Trail Shores			
Sky Harbor			18015
Nassau Bay II			
Waters Edge			18018
Ports O' Call			
Indian Harbor Cove			
Indian Harbor Canal			20215
Port Ridglea East			18038
Blue Water Shores			
Lk Granbury nr Grnbry			11861

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Cove Modeling

Oak Trail Shores

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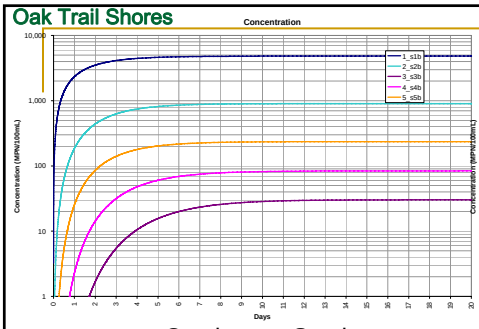
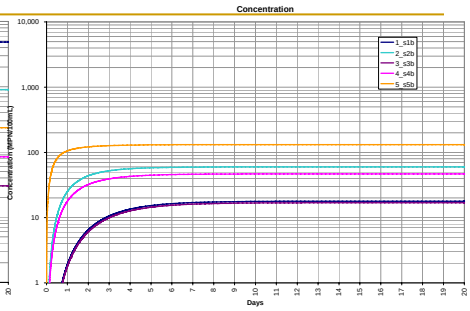
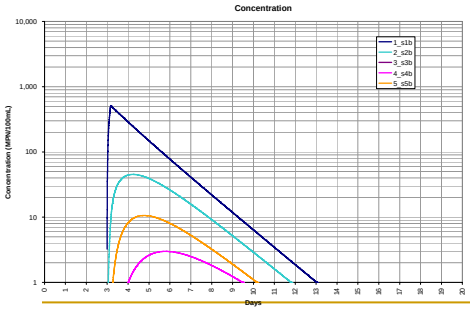
Oak Trail Shores



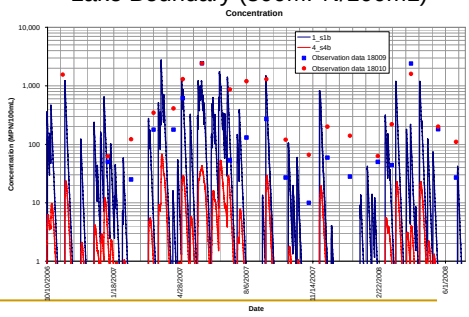
Continuous Septic



Lake Boundary (300MPN/100mL)



Septic (1/6 days' discharge)



Non Point Source (Urban)

Cove Model: Septic + NPS **Watershed Model : 81% Septic, 19% Dogs** **GeoMean: 92.9 MPN/100mL**

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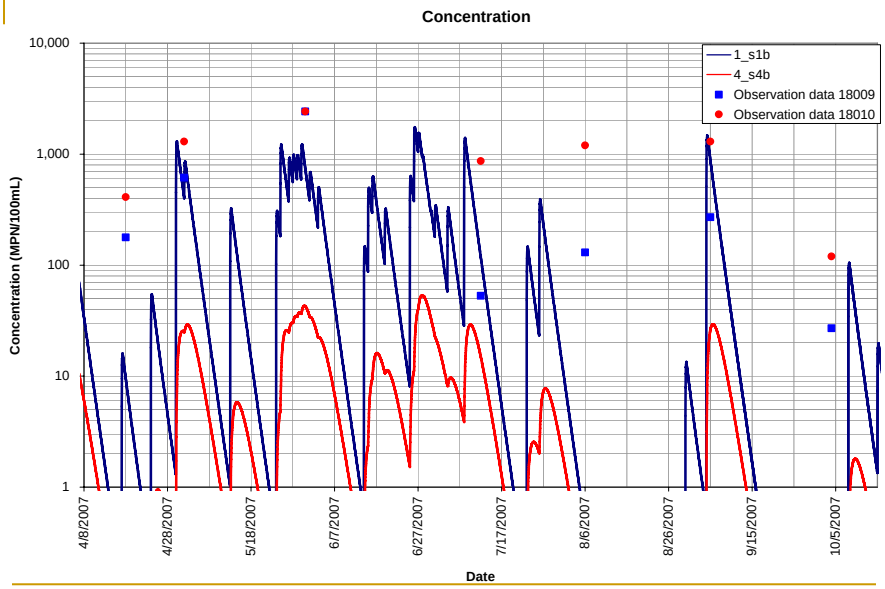

Non Point Source

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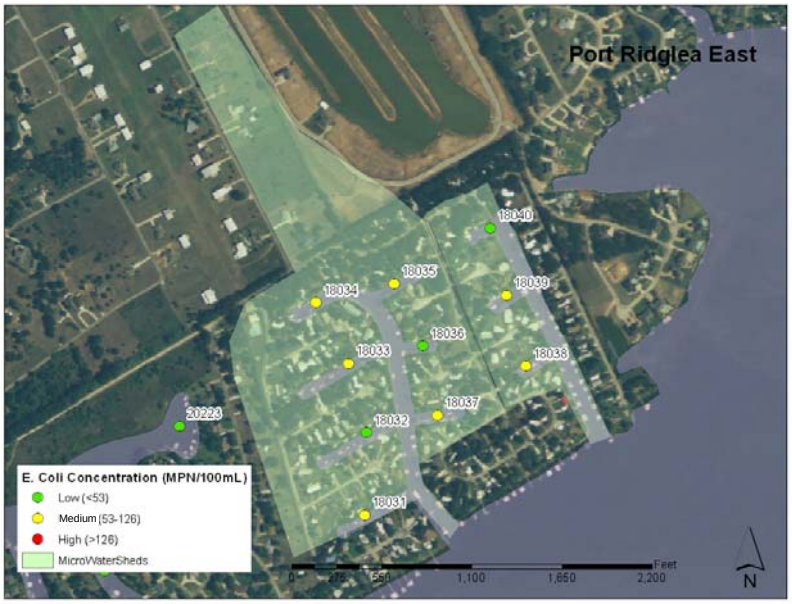
Port Ridglea East



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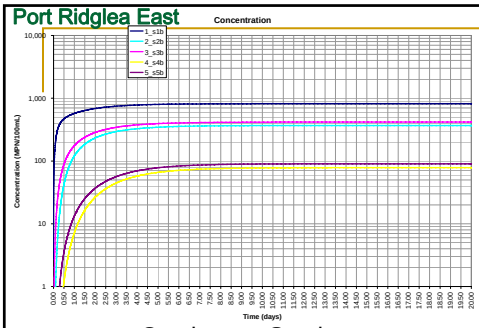
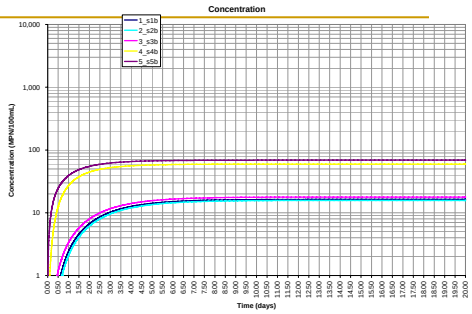
Port Ridglea East



Continuous Septic



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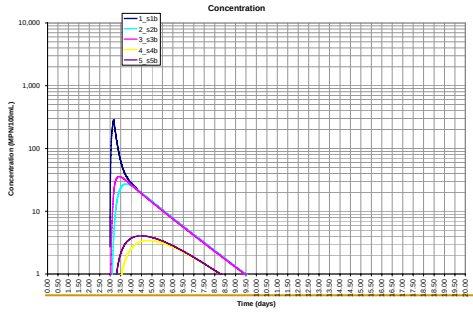

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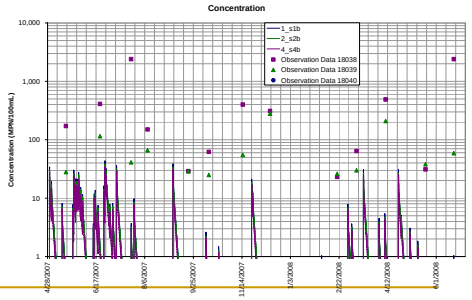

Non Point Source (Urban)

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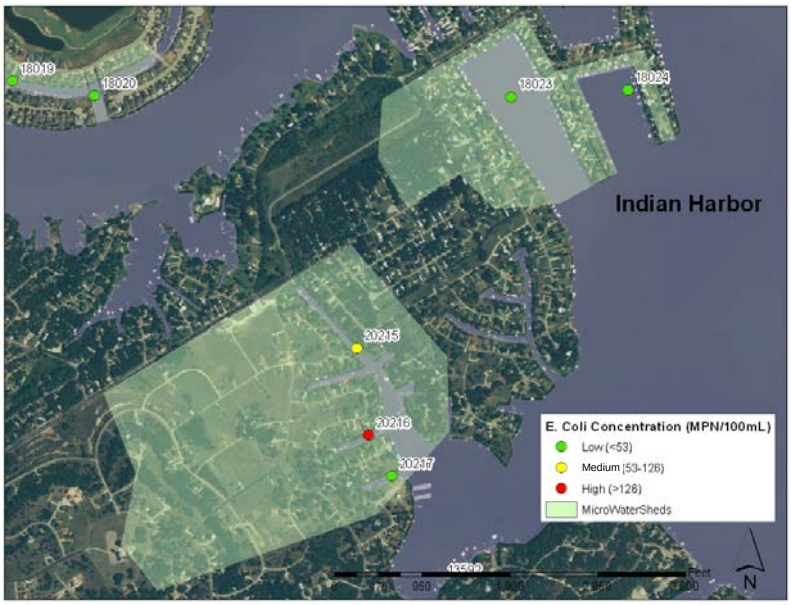
Cove Model: Septic Watershed Model : 99.7% Septic, <1% Dogs GeoMean: 110.5 MPN/100mL

Indian Harbor



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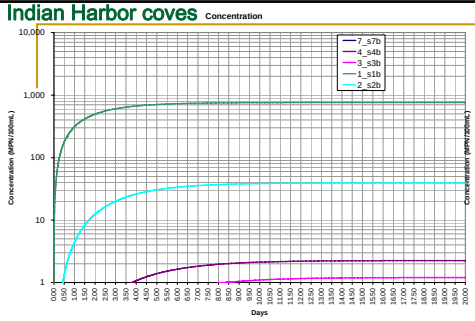
Indian Harbor coves



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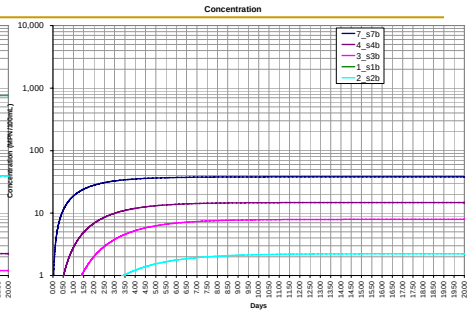

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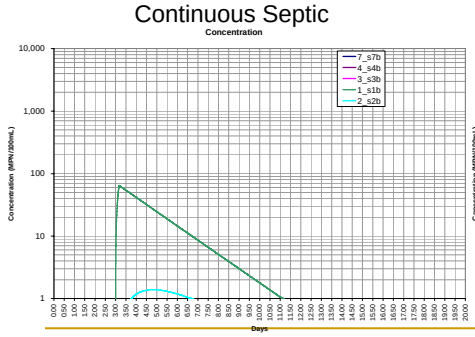
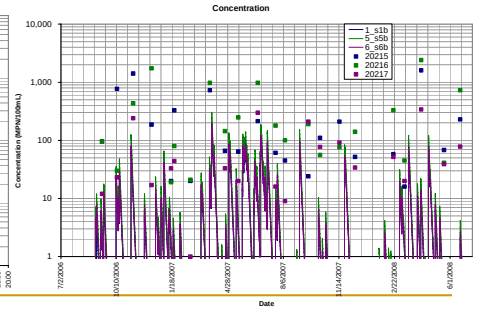


Septic (1/6 days' discharge)



Non Point Source (Urban)

Cove Model: Septic + NPS Watershed Model : 98.6% Septic, 1.4% Dogs GeoMean: 112.9 MPN/100mL

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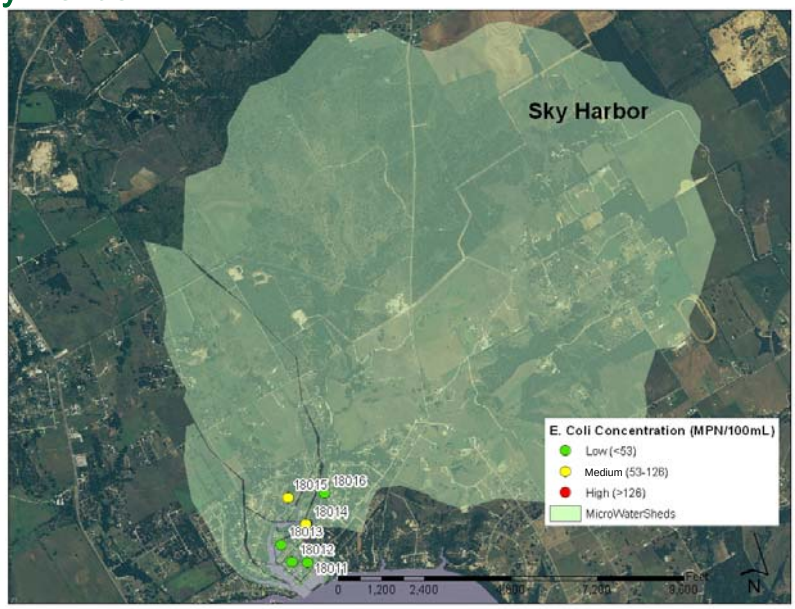
Sky Harbor



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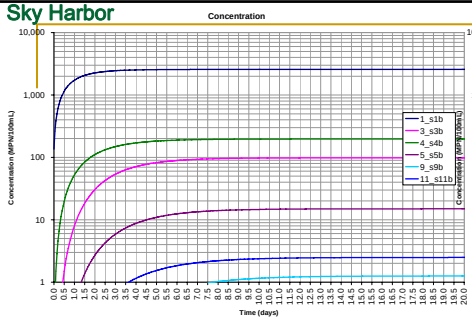
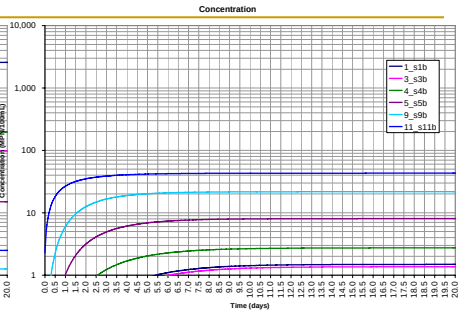
Sky Harbor



Continuous Septic



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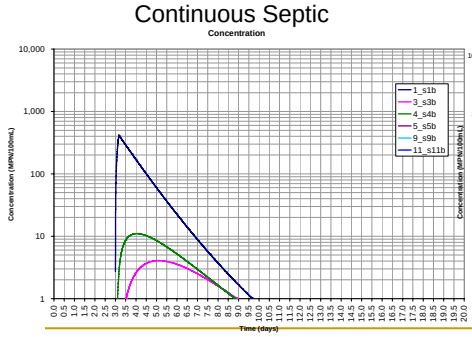

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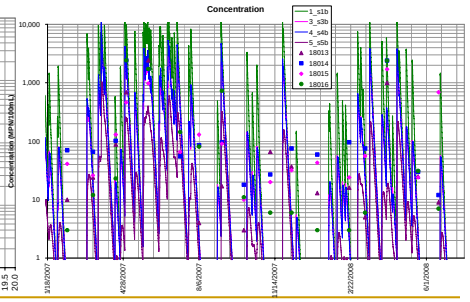

Non Point Source (Urban)

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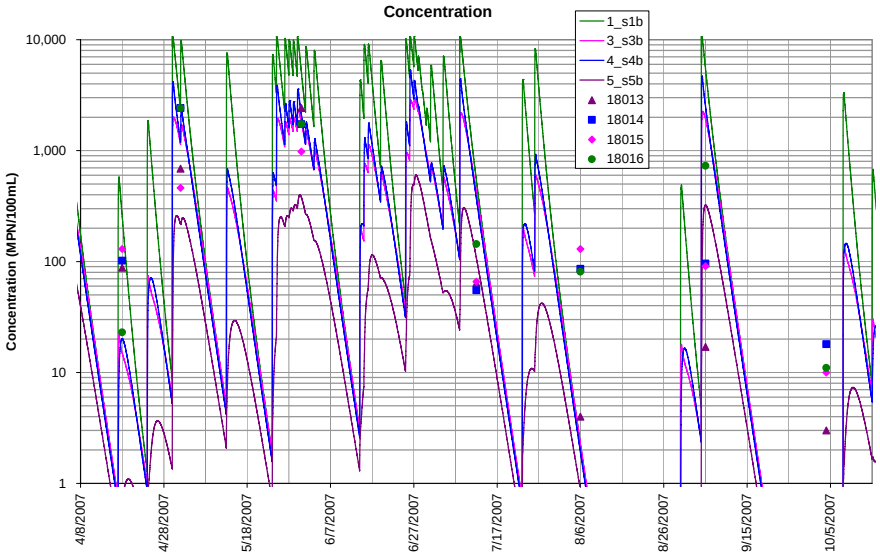
Cove Model: NPS Watershed Model : 86% Cattle, 11% Septic, 3% Dogs GeoMean: 107.4 MPN/100mL



Non Point Source

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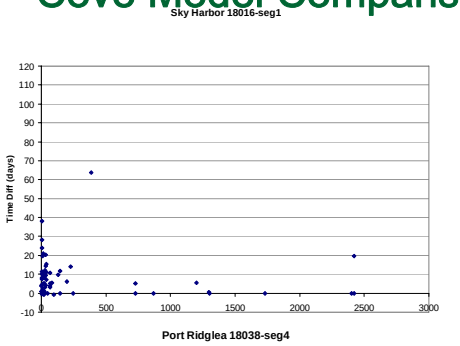
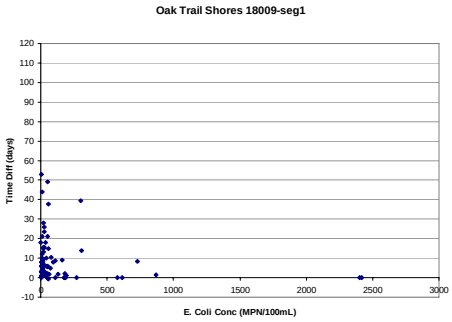
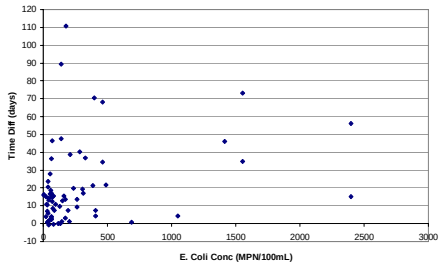
Cove Model Comparison with Monitoring Data







E. Coli in Sky Harbor and Oak Trail Shores are more likely from Non-point sources, compared to Port Ridglea East

Most likely potential sources – Cove Modeling

Subdivision	Most likely sources
Rolling Hills Shores	Septic + NPS
Arrowhead Shores	Septic + NPS
Oak Trail Shores	Septic + NPS
Sky Harbor 18015	NPS
Nassau Bay II	Septic + NPS
Waters Edge 18018	No problem exhibited; NPS
Ports O' Call	Septic
Indian Harbor Cove	Septic
Indian Harbor Canal 20215	Septic + NPS
Port Ridglea East 18038	Septic
Blue Water Shores	Septic

Note: Non Point Source = 16,048 MPN/100mL Urban runoff related to rainfalls

Watershed Modeling

Potential Bacteria Loading Methodology

- SELECT – Spatially Explicit Load Enrichment Calculation Tool
  - TAMU BAE department and Spatial Sciences Laboratory
  - Kendra Riebschleager and Dr. Raghupathy Karthikeyan
- Determine Potential Waste Load
  - Spatially distribute source populations based on land use
  - Apply fecal production rate
  - Aggregate to level of interest
- Develop a Qualitative Assessment of Pollutant Connectivity
  - Pollution Indicator
  - Run-off Indicator
  - Distance Indicator
  - PCF - Pollutant Connectivity Factor

Potential Bacteria Loading Methodology

- How is this different than last meeting?
  - Area-weighted potential loads
  - More uniform watershed sizes
  - Updated land use
  - Updated assumptions
  - Added feral hog*
  - PCF for each potential source

*BST positive detection of hogs

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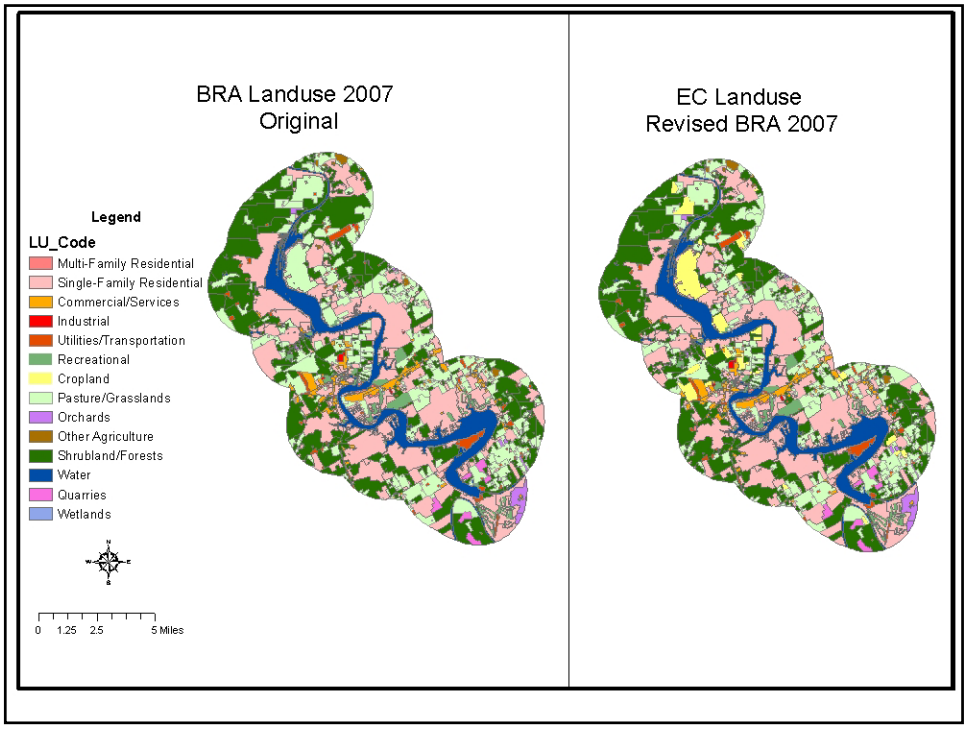
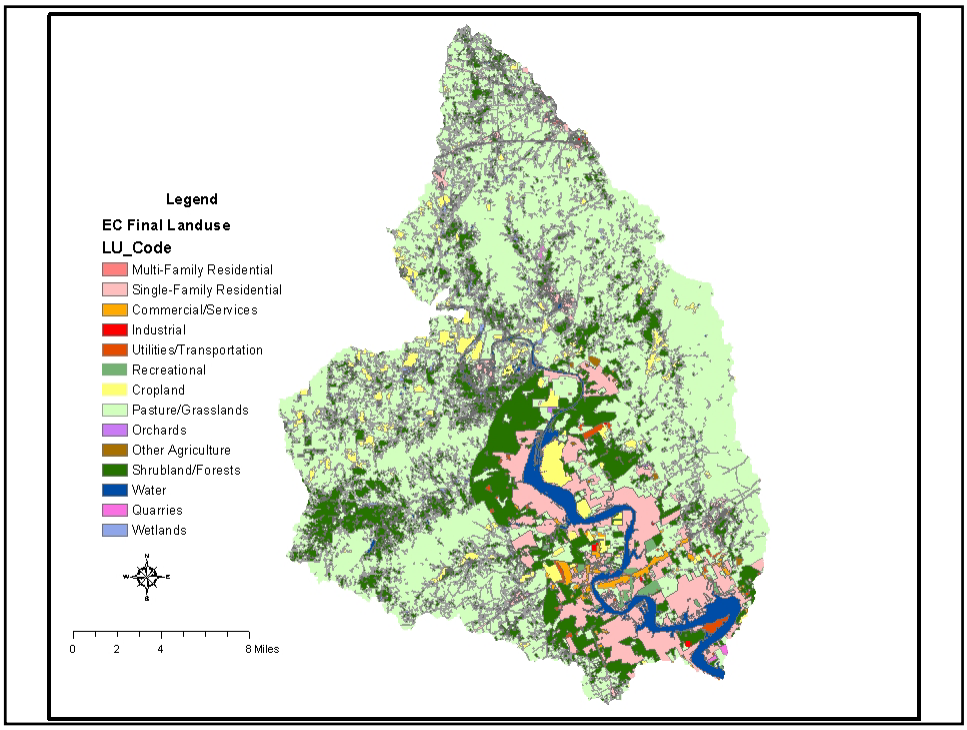
Land Use Updates

Land Use	BRA 0–2 Mile	BRA/EC 0–2 Mile	Final BRA/EC/NLCD
Multi-Family Residential	<1%	<1%	<1%
Single-Family Residential	33%	33%	11%
Commercial/Services	3%	3%	1%
Industrial	<1%	<1%	<1%
Utilities/Transportation	2%	2%	<1%
Recreational	2%	2%	<1%
Cropland/Pasture	23%		
Cropland		4%	3%
Pasture/Grasslands		21%	59%
Orchards	<1%	<1%	<1%
Other Agriculture	<1%	<1%	<1%
Rangeland (Shrubland/Forest)	33%	32%	24%
Quarries	<1%	<1%	<1%
Wetlands		0%	1%


BRA Landuse 2007
Original
EC Landuse
Revised BRA 2007
Legend
LU_Code
Multi-Family Residential
Single-Family Residential
Commercial/Services
Industrial
Utilities/Transportation
Recreational
Cropland
Pasture/Grasslands
Orchards
Other Agriculture
Shrubland/Forests
Water
Quarries
Wetlands
0 1.25 2.5 5 Miles


Legend
EC Final Landuse
LU_Code
Multi-Family Residential
Single-Family Residential
Commercial/Services
Industrial
Utilities/Transportation
Recreational
Cropland
Pasture/Grasslands
Orchards
Other Agriculture
Shrubland/Forests
Water
Quarries
Wetlands
0 2 4 8 Miles

Potential Sources

- Livestock
  - **Cattle**
  - *Other (Sheep, Goats, Swine, Horses)**
- Wildlife
  - **Deer**
  - **Feral Hogs *(new, added because of BST)***
  - *Other (Raccoons, Birds, Rodents)***
- Domestic
  - **Septic Systems**
  - **Septic Systems #2 *(new)***
  - **Pets**
- WWTPs

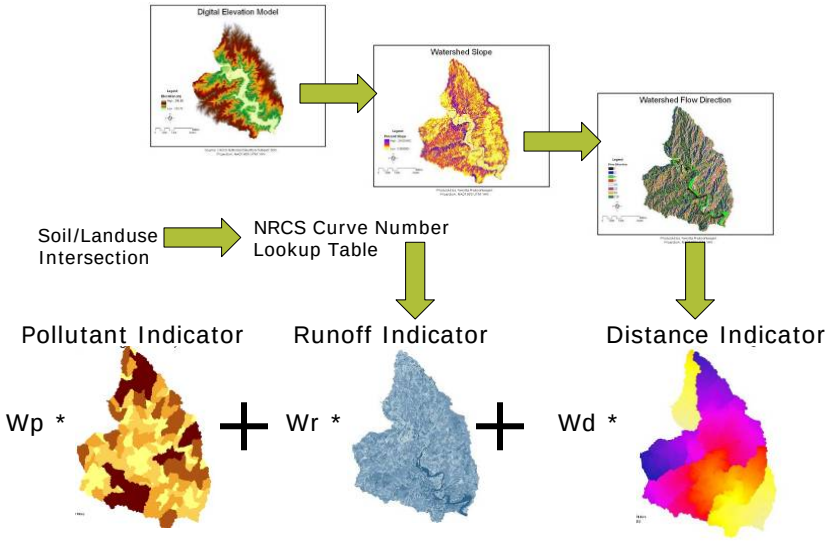
*Do not contribute significantly in this watershed

**Not enough information to model

Pollutant Connectivity Factor

- Contribution of Contaminant based on
  - Total pollutant loading
  - Fate and Transport driven by
    - runoff
    - travel distance
  - Growth and decay
- Estimate influence of driving forces using weighted overlay

Pollutant Connectivity Factor



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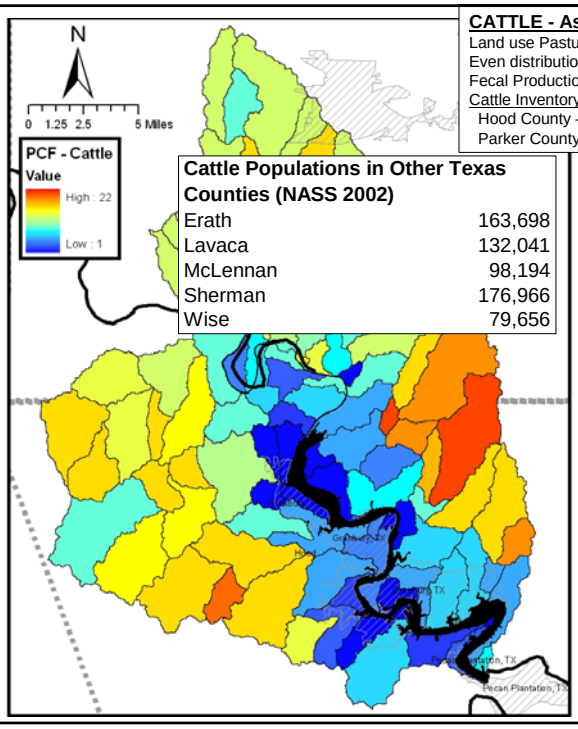


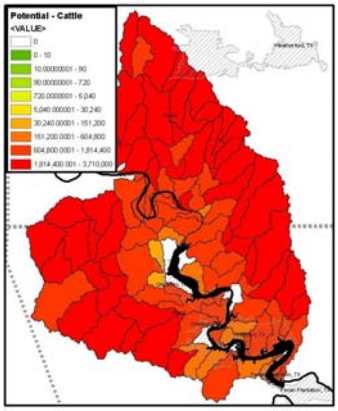
CATTLE - Assumptions

Land use Pasture/Hay and Grasslands/Herbaceous
Even distribution across county for appropriate landuse(s)
Fecal Production Rate – 5.4 x 10^9 cfu/day (EPA 2001)
Cattle Inventory (NASS 2002)
Hood County – 30,059
Parker County – 71,601

Cattle Populations in Other Texas Counties (NASS 2002)

Erath	163,698
Lavaca	132,041
McLennan	98,194
Sherman	176,966
Wise	79,656

Potential Load color scale based on maximum loading across all types



Potential = Potential Load in organisms per day per square meter

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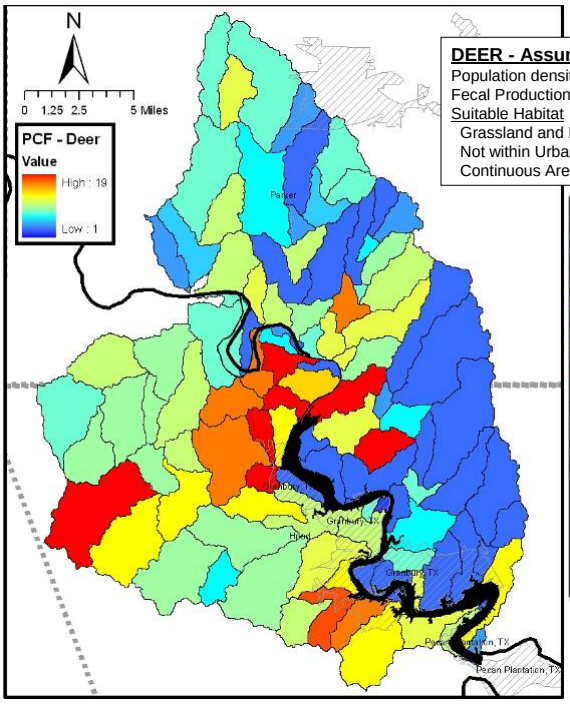
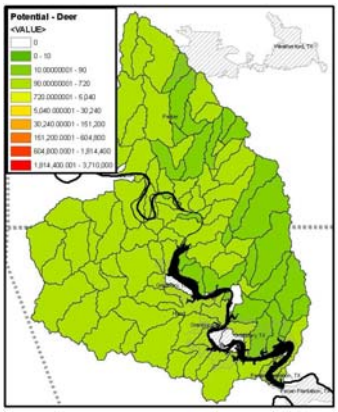


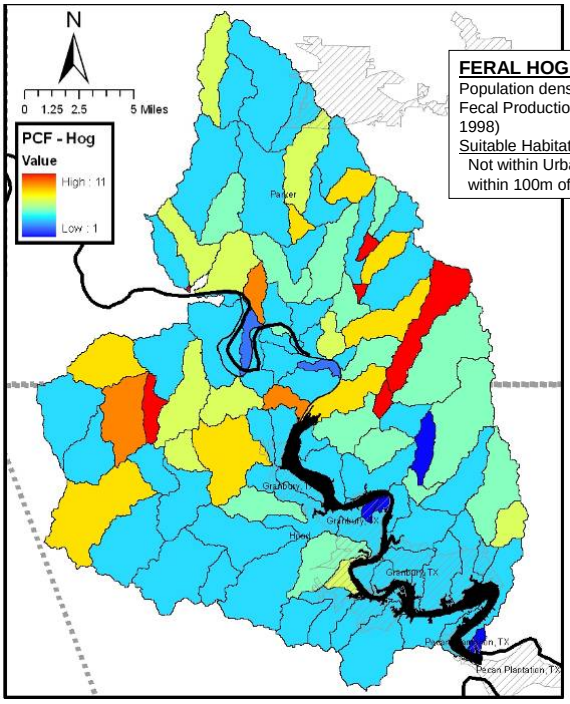
DEER - Assumptions

Population density – 13.25 Deer / 1000 ac (Lockwood, 2005)
Fecal Production Rate 3.5 x 10^8 cfu/day (Zeckoski et al 2005)
Suitable Habitat
- Grassland and Forest
- Not within Urban Areas
- Continuous Areas > 20 ac



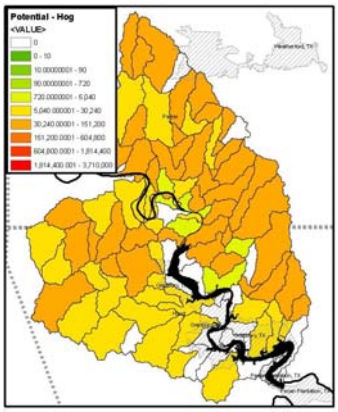
Potential = Potential Load in organisms per day per square meter

35



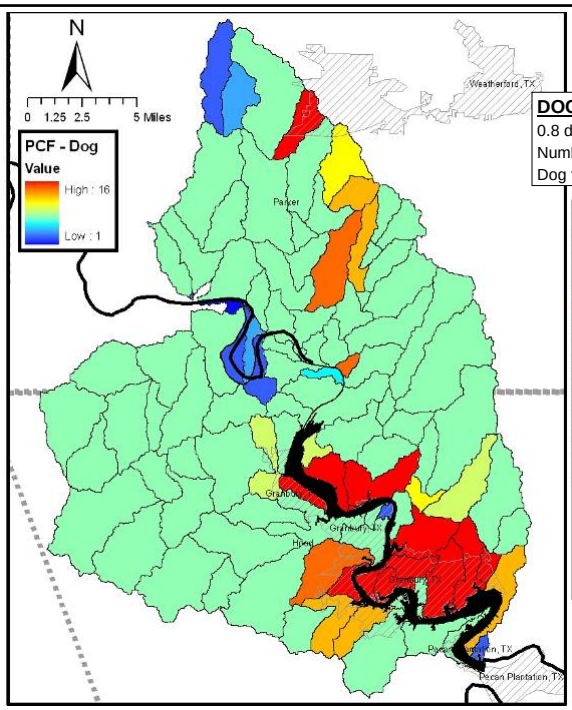
FERAL HOG - Assumptions

Population density – 4 Hog / sq. km (Teague, 2007)
Fecal Production Rate 1.1 x 10^{10} cfu/day (EPA 2001; ASAE 1998)
Suitable Habitat
- Not within Urban Areas
- within 100m of streams



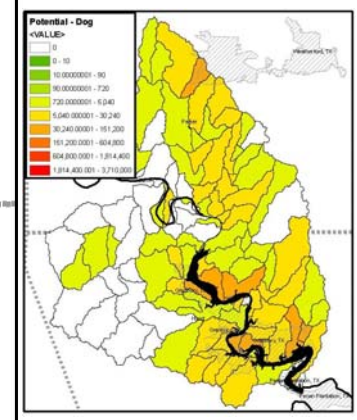
Potential = Potential Load in organisms per day per square meter

36



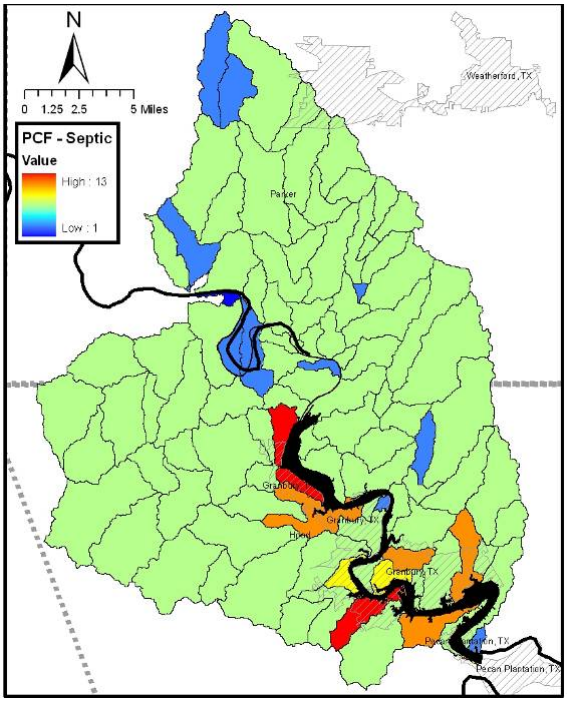
DOGS - Assumptions

0.8 dogs per house (AVMA 2002)
Number of houses per block (US Census 2000)
Dog fecal production rate (EPA 2001)



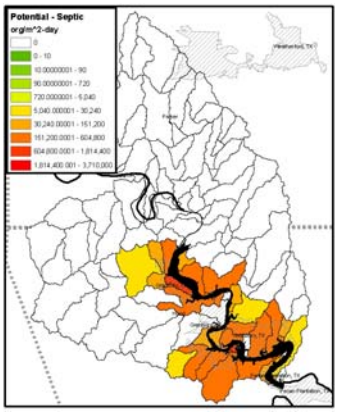
Potential = Potential Load in organisms per day per square meter

37



SEPTIC I - Assumptions

200 gallons per day per system
6.68 million e. coli MPN/100mL
Fecal concentration in sewage (EPA 2001)
Number of septic systems per area
Proportion of systems failing (Septic Index)
Risk Level 1 – 5%
Risk Level 2 – 10%
Risk Level 3 – 15%



Potential = Potential Load in organisms per day per square meter

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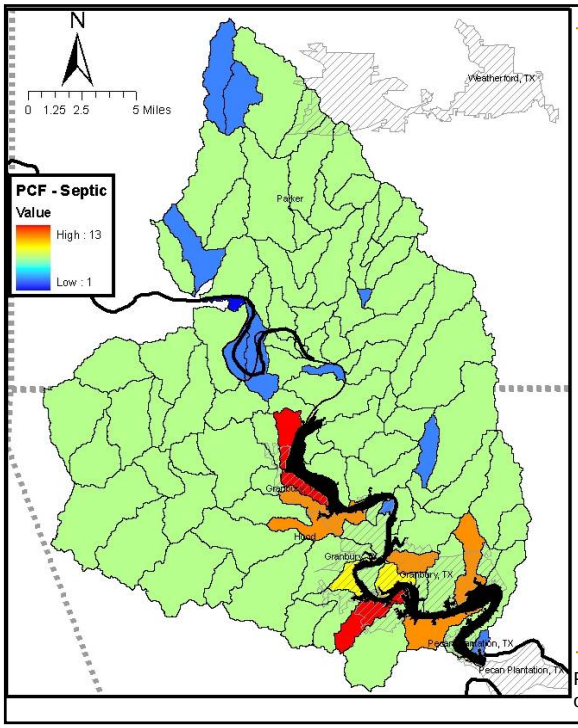
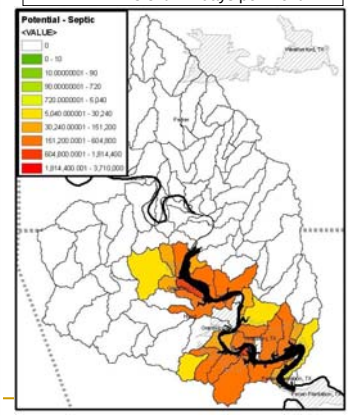


SEPTIC II - Assumptions

200 gallons per day per system
6.68 million e. coli MPN/100mL
Fecal concentration in sewage (EPA 2001)
Number of septic systems per area
Proportion of systems failing (Septic Index)
Risk Level 1 – 5%
Risk Level 2 – 10%
Risk Level 3 – 15%
Likelihood of systems failing on a given day
13.3% = 4 days per month



Potential = Potential Load in organisms per day per square meter

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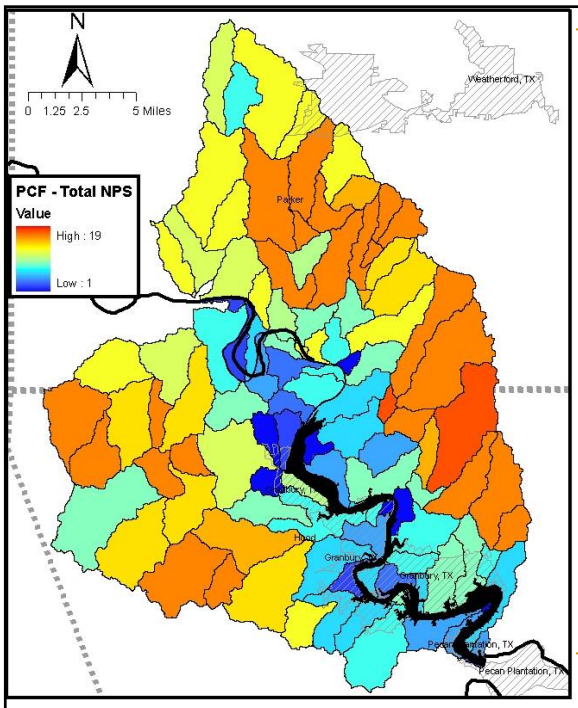

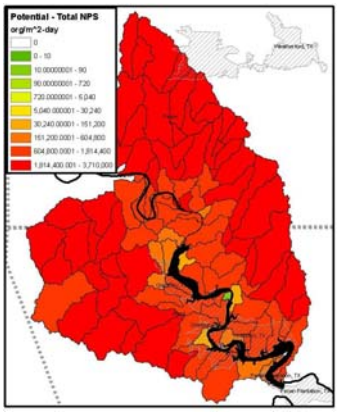

Potential = Potential Load in organisms per day per square meter

40

Microwatershed Potential Loads

- Potential loads for small watersheds near the lake are under investigation
- Distant watersheds may have small effects on Lake Granbury

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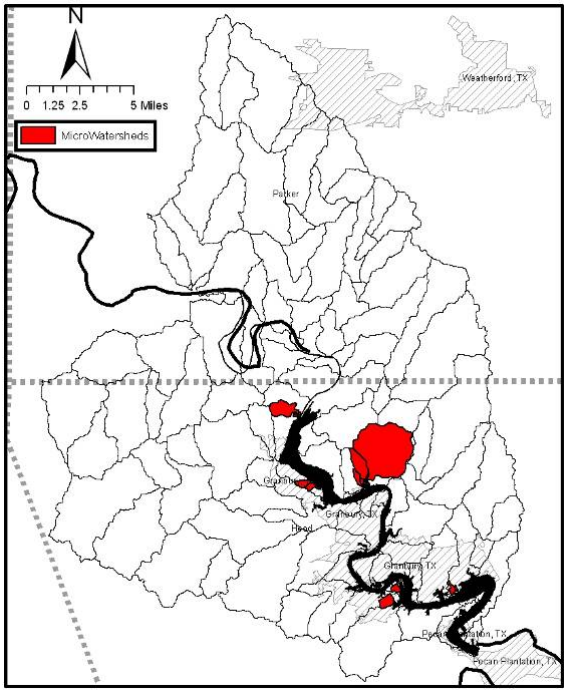
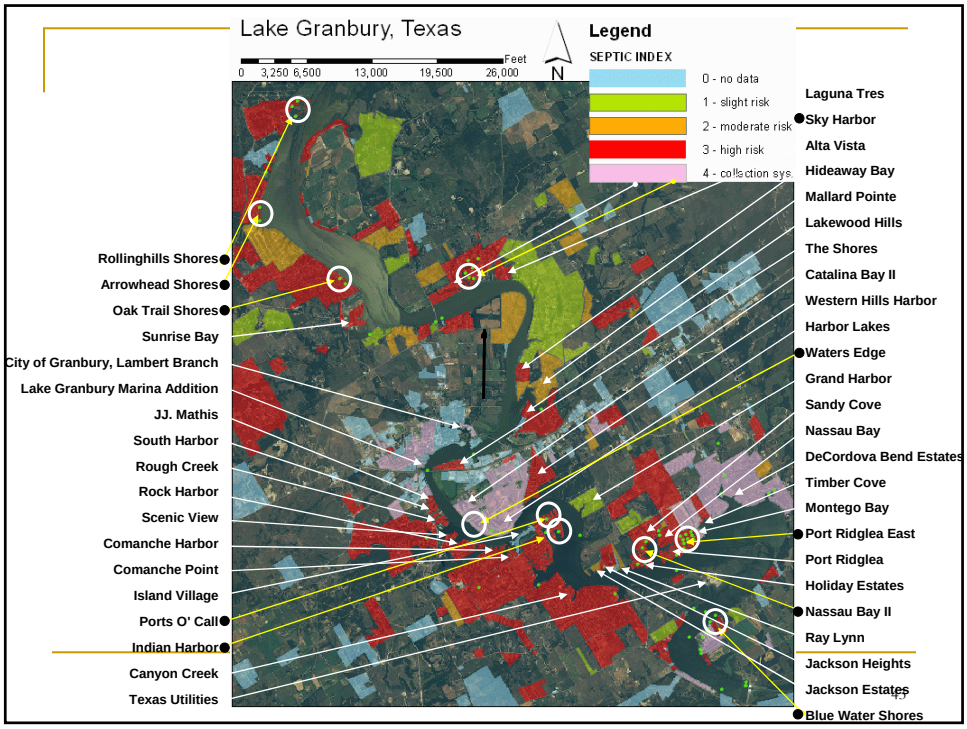
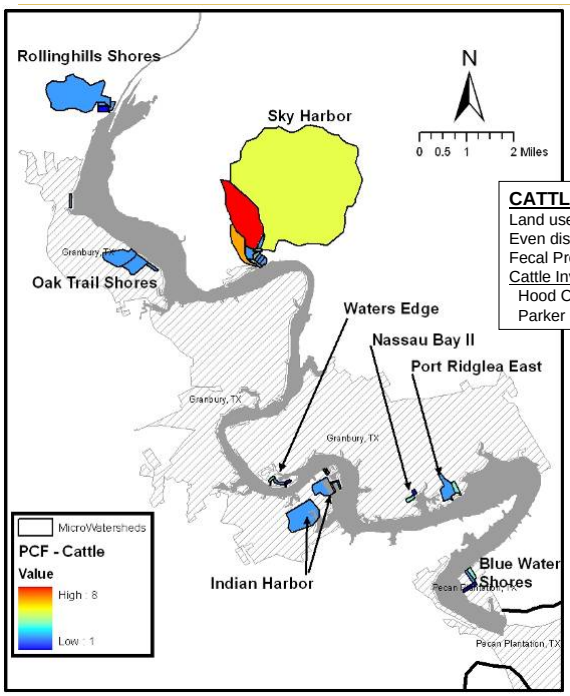


42





CATTLE - Assumptions

Land use Pasture/Hay and Grasslands/Herbaceous
Even distribution across county for appropriate landuse(s)
Fecal Production Rate – 5.4 x 10^9 cfu/day (EPA 2001)
Cattle Inventory (NASS 2002)
Hood County – 30,059
Parker County – 71,601

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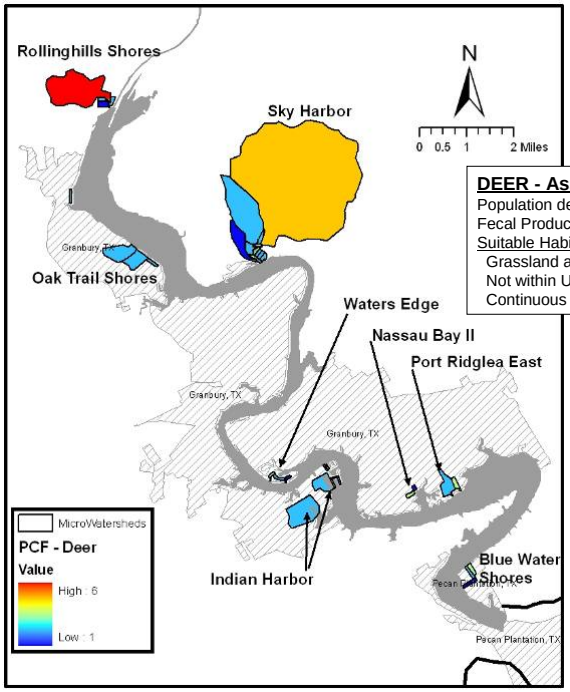

DEER - Assumptions

Population density – 13.25 Deer / 1000 ac (Lockwood, 2005)

Fecal Production Rate 3.5 x 10^8 cfu/day (Zeckoski et al 2005)

Suitable Habitat

- Grassland and Forest
- Not within Urban Areas
- Continuous Areas > 20 ac

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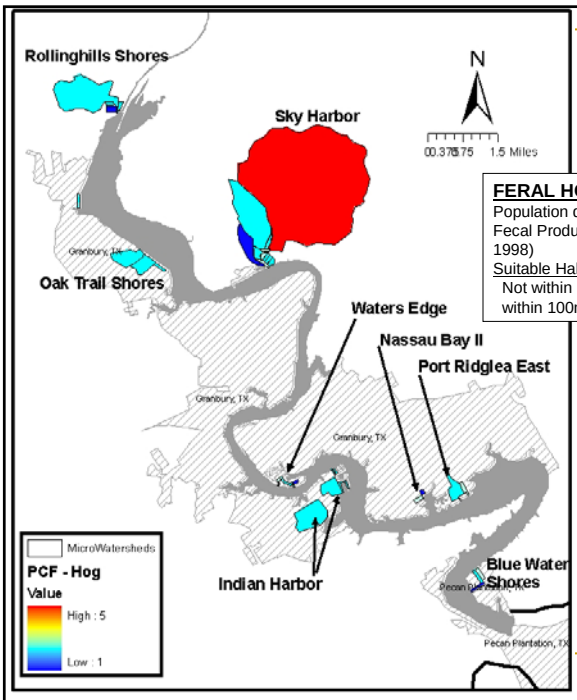

FERAL HOG - Assumptions

Population density – 4 Hog / sq. km (Lockwood, 2005)

Fecal Production Rate 1.1 x 10^{10} cfu/day (EPA 2001; ASAE 1998)

Suitable Habitat

- Not within Urban Areas
- within 100m of streams

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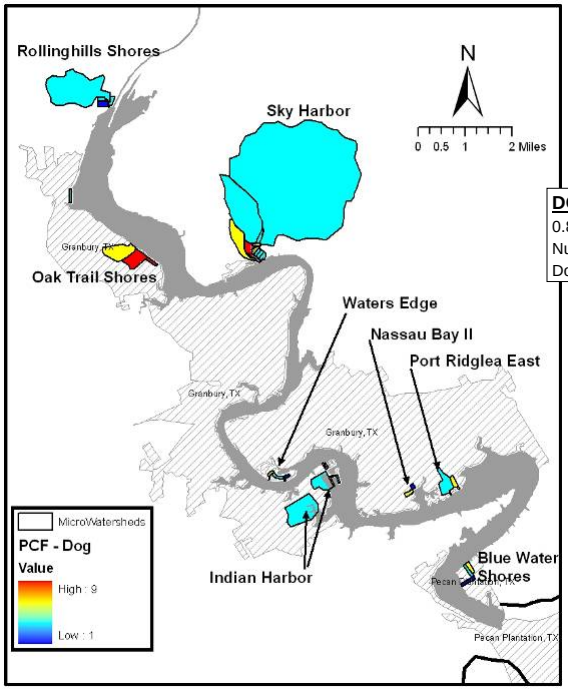

DOG - Assumptions

0.8 dogs per house (AVMA 2002)
Number of houses per block (US Census 2000)
Dog fecal production rate (EPA 2001)

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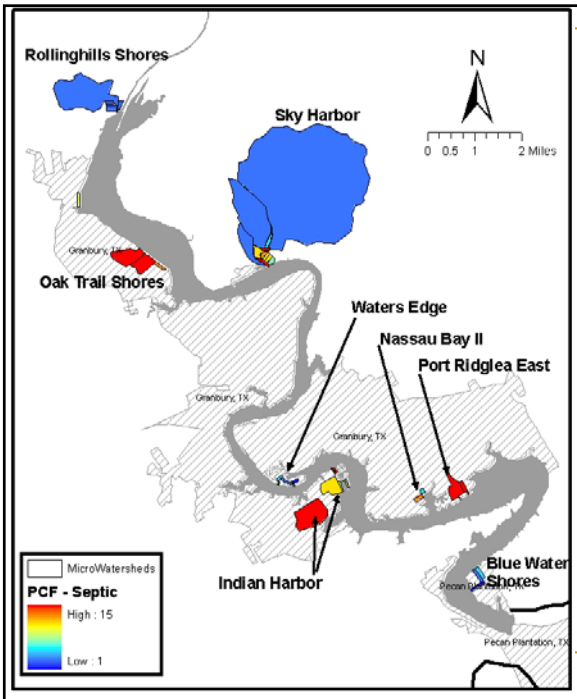

SEPTIC 2 - Assumptions

200 gallons per day per system
6.68 million e. coli MPN/100mL
Fecal concentration in sewage (EPA 2001)
Number of septic systems per area
Proportion of systems failing (Septic Index)
Risk Level 1 – 5%
Risk Level 2 – 10%
Risk Level 3 – 15%
Likelihood of systems failing on a given day
13.3 % = 4 days per month

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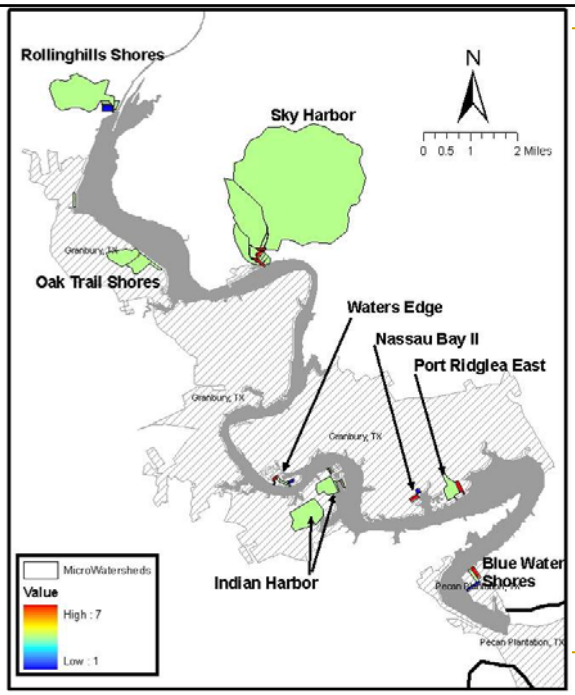

Total Non-Point Source PCF

Non-point source = Cattle, Feral hogs, Deer, Dogs, and Septic

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Most likely potential sources – Watershed modeling

Subdivision	Most likely sources
Rolling Hills Shores	84.1% Cattle, 14.1% Septic, 1.3% Dog, 0.4% Deer
Arrowhead Shores	99% Septic, <1% Pets, <1% Deer
Oak Trail Shores	81.1% Septic, 18.87% Dog
Sky Harbor 18015	86.1% Cattle, 11.1% Septic, 2.8% Pets, <1% Feral Hogs
Nassau Bay II	80.6% Cattle, 16.9% Septic, 2% Pets, <1% Feral Hog
Waters Edge 18018	Very low potential; Dog
Ports O' Call	99.6 % Septic, <1% Dog
Indian Harbor 20215	98.6% Septic, 1.4% Dog
Port Ridglea East 18038	99.7% Septic, <1% Dog
Blue Water Shores	Dogs

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Wrap-up: Source evaluation summary

Most Likely Potential Sources

Subdivision	Most likely potential sources		
	Lake	Watershed	BST**
Rolling Hills Shores	Septic + NPS	Cattle, Septic, Dogs, Deer	
Arrowhead Shores	Septic + NPS	Septic, Dogs, Deer	
Oak Trail Shores	Septic + NPS	Septic, Dogs	
18015 Sky Harbor	NPS	Cattle, Septic, Dogs	*Wildlife (deer, feral hogs), Sewage*
Nassau Bay II	Septic + NPS	Cattle, Septic, Dogs, Feral hogs	
18018 Waters Edge	No problem exhibited; NPS	Very low potential; Dogs	*NPS, Wildlife (feral hogs)*
Ports O' Call	Septic	Septic, Dogs	
Indian Harbor Cove	Septic	Septic, Dogs	
20215 Indian Harbor Canal	Septic + NPS	Septic, Dogs	*Wildlife (deer, feral hogs), Livestock (Cattle, Other)*
18038 Port Ridglea East	Septic	Septic, Dogs	*Wildlife (deer, feral hogs), Livestock, conflicting results for sewage*
Blue Water Shores	Septic	Dogs	
11861 Lk Granbury nr Grnbry			*Wildlife (deer, feral hogs), Sewage, Livestock*

**BST potential source evaluation based upon preliminary results.

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Questions or Comments?

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