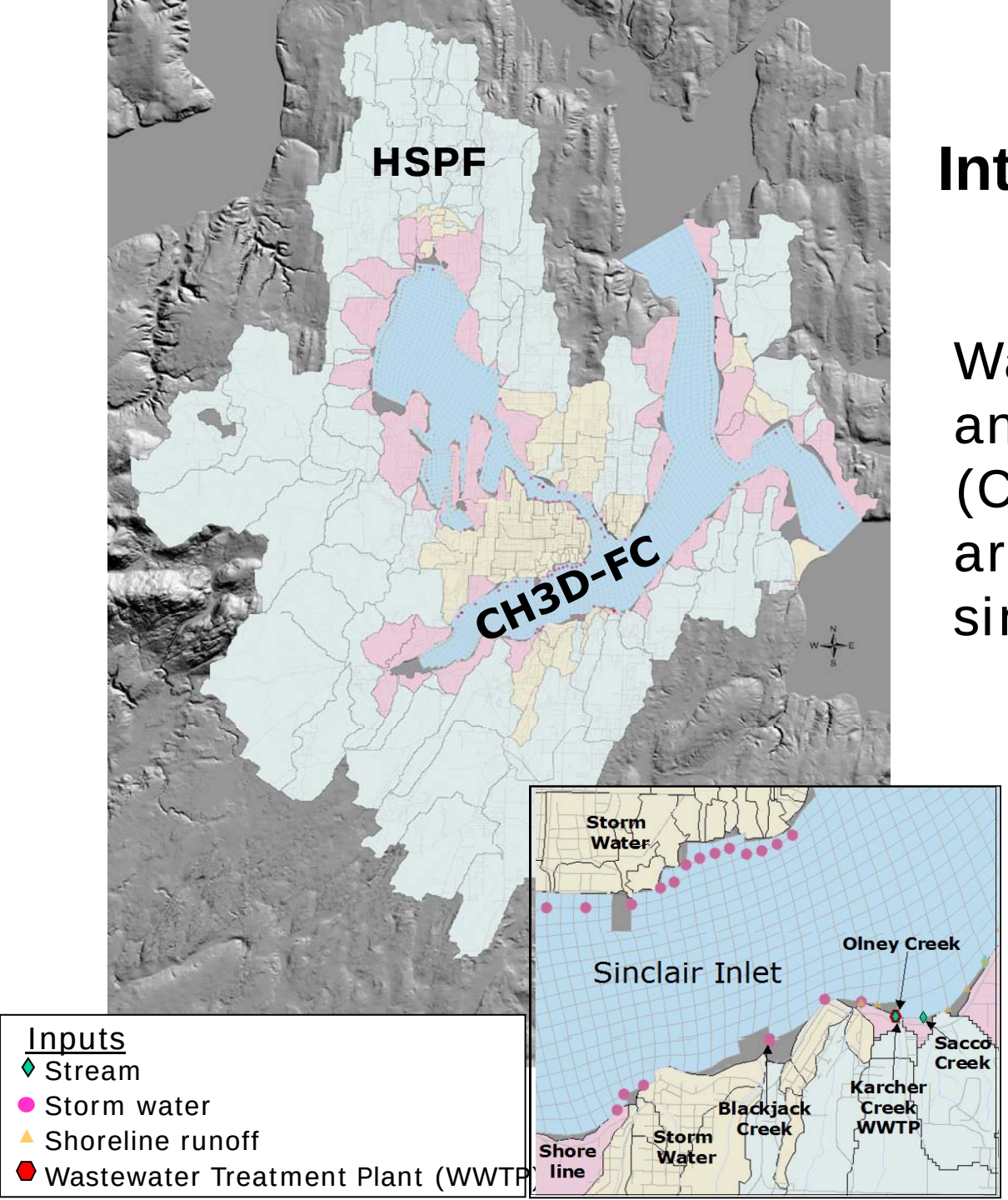
ENVVEST Monitoring and Modeling Results:
Development of an Integrated Watershed and Receiving Water Model to Support the Sinclair and Dyes Inlet Fecal Coliform TMDL Study

- Introduction
- Monitoring
- Watershed Model (HSPF)
- FC Loading Analysis
  - Streams, Stormwater, WWTPs
- Estuarine Model (CH3D-FC)
- Integrated Model Predictions
  - Comparison to Observed Data
  - Sensitivity and Uncertainty
- TMDL Simulations
  - Actual Conditions
  - 100/200 Simulation (Part I)
  - 200/400 Simulation (Part II)
  - WY2003 Observed Data
- Distribution DVD and Web Site
- Questions?

Integrated Modeling



Watershed (HSPF) and receiving water (CH3D-FC) models are combined to simulate all inputs.

```
Final Configuration:
 39 Streams
 58 Stormwater Outfalls
 44 Shoreline Drainages
  4 Treatment Plants
---
147 Separate Inputs
```

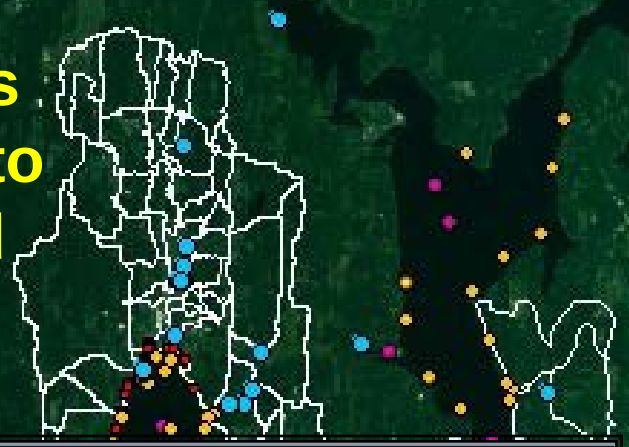
Supplemental Information Available on Distribution DVD and via the internet

- Supplemental information available on the distribution DVD or via the internet at
  http://environ.spawar.navy.mil/Projects/ENVVEST/FC_Model_Report/

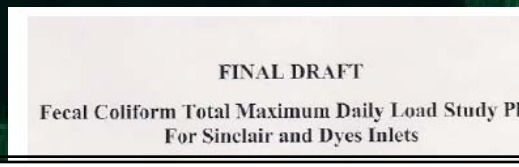
- Supplemental information accessible with the ENVVEST Spatial Viewer at
  http://kairos.spawar.navy.mil/Website/spatialviewer

Predicting FC Loads from Watershed

The watershed scale is the appropriate scale to address problems and engage stakeholders

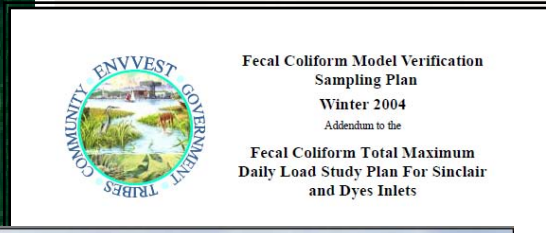


- Stream
- Stormwater
- Nearshore
- Marine



FINAL DRAFT

Fecal Coliform Total Maximum Daily Load Study Pl
For Sinclair and Dyes Inlets



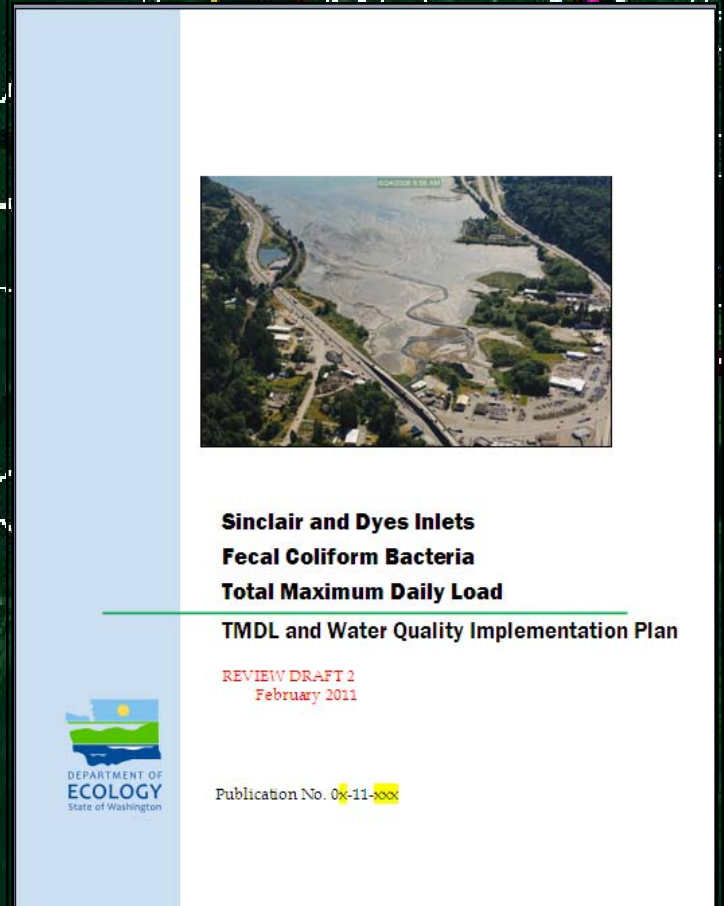
Fecal Coliform Model Verification Sampling Plan

Winter 2004

Addendum to the

Fecal Coliform Total Maximum Daily Load Study Plan For Sinclair and Dyes Inlets

An Analysis of Microbial Pollution in the Sinclair-Dyes Inlet Watershed



Sinclair and Dyes Inlets

Fecal Coliform Bacteria

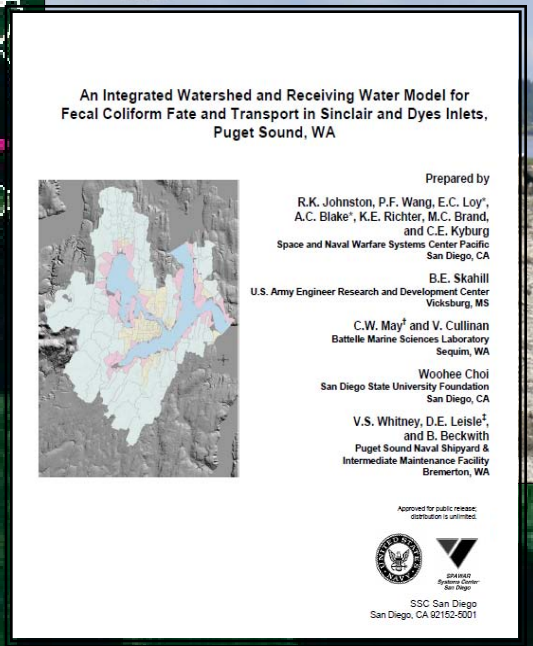
Total Maximum Daily Load

TMDL and Water Quality Implementation Plan

REVIEW DRAFT 2
February 2011

DEPARTMENT OF ECOLOGY
State of Washington

Publication No. 0X-11-XXX



An Integrated Watershed and Receiving Water Model for Fecal Coliform Fate and Transport in Sinclair and Dyes Inlets, Puget Sound, WA

Prepared by

R.K. Johnston, P.F. Wang, E.C. Loy*, A.C. Blake*, K.E. Richter, M.C. Brand, and C.E. Kyburg
Space and Naval Warfare Systems Center Pacific
San Diego, CA

B.E. Skahill
U.S. Army Engineer Research and Development Center
Vicksburg, MS

C.W. May† and V. Cullinan
Battelle Marine Sciences Laboratory
Sequim, WA

Woohee Choi
San Diego State University Foundation
San Diego, CA

V.S. Whitney, D.E. Leisle‡, and B. Beckwith
Puget Sound Naval Shipyard & Intermediate Maintenance Facility
Bremerton, WA

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Stream Monitoring

Storm Water Flow Monitoring

Storm Water Flow Monitoring Cont.

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Puget Sound Naval Shipyard Project ENVVEST Fecal Coliform TMDL Study

Sampling and Logistics Plan

Updated 10 JAN 2003

SAMPLING is **A GO** for JAN 13-17, 2003; - Check the Schedule

Look at some preliminary data from fecal coliform sampling https://swdata.spawar.navy.mil/envvest/DATA/

Review Chain of Custody Information https://swdata.spawar.navy.mil/envvest/DATA/FC_TMDL_Study/Chain_of_Custo

Check Current Weather Forecast

National Weather Service - Seattle

UW Department of Atmospheric Sciences

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Sampling Team Standings (Samples collected between Nov 2002 a Mar 2003)

	events[1]	stations	samples	field dups
Kitsap SSWM	18	11	197	35
South Streams	17	9	153	17
POKC	17	7	103	14
North Streams	14	14	194	37
PSNS	14	13	121	11
Bremerton	13	8	86	12
TEC Storm Event	12	11	128	14
PSNS NS/Marine	4	26	104	11
Bainbrigde Island	4	6	23	3
BKCHD NS/Marine	1	25	25	3
		Subtotal	1134	157
			Total Samples	1291

[1] Days samples collected

Feedback on analytical support provided by MEL

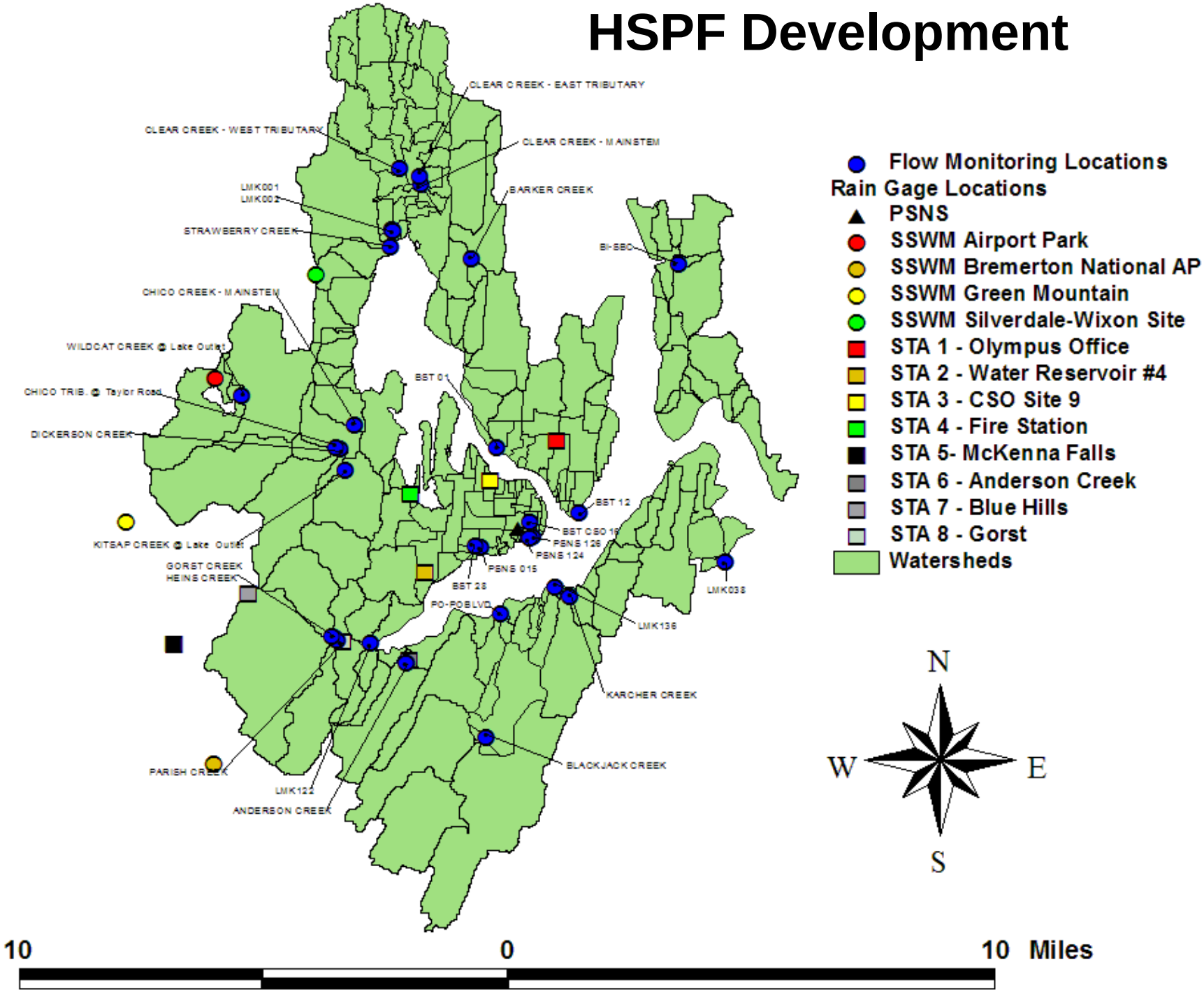
Link to In-Stream Storm Sampling Page

Watershed Model (HSPF) Development

- Data Collection
- Calibration
- Verification
- Evaluation Results

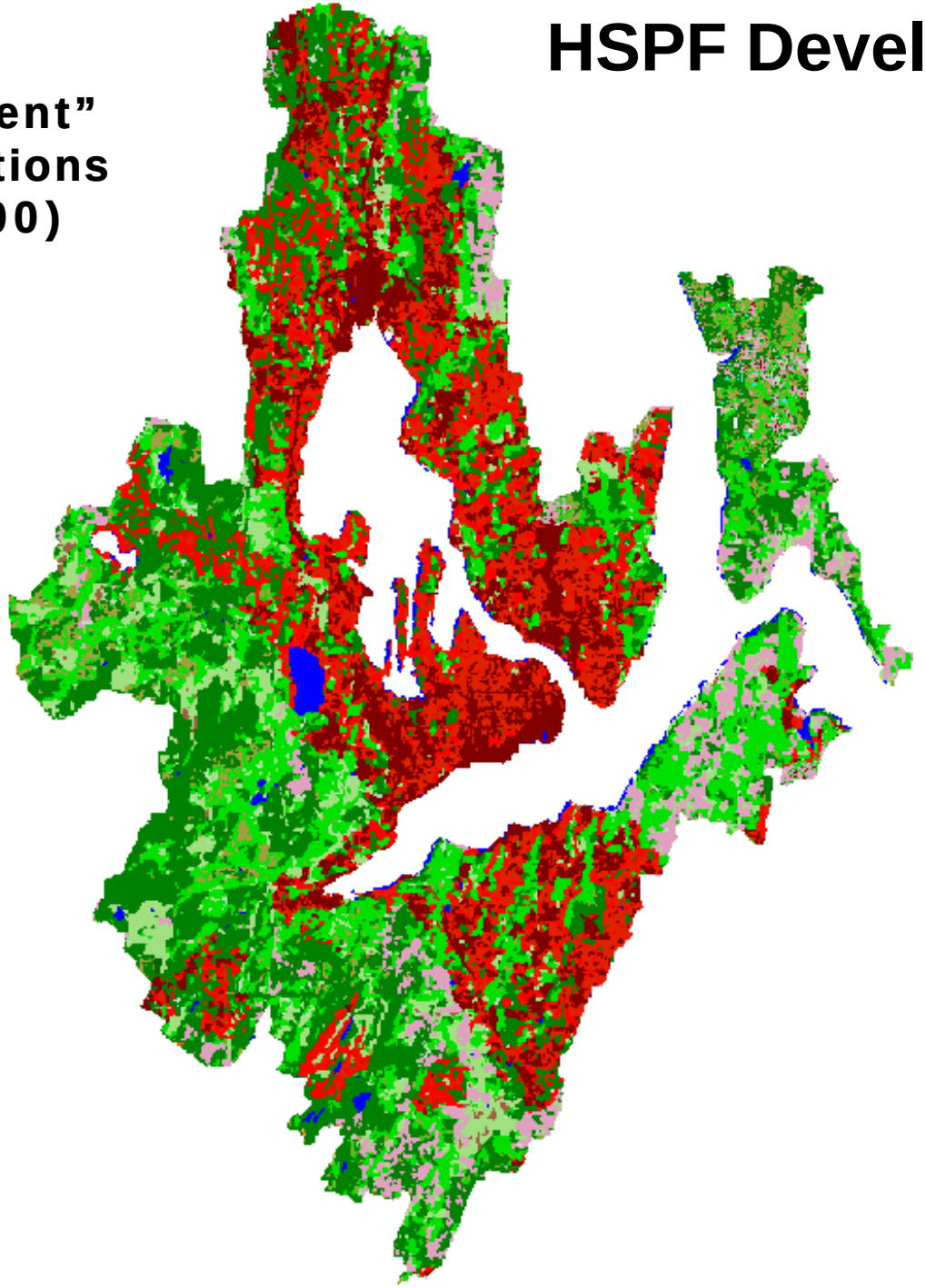
Performer: Dr. Brian Skahill, US Army Corps, ERDC

HSPF Development



HSPF Development (Cont.)

"Current" Conditions (2000)



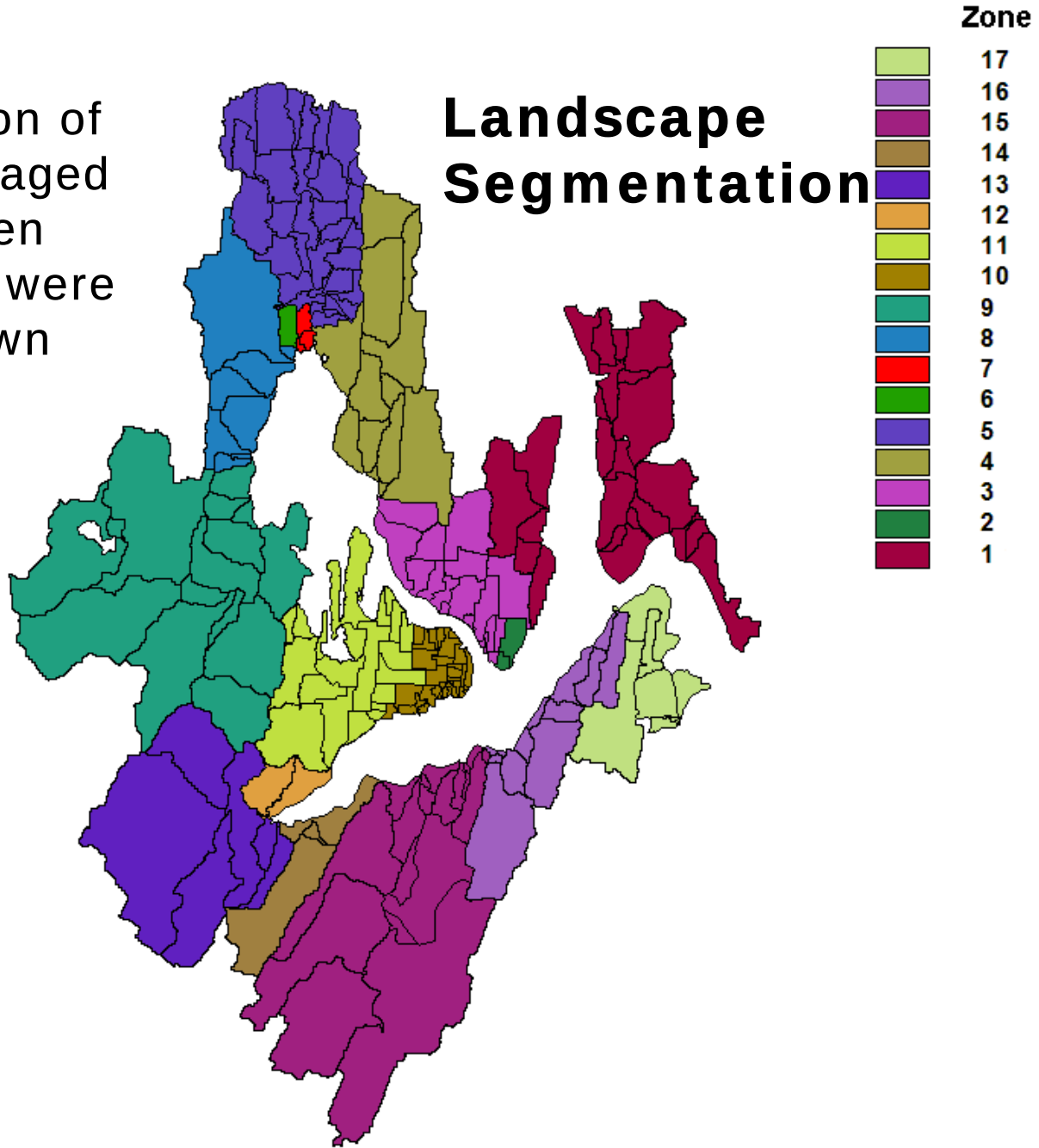
LULC Data

LULC

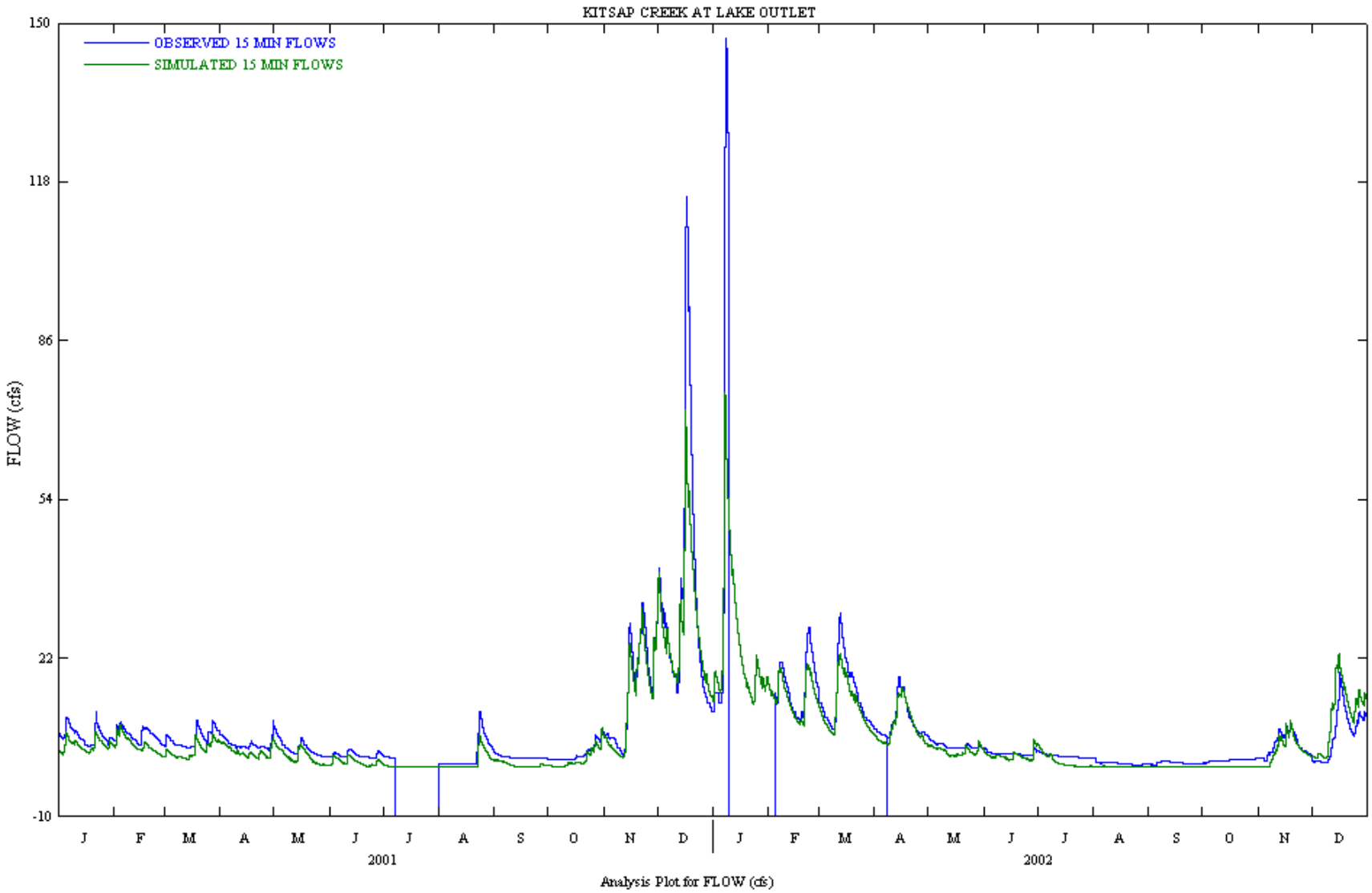
- Bare Soil
- Commercial & Industrial
- Commercial/Industrial/Trans.
- Coniferous Forest
- Deciduous Forest
- Evergreeen Forest
- Grassland
- Grassland/Turf/Pasture
- HD Residential-Urban
- LD Residential-Rural
- Lakes/Wetlands
- Low Intensity Residential
- MD Residential-Suburban
- Mixed Forest
- Open Water
- Pasture/Hay
- Quarries/Strip Mines/Gravel Pits
- Shoreline/Beach
- Shrub & Brush
- Shrubland
- Transitional
- Urban/Recreational Grasses
- Woody Wetlands

HSPF Development (Cont.)

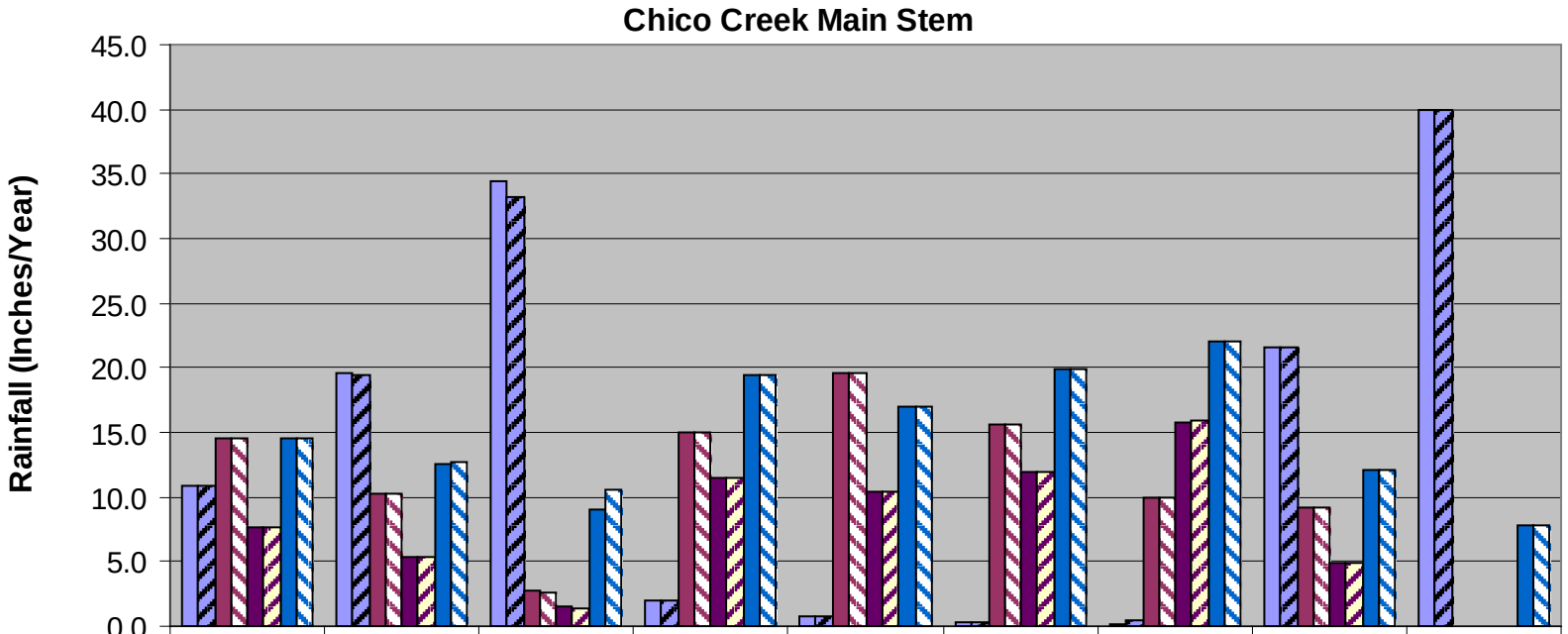
To support parameterization of models for ungaged areas, seventeen land segments were defined as shown



Representative Results from HSPF



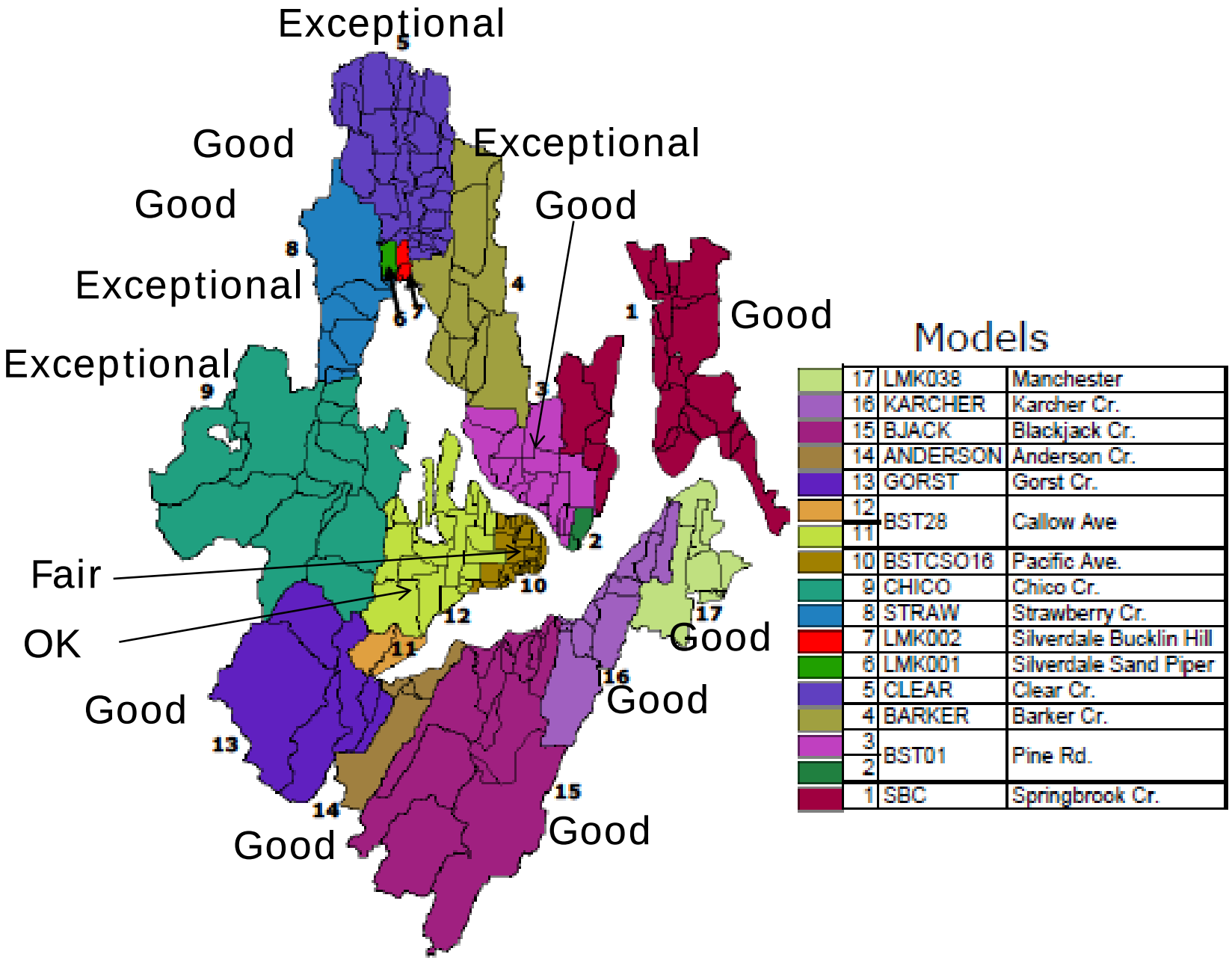
Simulated Partition of Average Annual Precipitation for Chico Creek Basin



	SUBURBAN (MD)	MULTI-FAMILY (HD)	COMM (CI)	RURAL (LD)	SCHRUB (SB)	PASTURE (HL)	FOREST CF+DF+MF	BARE (BL)	IMPERV
oSURO	10.9	19.6	34.5	1.9	0.7	0.3	0.1	21.6	40.0
sSURO	10.9	19.5	33.3	1.9	0.7	0.4	0.4	21.6	40.0
oIFWO	14.5	10.2	2.8	14.9	19.6	15.6	9.9	9.2	
sIFWO	14.5	10.2	2.7	15.0	19.6	15.6	10.0	9.2	
oAGWO	7.7	5.4	1.5	11.4	10.4	11.9	15.7	4.9	
sAGWO	7.7	5.4	1.3	11.4	10.4	11.9	16.0	4.9	
oTAET	14.6	12.6	9.1	19.5	17.0	20.0	22.0	12.1	7.8
sTAET	14.6	12.6	10.6	19.5	17.0	20.0	22.1	12.2	7.8

SURO = direct surface runoff; AGWO = baseflow runoff;
IFWO = interflow runoff; TAET = total simulated evapotranspiration

Results of HSPF Evaluation



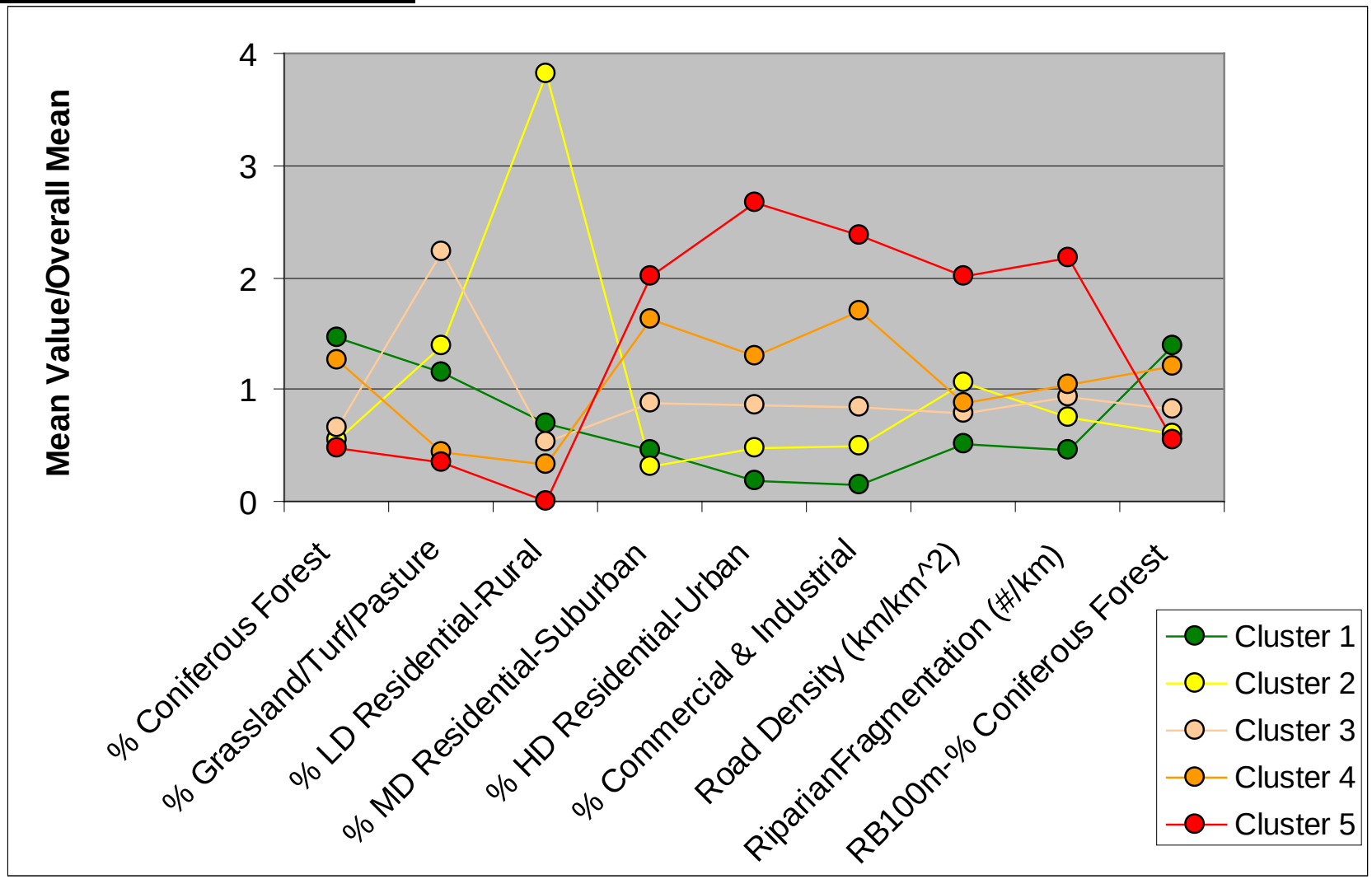
FC Loading Analysis

- Data
- Statistical Analysis
  - Streams
    Cluster analysis of LULC and regression against FC data (*k-means regression*)
  - Stormwater
    Empirical data from classes of stormwater basins
- Evaluation

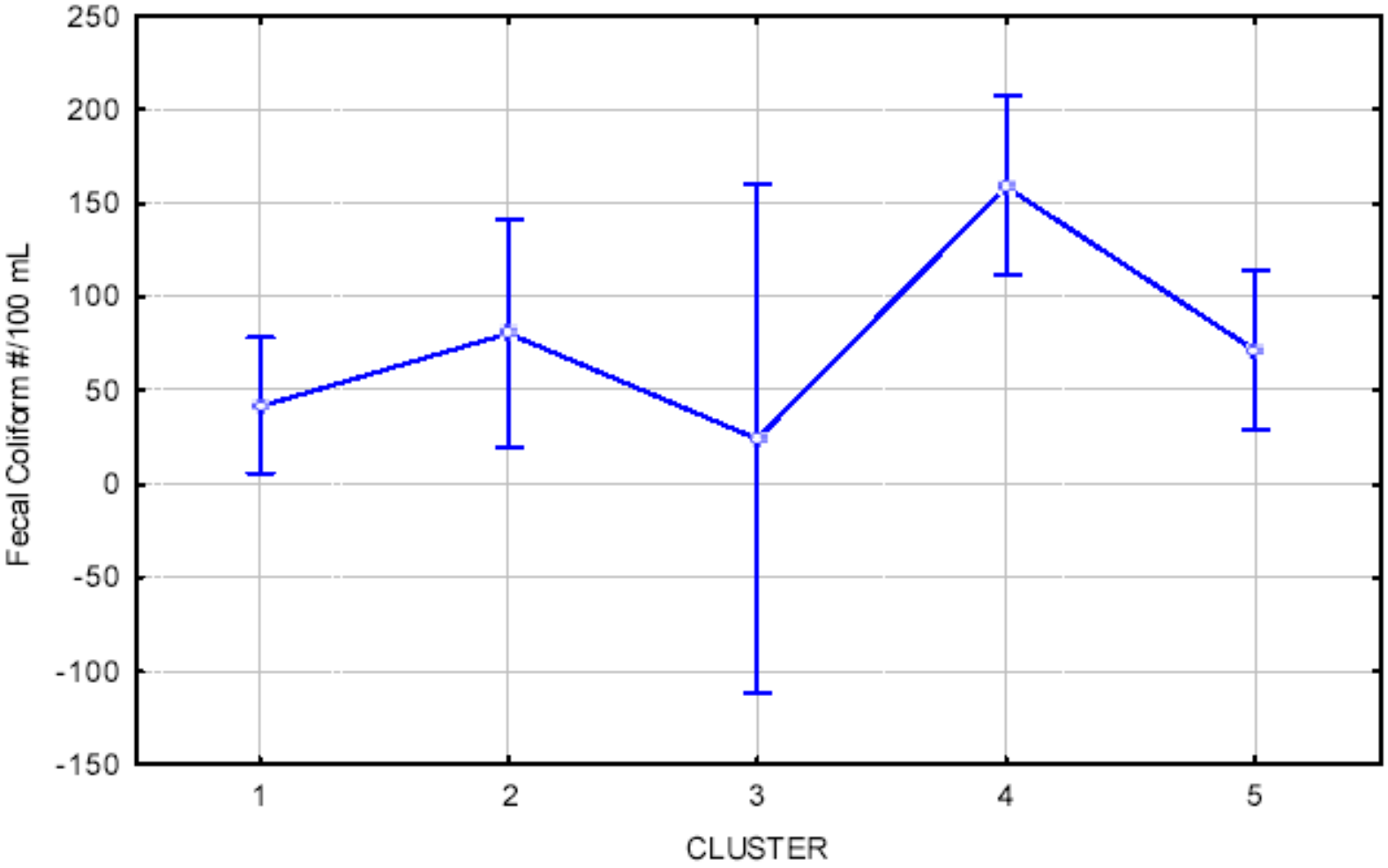
Performers: Val Cullinan and Dr. Chis May PNNL/BMSL

Land Use/Land Cover Clusters

Cluster	Description
1	Least Developed
2	Rural/LD Residential
3	Grass/Turf/Pasture
4	MD-HD Residential
5	Greatest Development



Estimating FC Loading Conc.



Cluster	Description
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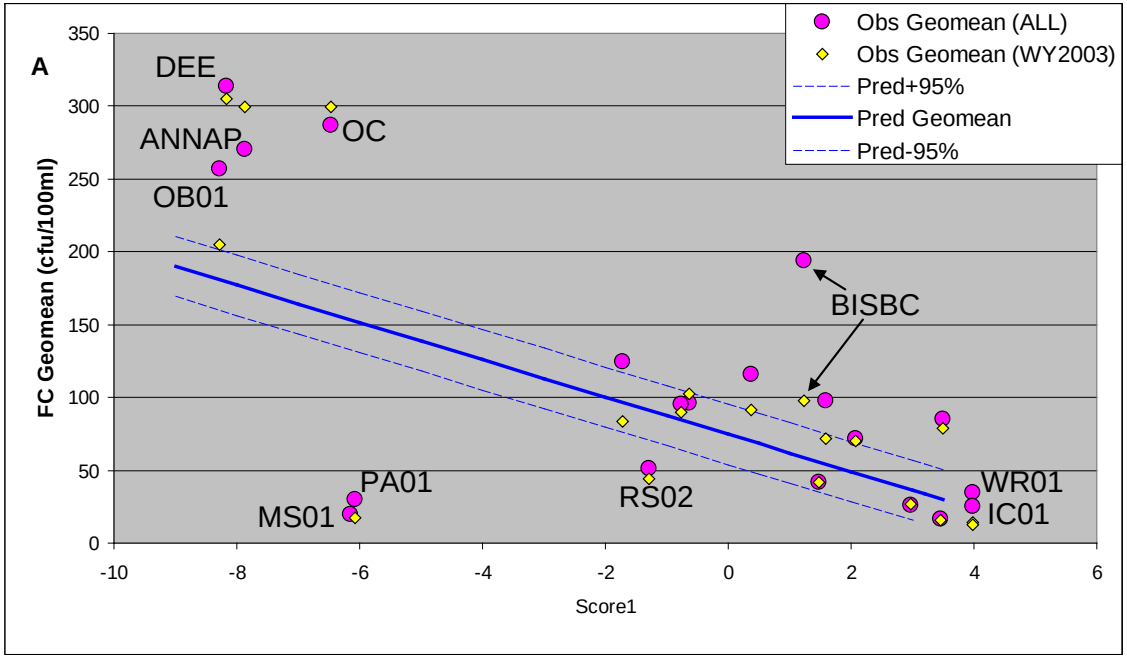
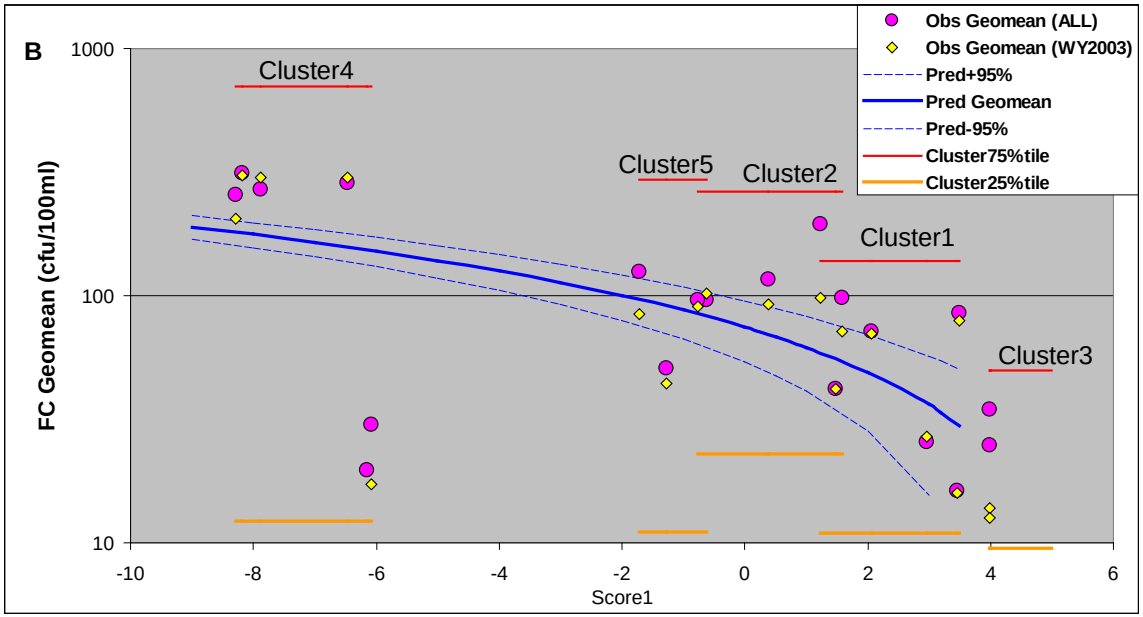
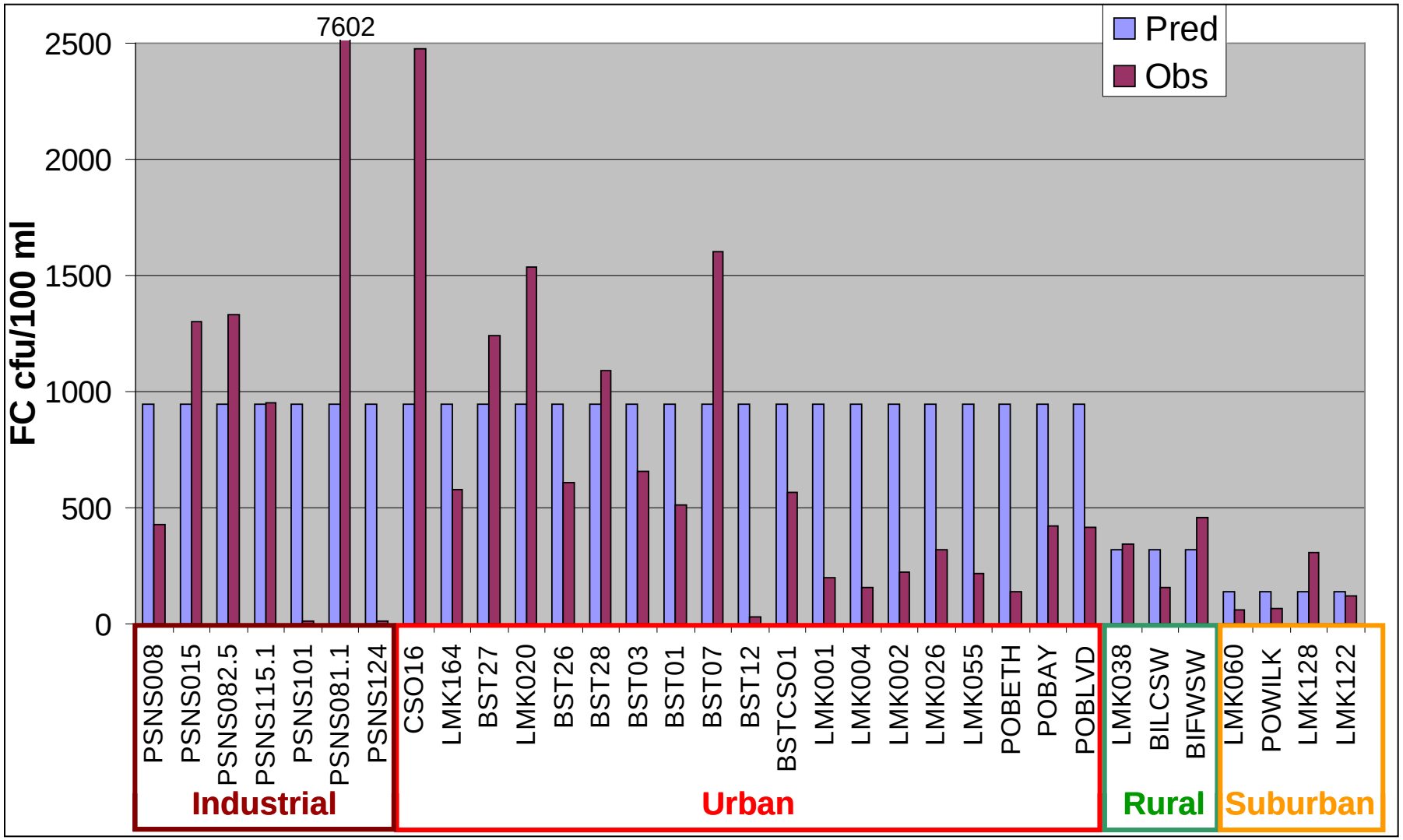




Predicted and Observed Geomeans and Cluster Bounds for Stream Mouths

Predicted and Observed FC Geomean for Stormwater



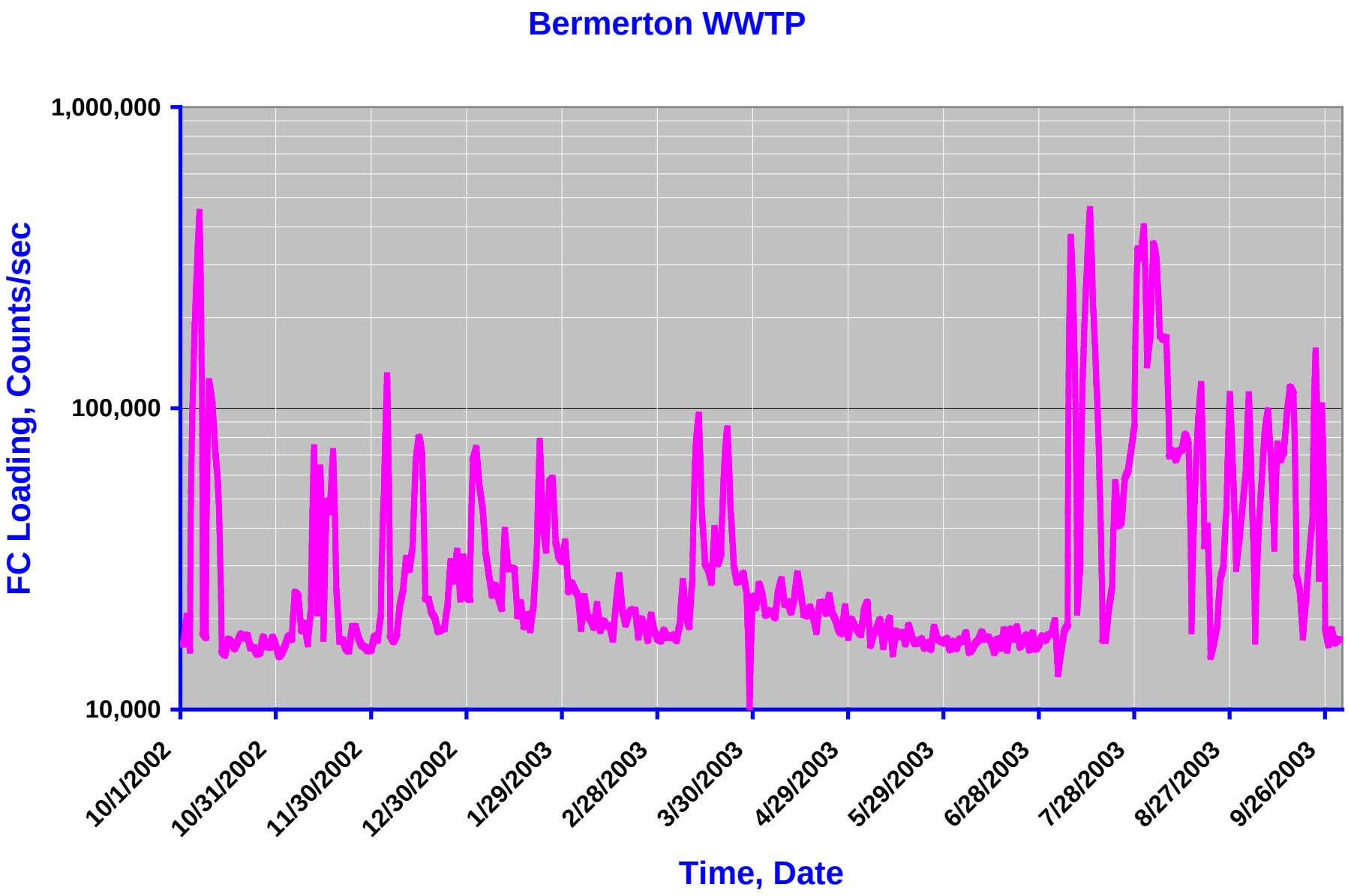
Example of FC Concentration Assignments for Selected Watersheds

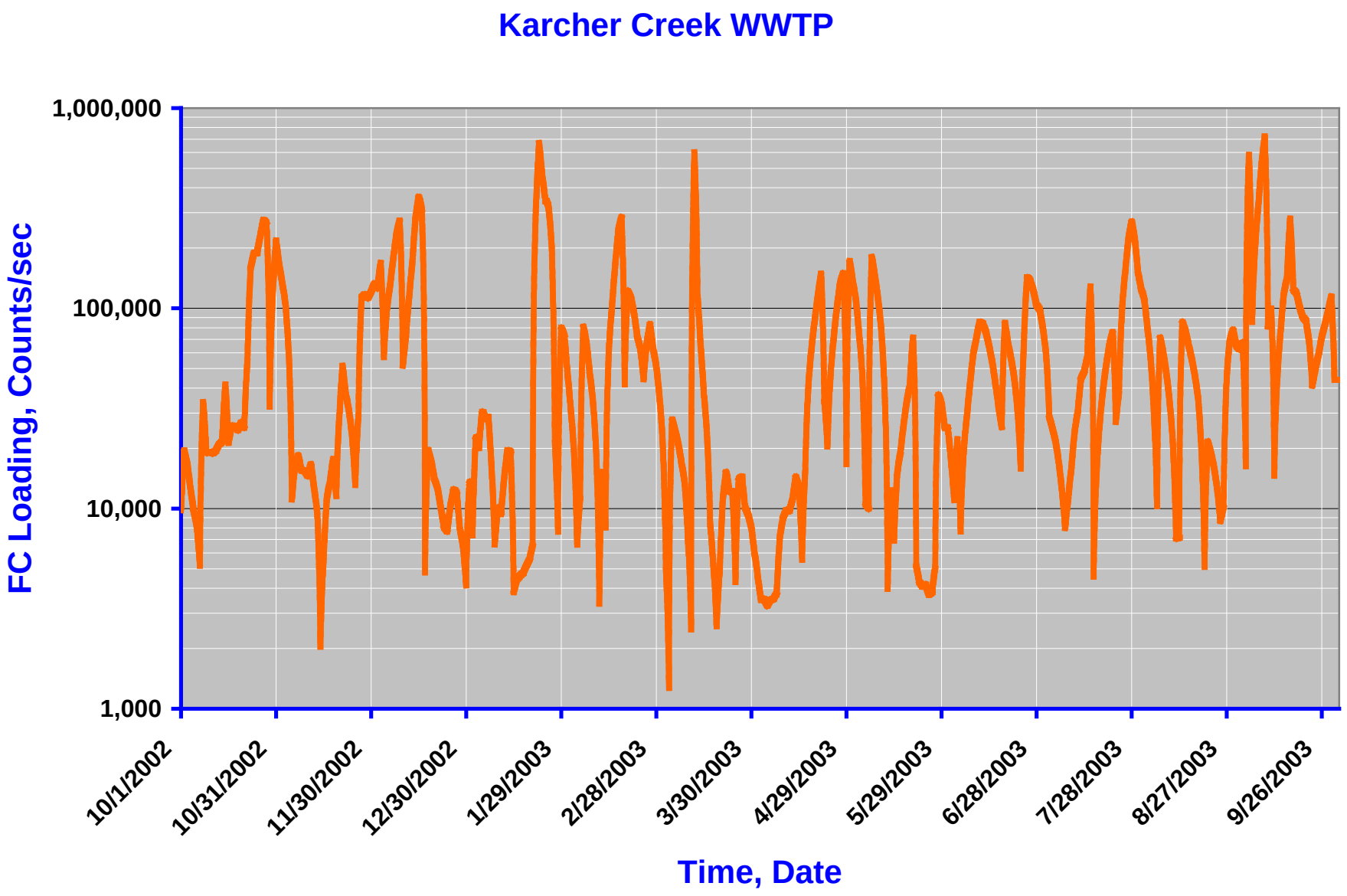
		Cluster	Cluster Percentile		
TYPE	Basin Description/Location	Assignment	25th	GeoMean	75th
Shore	East Bremerton-Parkside Dr	4	12.3	179.8	705.0
Stormwater	East Bremerton-Manette Bridge	1	210.0	947.0	1255.0
Stormwater	East Bremerton-Upper Trenton	1	210.0	947.0	1255.0
Shore	Illahee (MESO-NW)	3	9.5	23.7 *	50.0
Shore	Ross Point Shore	5	11.1	65.5	294.0
Stormwater	Port Orchard Downtown - Wilkens	3	62.0	140.0	263.0
Stormwater	Port Orchard Downtown - Bay St	1	210.0	947.0	1255.0
Shore	Port Orchard Annapolis Point	4	12.3	131.2	705.0
Shore	BI-Crystal Springs	1	11.0	26.0	138.0
Stream	Schel Chelb Creek (BI)	2	23.0	48.6	263.0
Stormwater	BI-Fort Ward	2	158.0	321.0	459.0
Shore	Manchester Point Shore	2	23.0	31.2	263.0
Stream	Gorst Creek @ Sam Christopherson	1	11.0	29.9	138.0
Stream	Barker Creek	2	23.0	84.3	263.0
Stream	Earlands Creek	3	9.5	23.7 *	50.0
Stormwater	Silverdale Bayview Dr	1	210.0	947.0	1255.0
Stormwater	PSNS015 McDonalds NavSta	1	210.0	947.0	1255.0
Stormwater	PSNS124 Dry Dock 3	1	210.0	947.0	1255.0
Stream	Blackjack Lower Mainstem	1	11.0	48.2	138.0

* Predicted geomean was greater than the Cluster 75th percentile, the 75th percentile was used.

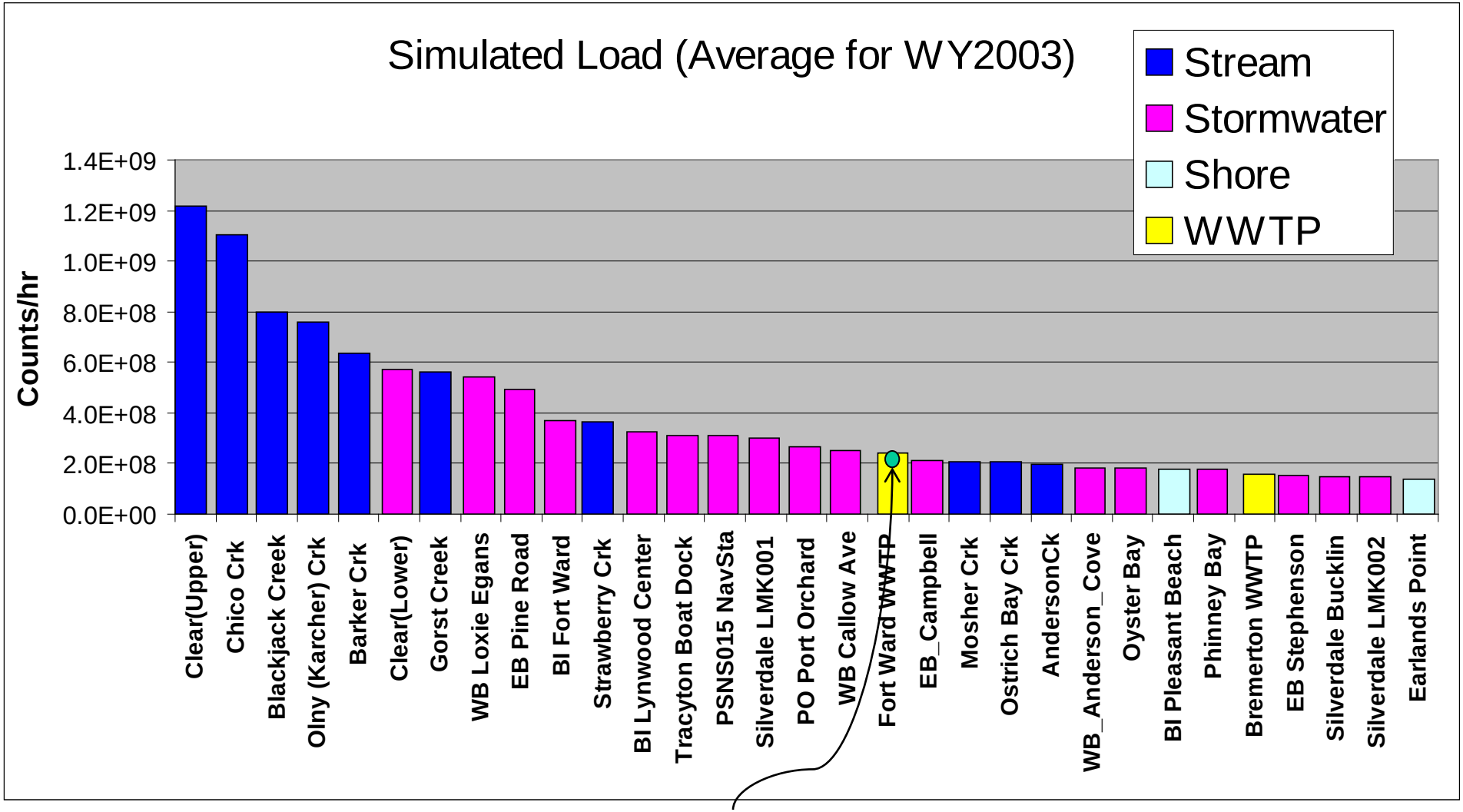
Loading from WWTPs

- DMR data used to develop empirical loading for WY2003
  - BREM WWTP
  - BREM ETF (no discharge in WY2003)
  - Karcher Cr. WWTP
  - Fort Ward WWTP
- Observed flow and measured FC levels used to simulate 2004 storm events
  - BREM WWTP
  - BREM ETF (no discharge during events simulated)
  - Karcher Cr. WWTP
  - Fort Ward WWTP (not included)

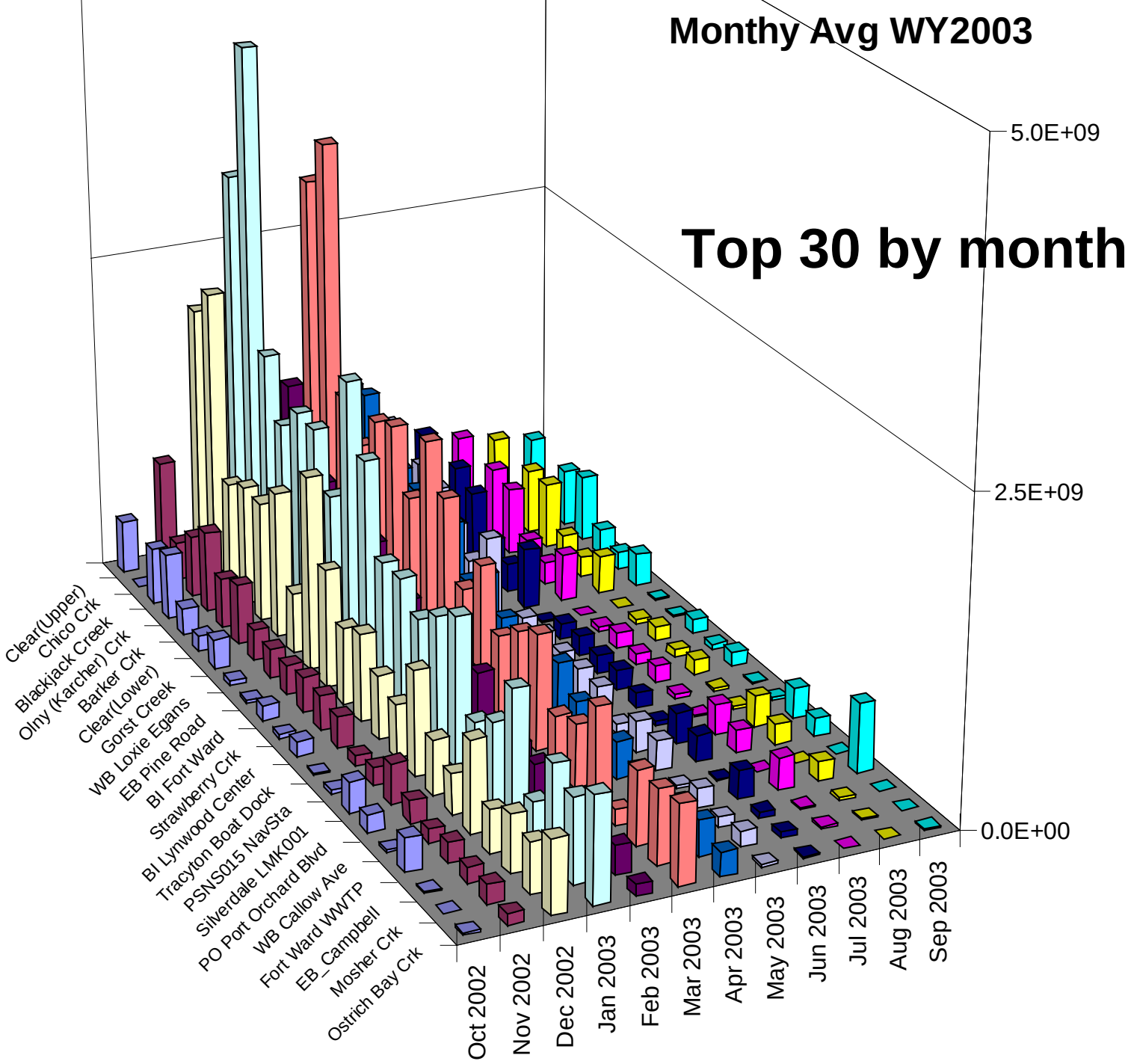

Bermerton WWTP
1,000,000
100,000
10,000
FC Loading, Counts/sec
10/1/2002
10/31/2002
11/30/2002
12/30/2002
1/29/2003
2/28/2003
3/30/2003
4/29/2003
5/29/2003
6/28/2003
7/28/2003
8/27/2003
9/26/2003
Time, Date


Karcher Creek WWTP
1,000,000
100,000
10,000
1,000
FC Loading, Counts/sec
10/1/2002
10/31/2002
11/30/2002
12/30/2002
1/29/2003
2/28/2003
3/30/2003
4/29/2003
5/29/2003
6/28/2003
7/28/2003
8/27/2003
9/26/2003
Time, Date

Top Thirty Loads from Watershed



Note: DMR data from the City of Bainbridge Island WWTP were inadvertently used for the Fort Ward WWTP

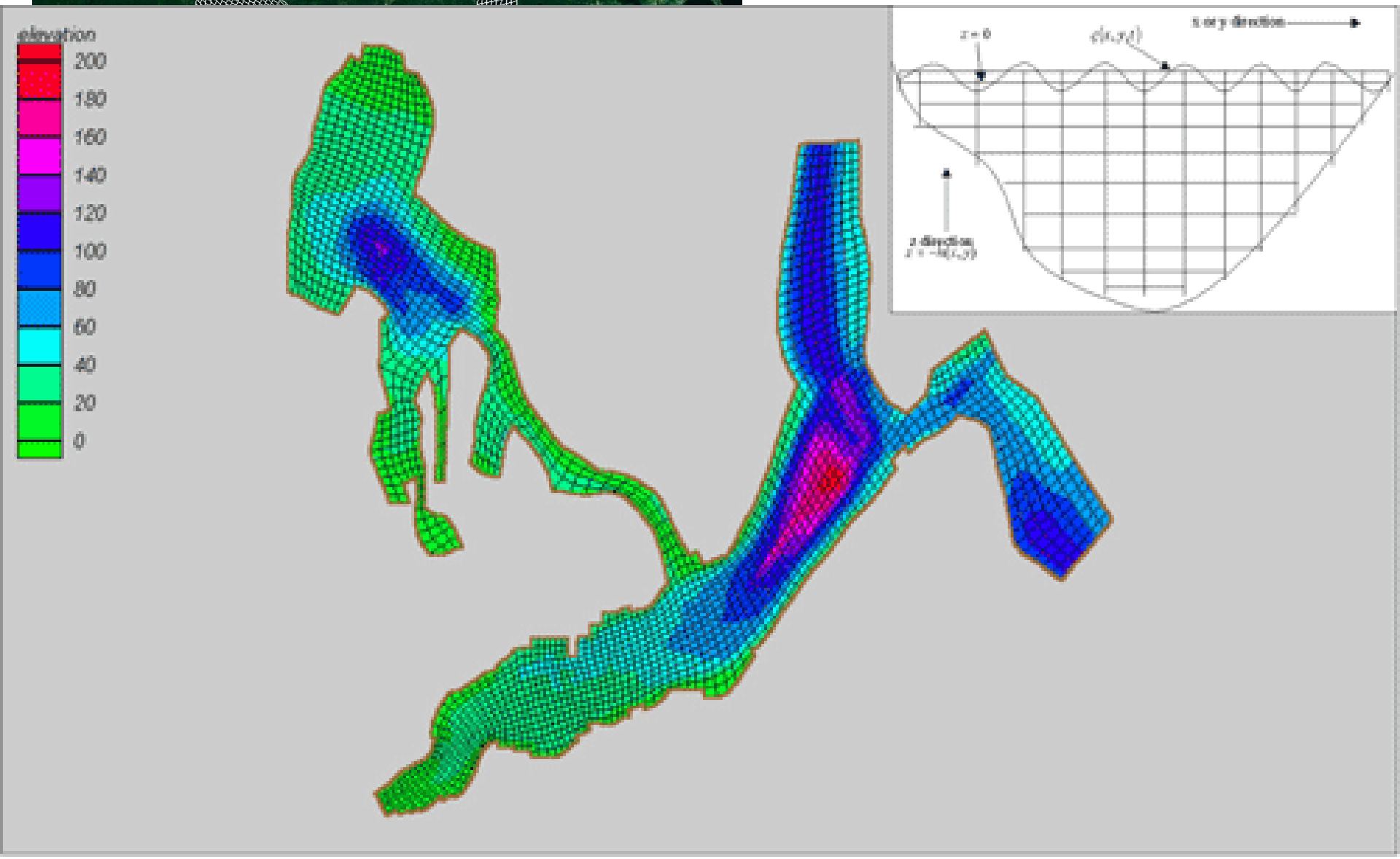

Monthy Avg WY2003
Top 30 by month
5.0E+09
2.5E+09
0.0E+00
Clear(Upper)
Chico Crk
Blackjack Creek
Olny (Karcher) Crk
Barker Crk
Clear(Lower)
Gorst Creek
WB Loxie Egans
EB Pine Road
BI Fort Ward
Strawberry Crk
BI Lynwood Center
Tracyton Boat Dock
PSNS015 NavSta
Silverdale LMK001
PO Port Orchard Blvd
WB Callow Ave
Fort Ward WWTP
EB_Campbell
Mosher Crk
Ostrich Bay Crk
Oct 2002
Nov 2002
Dec 2002
Jan 2003
Feb 2003
Mar 2003
Apr 2003
May 2003
Jun 2003
Jul 2003
Aug 2003
Sep 2003

Estuarine Model (CH3D-FC) Development

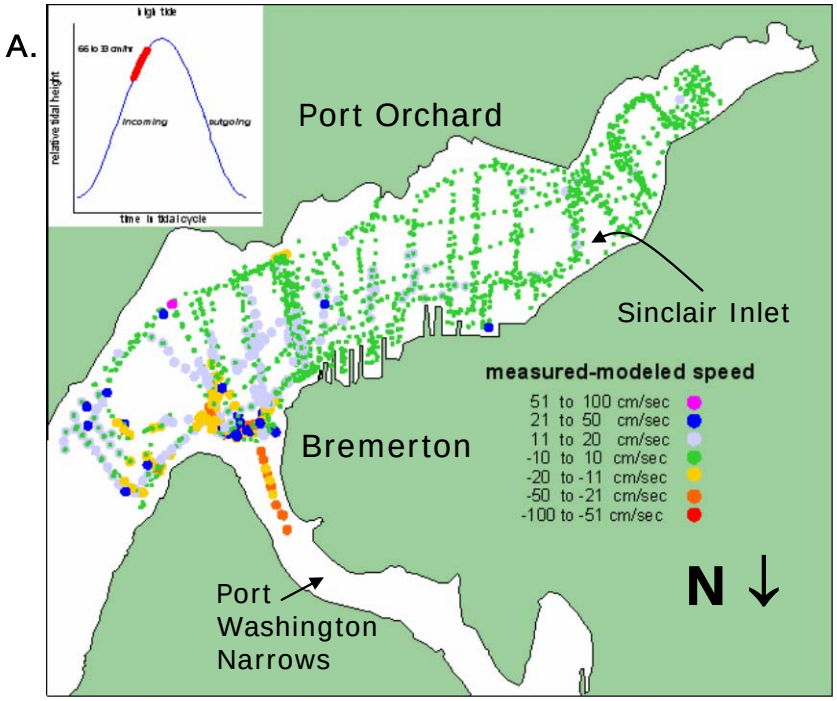
- Hydrodynamics
- Freshwater Inputs
- FC Fate and Transport
- Evaluation

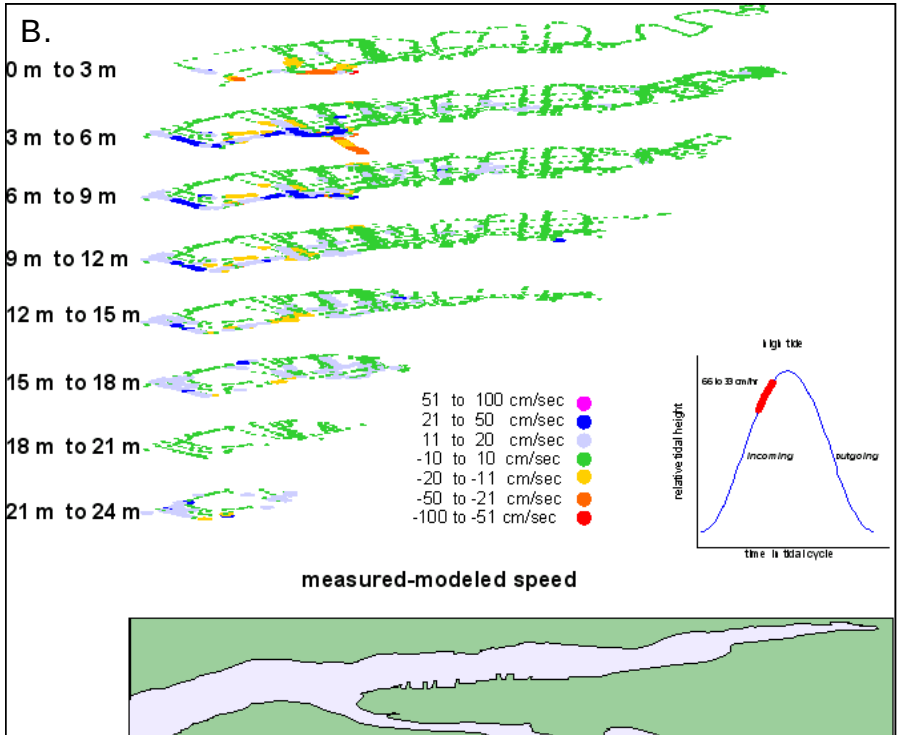
Performers: Drs. PF Wang, Woohee Choi, Ken Richter, SSC-Pacific

CH3D Development



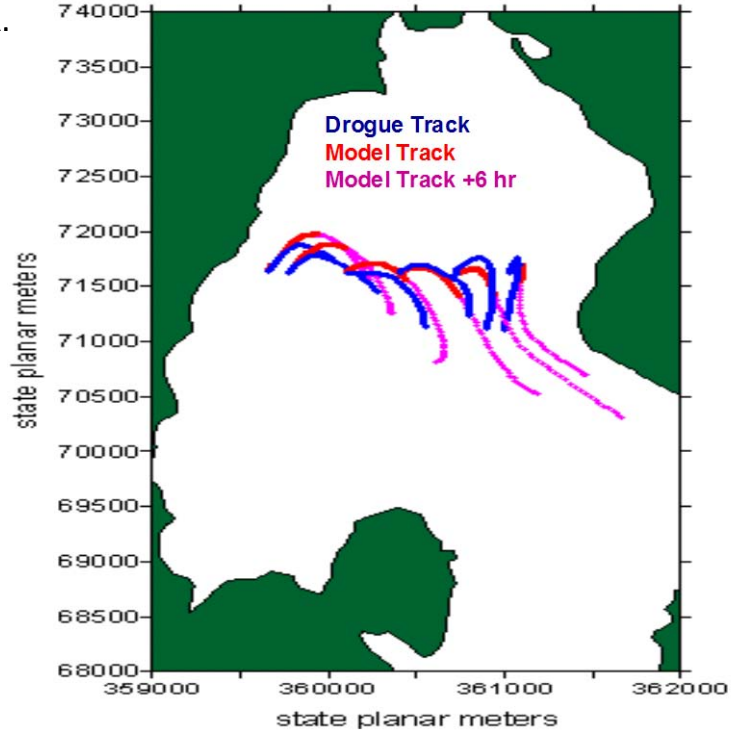
Hydrodynamic Verification Sinclair Inlet



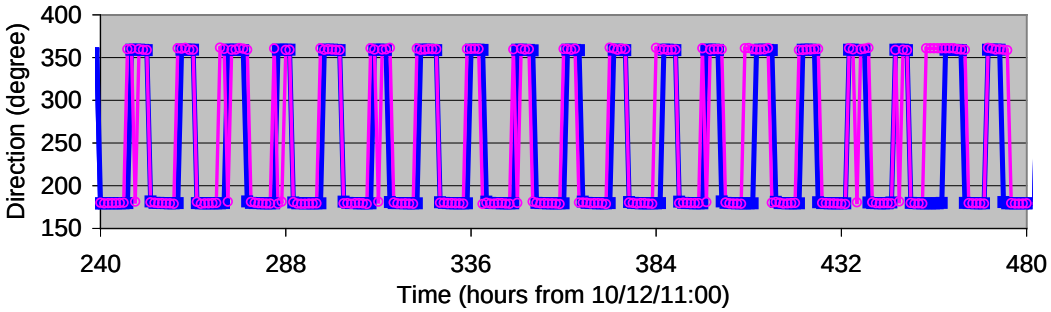


Hydrodynamic Verification Dyes Inlet

A.



B.



CH3D-FC Simulation

C_t = $= C_0 e^{-kt}$

Where:

C_t = surviving concentration [cfu/100 ml]

C_0 = initial concentration [cfu/100 ml]

t = time

k = bacterial death rate

$$= \left[0.8 + 0.0 \quad (S)\right] \times 1.0^{(T-2)} + \frac{I}{K_E H}\left[1 - e^{-(K_E H)}\right]$$

$$= \left[0.8 + 0.0 \quad (S)\right] \times 1.0^{(T-2)} + 7^{0} e^{-(K_E Z)}$$

S = percent seawater

I = incident radiation at water surface [Langleys J/m²]

T = temperature [°C]

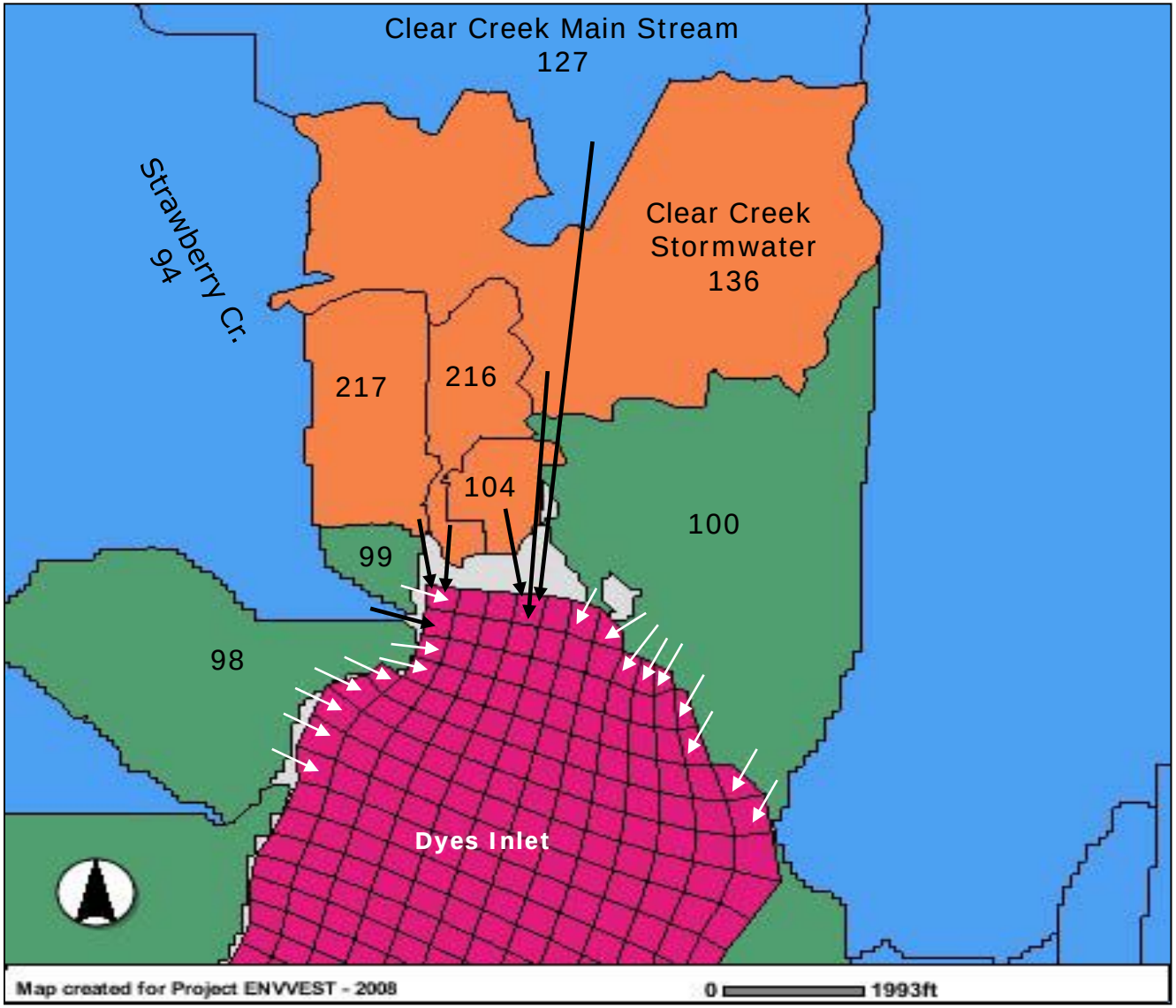
K_E = light extinction coefficient of photosynthetically active radiation (PAR)

H = mixing depth [m]

Z = model depth [m]

Mancini, J. L. 1978. Numerical estimates of coliform mortality rates under various conditions. J. Water Poll. Control Fed. 50:2477-2484.)

HSPF-CH3D Linkage



Integrated Watershed and Receiving Water Model

- Verification
  - Loading
  - Fate and Transport
  - Evaluation
- Sensitivity
- Uncertainty

Performers: Erin Loy, Amy Blake, Chris Kyburg, Marrisa Brand, SSC Pacifc
Victoria Whitney, Dwight Leisle, Bruce Beckwith, PSNS&IMF

R.K. Johnston, P.F. Wang, E.C. Loy, A.C. Blake, K.E. Richter, M.C. Brand, B.E. Skahill, C.W. May, V. Cullinan, W. Choi, V.S. Whitney, D.E. Lei

2004 Storms Simulation Results

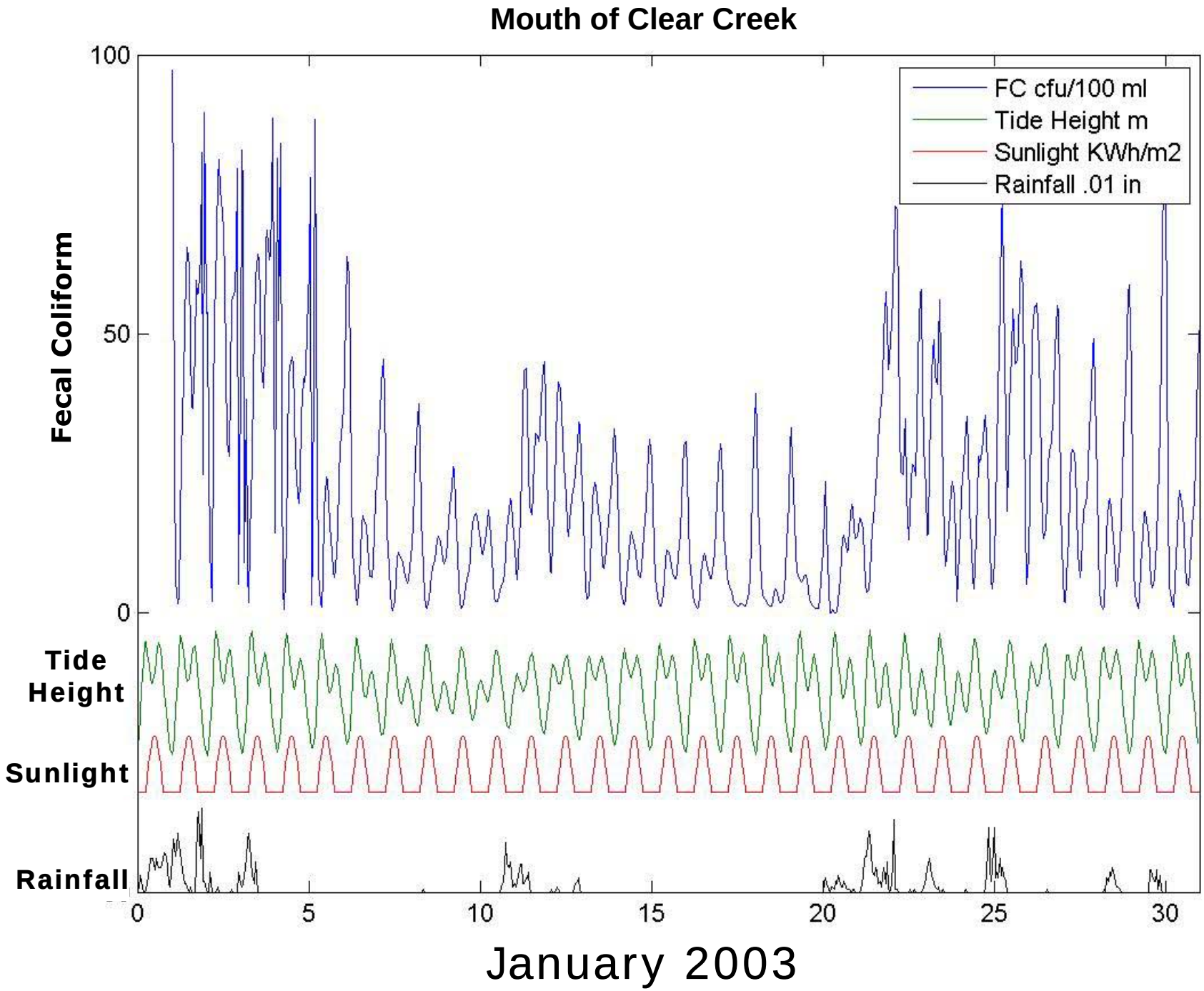
A series of simulations of storm events sampled in 2004 were conducted to evaluate model performance by comparing to field data. Output fro the runoff for each storm event and the estuarine CH3D-FC model was run to simulate the tides, circulation conditions, and FC inputs occurring starting from 24 hours before the storm event and ending 24 hours after the storm event. CH3D-FC was used to simulate the 25th percentile, g the FC loading concentrations. The model output a time series of FC concentrations for each of the loading concentrations simulated. The obs station were compared to the simulated data from the corresponding (or nearest) model grid. The simulated and observed salinity at each stati

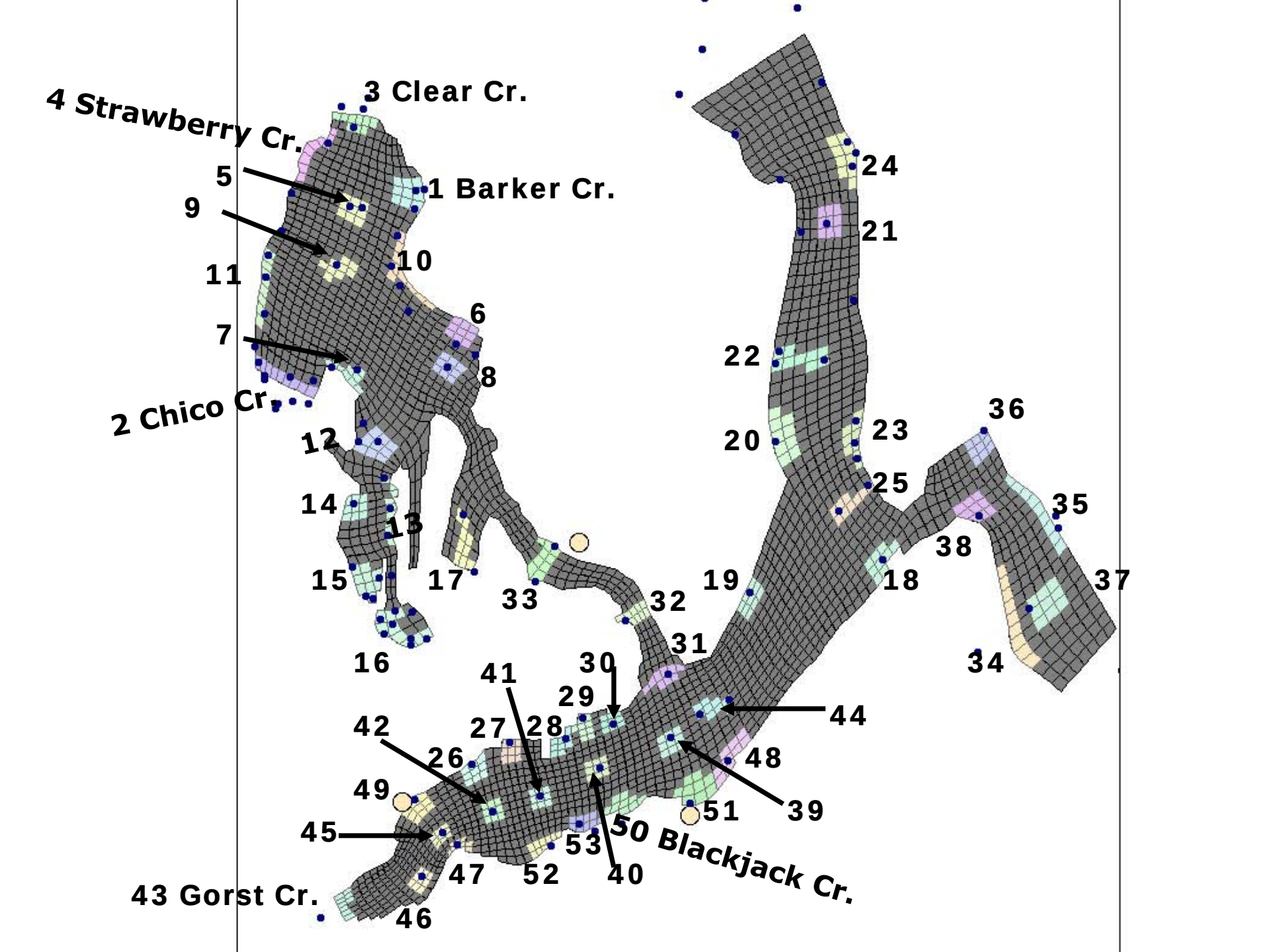
Three specific sampling events were simulated. Output is available from the 94x105 and 91x96 grids:

#	Simulation	Rainfall	FC Concentration	94x105 grid		91x96 grid	
S1	April 19-20, 2004	21-Apr-2004	25th Percentile	S1	apr94x105.htm apr94x105.pdf	S1b, Surf	apr91x96.htm apr91x96.pdf SaltSimulation
S2			Geomean	S2		S2b, Surf	
S3			75th Percentile	S3		S3b, Surf	
S4	May 26-27, 2004	18-May-2004	25th Percentile	S4	may94x105.htm may94x105.pdf	S4b, Surf	may91x96.htm may91x96.pdf SaltSimulation
S5			Geomean	S5		S5b, Surf	
S6			75th Percentile	S6		S6b, Surf	
S7	Oct 19-20, 2004	10-Oct-2004	25th Percentile	S7	oct94x105.htm oct94x105.pdf	S7b, Surf	oct91x96.htm oct91x96.pdf SaltSimulation
S8			Geomean	S8		S8b, Surf	
S9			75th Percentile	S9		S9b, Surf	

Identifying Critical Conditions

- **Spatial Considerations**
  - **Arial extent of plume**
  - **Depth of plume**
- **Temporal Considerations**
  - **Weather conditions**
  - **Tidal variations**
  - **Sunlight**
  - **Mixing processes**
- **Combination of Factors**
  - **Multiple sources**


Mouth of Clear Creek
FC cfu/100 ml
Tide Height m
Sunlight KWh/m2
Rainfall .01 in
Fecal Coliform
100
50
0
Tide Height
Sunlight
Rainfall
0
5
10
15
20
25
30
January 2003



3 Clear Cr.
4 Strawberry Cr.
1 Barker Cr.
2 Chico Cr.
43 Gorst Cr.
50 Blackjack Cr.
5
9
10
11
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21
24

Evaluation Criteria for Loading from Watershed

Observed Load = Model Flow x Obs FC

Simulated Load = Model Flow x Pred FC (Geomean)

Calculate

- Observed Mean, Median, Mode
- Simulated Mean, Median, Mode
- Simulated/Observed
  - Mean
  - Median
  - Mode

Evaluation Criteria			
	2	0.50	**Excellent**
	5	0.20	**Good**
	10	0.10	**Fair**
	50	0.02	**Poor**
>	50	0.02	**Very Poor**
n<7 Not Evaluated			

Outcome was the lowest of score between Mean and Median.
Did simulated average over or under predicted observed data?

Evaluation Criteria for CH3D-FC Simulation of WY2003

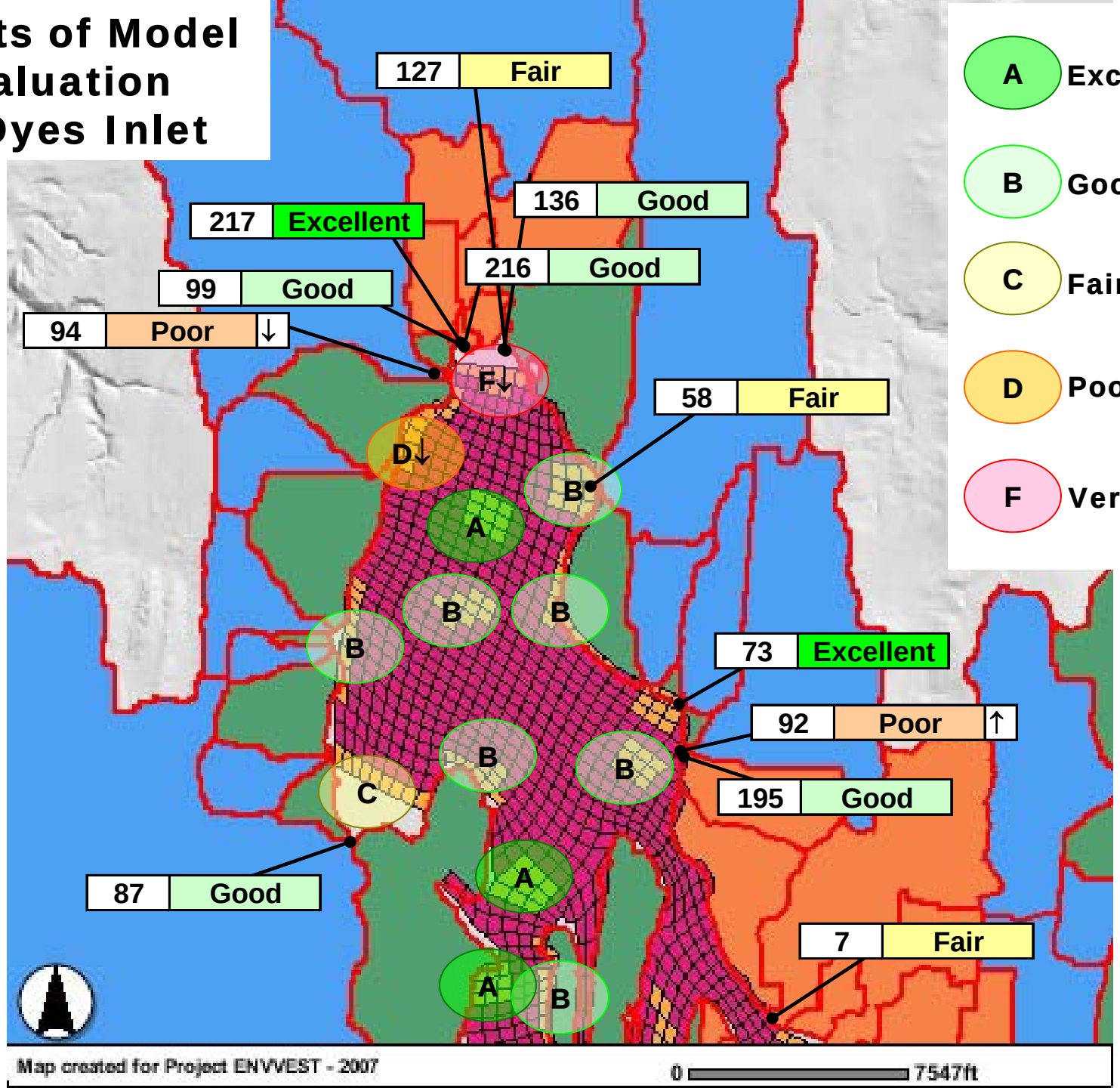
Comparison of the root mean square error (***RMSE***) between the observed (***OBS***$_i$) and predicted (***PRED***$_i$) values averaged over the number of observations (***n***)

$$\mathrm{RMSE}_{\mathrm{CN}} = \sqrt{\frac{\sum_{i=1}^{n}\left(OBS_i - PRED_i\right)^2}{n}}$$

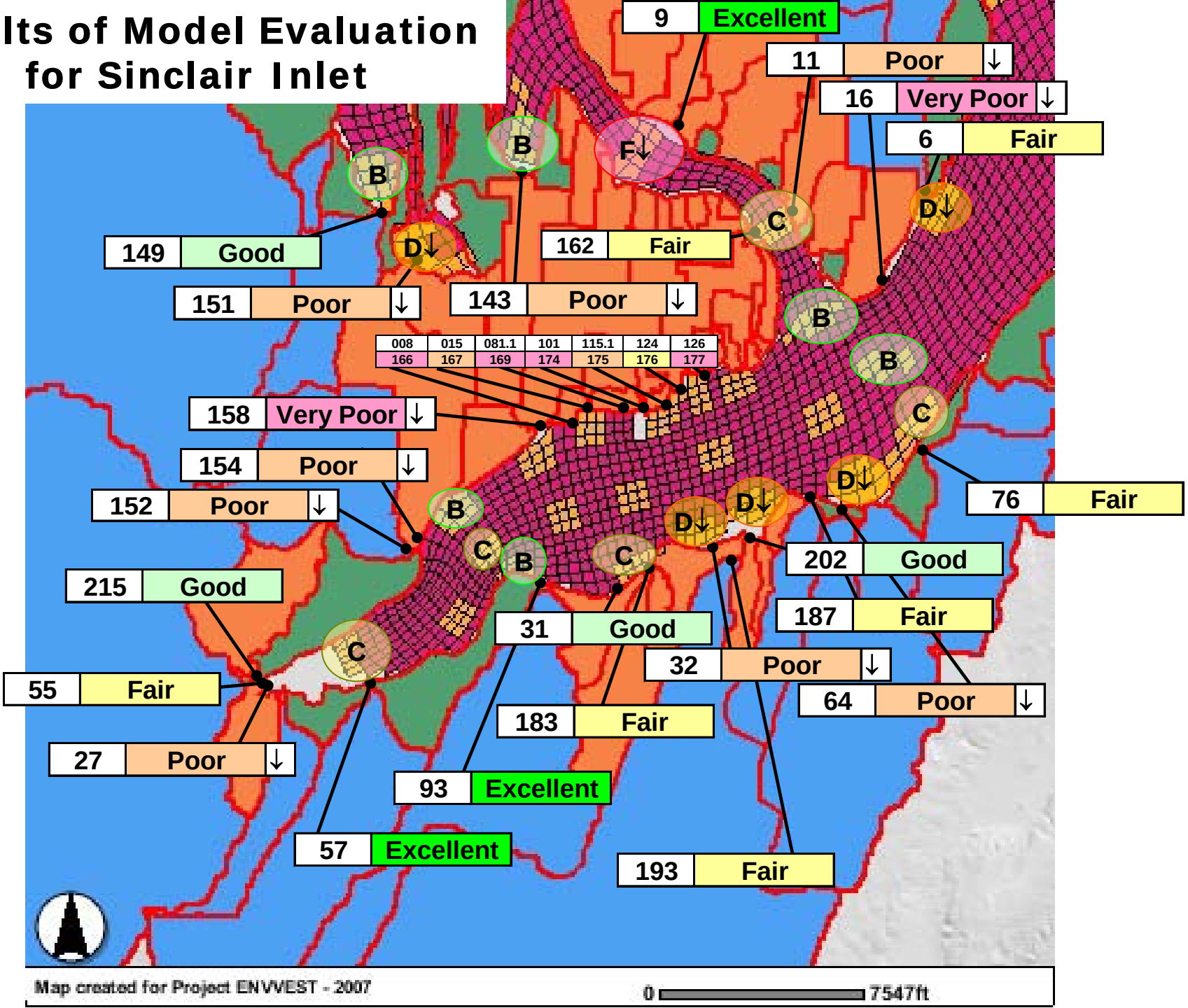
The magnitude of the RMSE was used to evaluate the goodness of fit for those points by using cutoff values based on the geometric progression of e:

		RSME <=
EXCELLENT	e	2.72
GOOD	e^2	7.39
FAIR	e^3	20.09
POOR	e^4	54.60
VERY POOR	e^4	>54.60

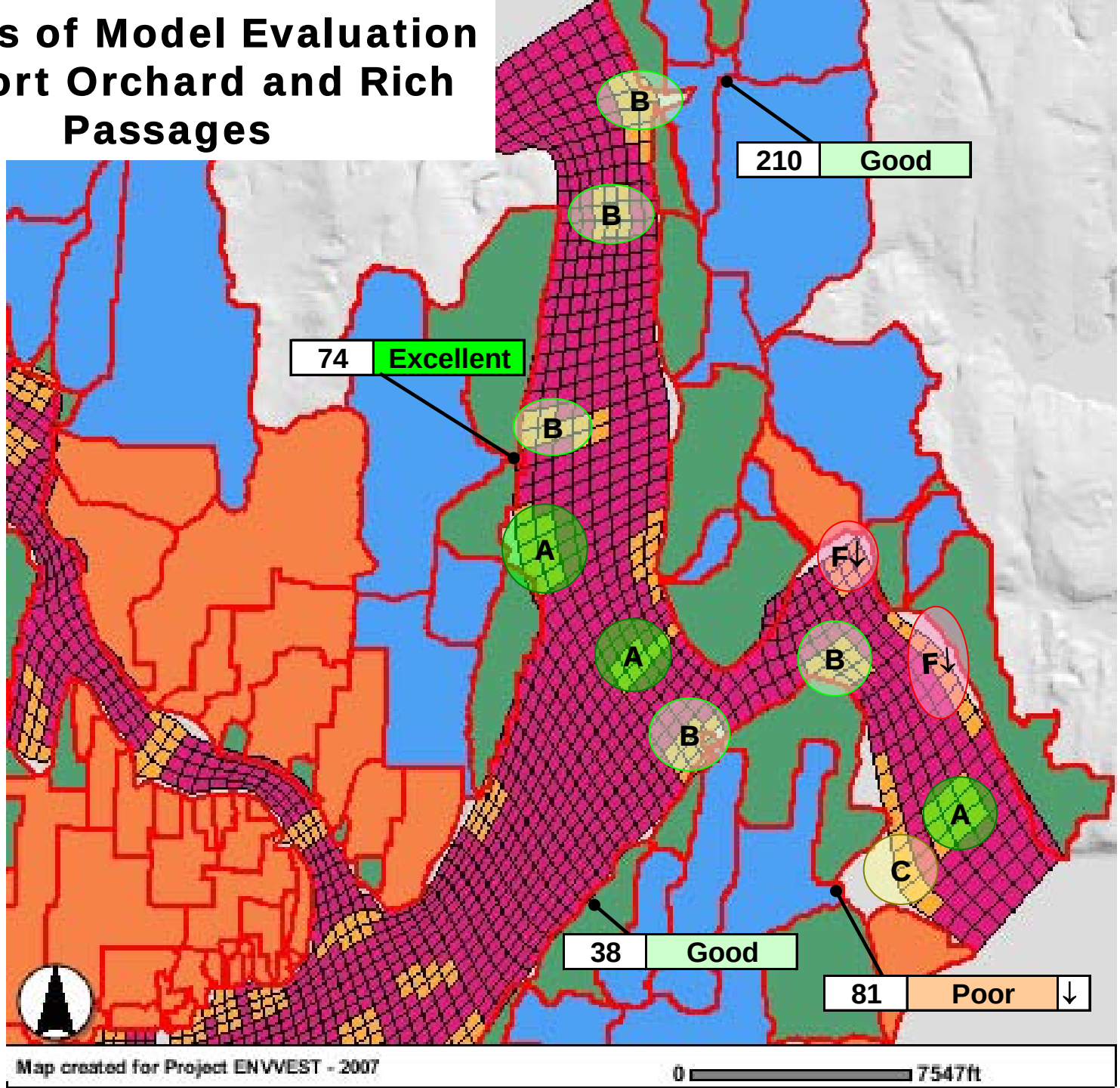
Results of Model Evaluation for Dyes Inlet



Results of Model Evaluation for Sinclair Inlet



Results of Model Evaluation for Port Orchard and Rich Passages



How Good Are the Model Predictions?

- **FC loading predicted by upstream land use/land cover and runoff from watershed**
  - √ **Yes – High degree of confidence with Good to Excellent agreement with observed data for most watersheds, however tendency to under predict loads in certain areas**
- **CH3D-FC simulates FC concentrations in the Inlets**
  - √ **Yes – High degree of confidence with Good to Excellent agreement with observed data for marine waters, however tendency to under predict FC concentrations in certain nearshore areas**

Nearshore Areas Under Predicted

- **Clear/Strawberry**
- **Oyster Bay**
- **Dee Creek**
- **Port Orchard waterfront**
- **South Bainbridge Island**

Model Limitations

- **Indirectly accounts for:**
  - **Failed septic systems**
  - **Upland Waterfowl and Wildlife**
- **Inputs do not include:**
  - **Marinas**
  - **Broken pipes**
  - **CSO Events**
  - **Nearshore waterfowl and marine mammals**
  - **Sediment resuspension and regeneration of bacteria spores**
  - **Other unknown sources**

Sensitivity and Uncertainty Analysis

- Vary FC Loading Concentration
  - 25th, 50th, 75th Percentile
- Vary Fresh Water Flows
  - 20% increase, 100% increase
- Add Wind (20 mph)
- No Fecal Coliform Die Off
- Future Build Out

R.K. Johnston, P.F. Wang, E.C. Loy, A.C. Blake, K.E. Richter, M.C. Brand, B.E. Skahill, C.W. May, V. Cullinan, W. Choi, V.S. Whitney, D.E. Leisle, and

Sensitivity Analysis Simulations

Model sensitivity was evaluated using simulations of the May 2004 storm event. The geomean (50th percentile) simulation for the May 2004 storm ev simulation (S5) and compared to the effect of varying FC concentrations (S4 25th percentile and S6 75th percentile), increasing flow by 20% (S14), i of 2 (S15), applying a constant wind speed of 10 m/sec (22.6 mph) from the SW (S16), and eliminating FC decay to simulate FC inputs as a conserv parameters were held constant.

Simulate Effect of Increasing FC Loading Concentrations

May 2004 storm event with varying FC loading concentrations

S4: FC Loading set to 25th percentile
S5: FC Loading set to 50th percentile (**Base Simulation**)
S6: FC Loading set to 75th percentile

Open animation of all three simulations

Simulate Effect of Increasing Flows

May 2004 storm event using geomean FC loading concentration and varying flows for all the streams, stormwater outfalls, and WWTPs by a fac

S5: Flow set to 1.0 (**Base Simulation**)
S14: Flow set to 1.2
S15: Flow set to 2.0

Open animation of all three simulations

Simulate Effect of Wind

May 2004 storm event using geomean FC loading concentration, flow set to 1 (base simulation flow) and a constant wind speed of 10 m/sec (2 the duration of the simulation.

S5: No Wind (**Base Simulation**)
S16: Constant wind speed of 10 m/sec (22.6)

Open animation of both simulations

Uncertainty

“*We don’t know enough about how the present leads to the future*” – Gregory Bateson

***“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.*” – Donald Rumsfeld**

“For all of its uncertainty, we cannot flee the future.” – Barbara Jordan

“It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.”
– Mark Twain

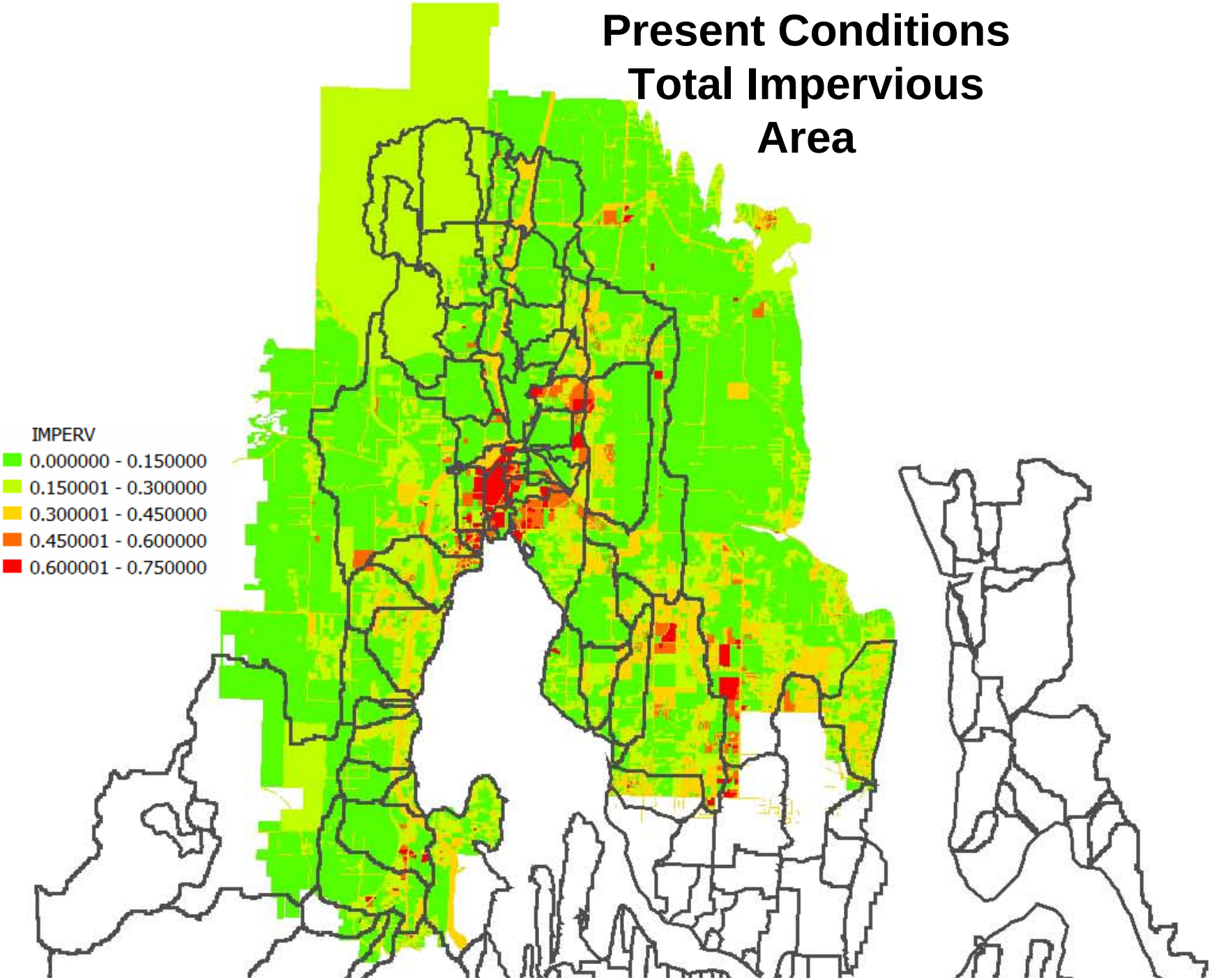
Uncertainty

- Future Conditions
- Kitsap County Watershed Planning for Northern Dyes Inlet (Alternative Futures Land Use)
  - Current Conditions
  - Conservative Growth Scenario
  - **Expansive Growth Scenario**
- Land use coverage based on county parcel map

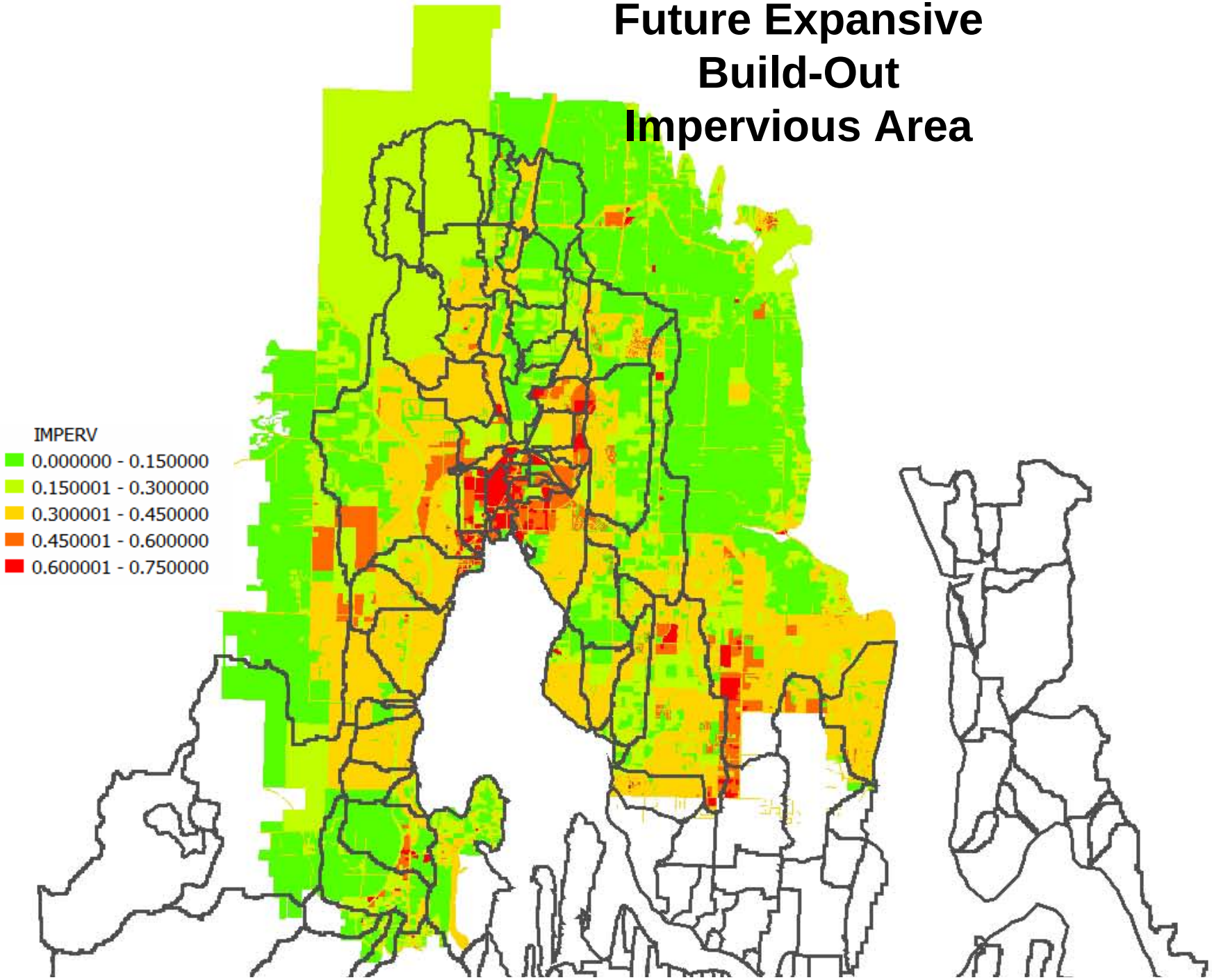
Future Simulation

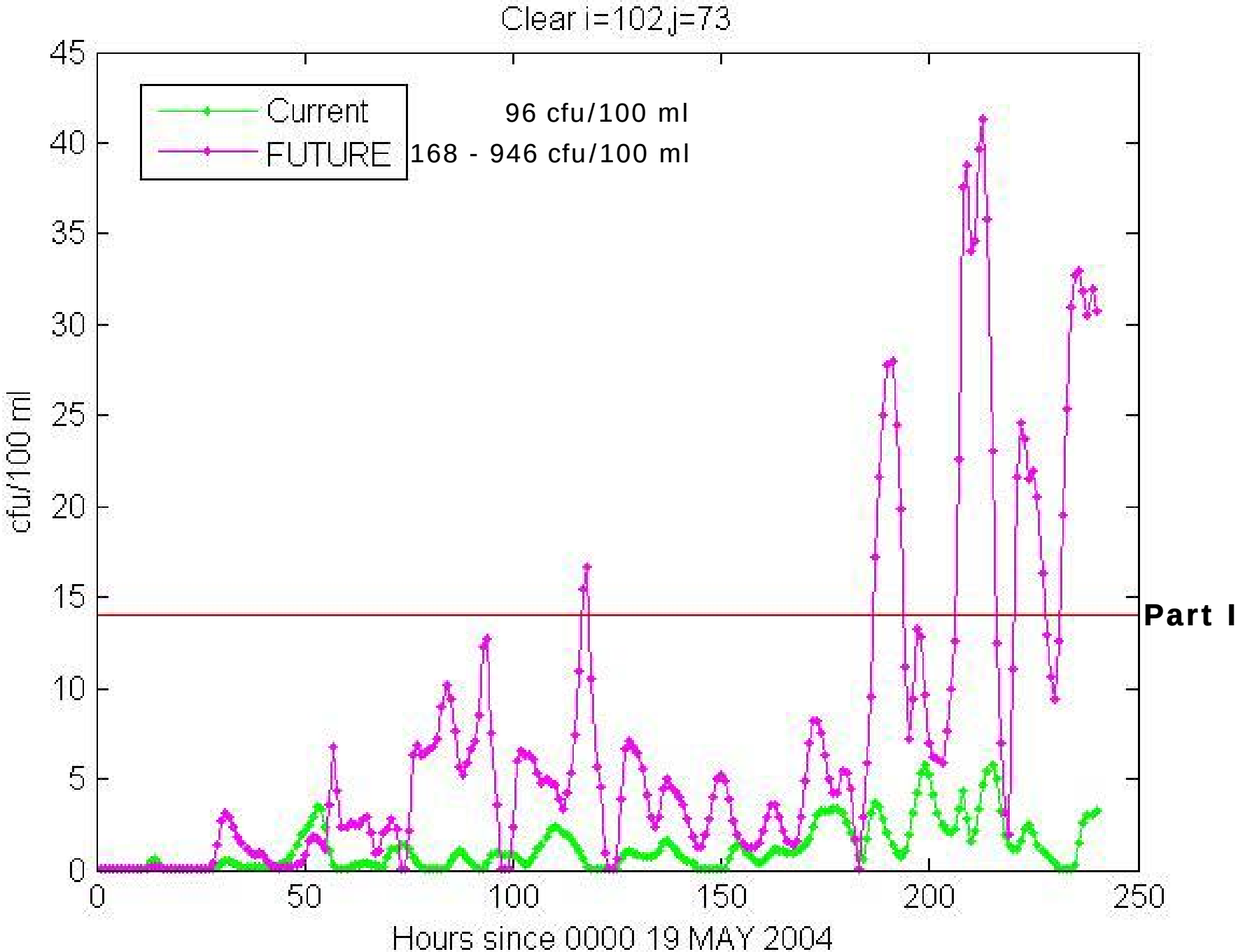
- Update land use and cover to match future buildout
- Model changes in flow
- Estimate FC input based on the change in land use and land cover
- Simulate storm event for May 26-27, 2004 under future conditions
- Future buildout was only applied to Northern Dyes Inlet

Present Conditions Total Impervious Area



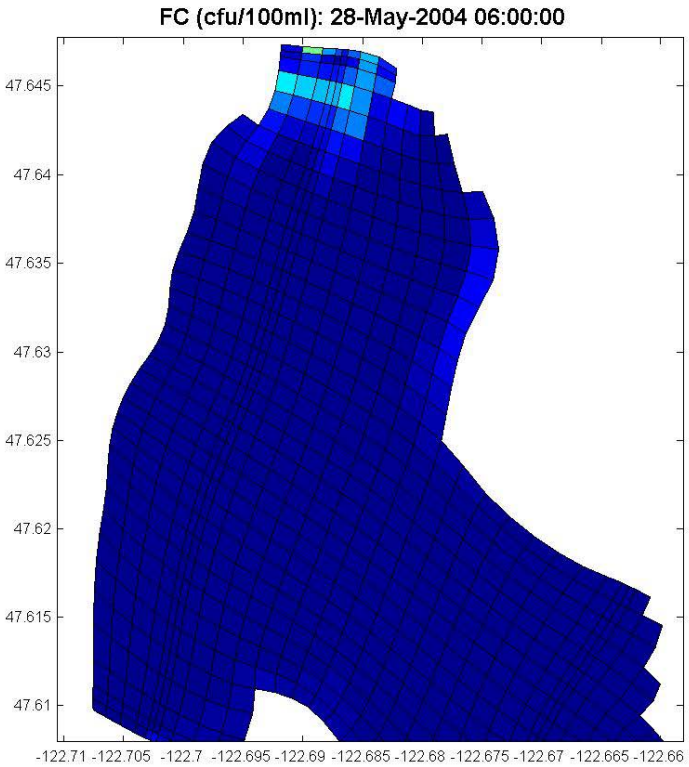
Future Expansive Build-Out Impervious Area



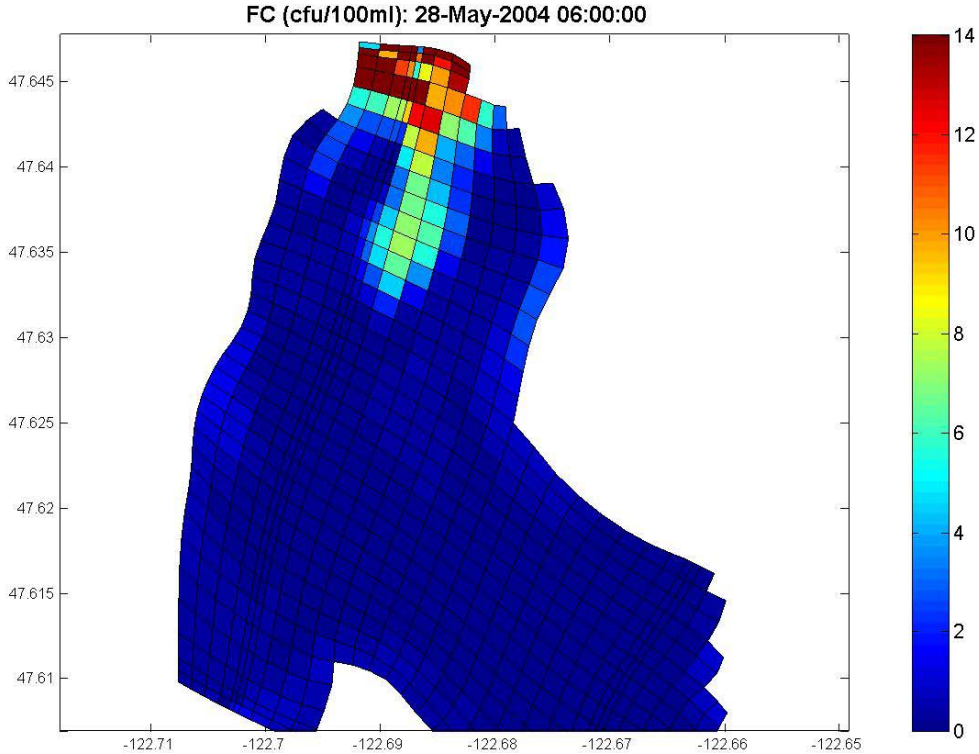

Clear i=102,j=73
Current
FUTURE
96 cfu/100 ml
168 - 946 cfu/100 ml
Part I
cfu/100 ml
Hours since 0000 19 MAY 2004
0
5
10
15
20
25
30
35
40
45
0
50
100
150
200
250

Current and Future Build Out

Current Conditions



Future Expansive Build Out



Link to Future Simulation Scenario

http://kairos.spawar.navy.mil/ENVVEST/Modelling/Sinclair_Dyes/CH3D-FC/Animations/S19.html

SPAWAR
Systems Center PACIFIC

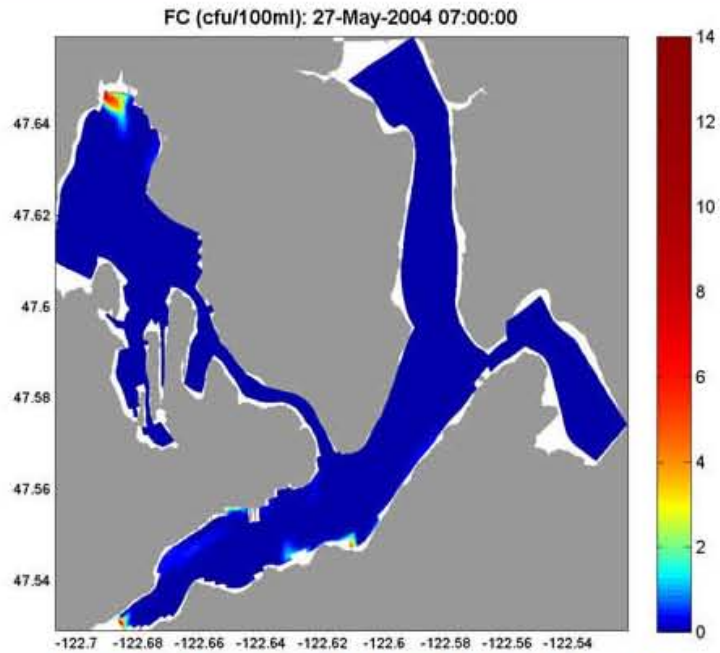
An Integrated Watershed and Receiving Water Model for Fecal Coliform Fate and Transport in Sinclair and Dyes In

R.K. Johnston, P.F. Wang, E.C. Loy, A.C. Blake, K.E. Richter, M.C. Brand, B.E. Skahill, C.W. May, V. Cullinan, W. Choi, V.S. Whitney, D.E. Leisle, a

Simulate Future Uncertainty

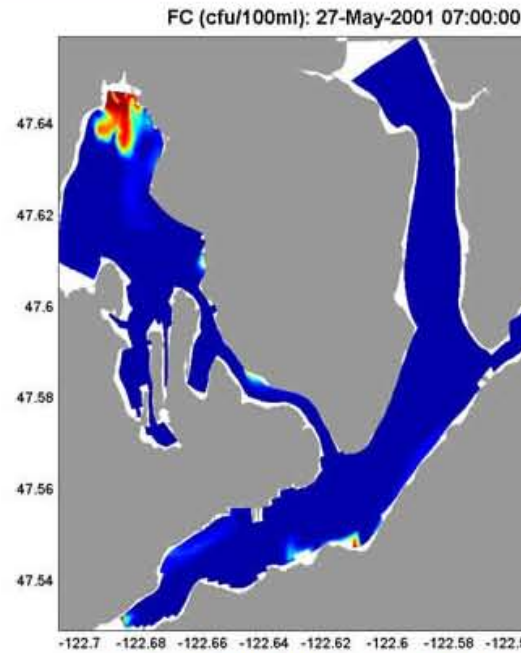
May 2004 storm event with future land use and cover (LULC) conditions in Northern Dyes Inlet assuming expansive buildout and various levels of th around streams.

S5: Base Simulation Current LULC



Base Model: May 2004 Model Verification for Dyes Inlet Stations (Average Loading)

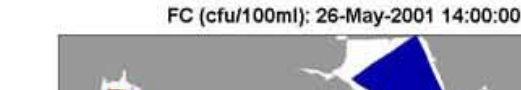
S18: Future LULC with Same CF



Future Build Out Scenario with Same Buffer

S19: Future LULC with Reduced CF Buffer

S20: Future LULC with Full CF



Future Conditions Conclusions

- **Effect of Future Build Out on FC Loading**

  Low confidence because future is unknown

  Expanded Build Out would likely increase the frequency, magnitude, extent, and duration of FC levels exceeding water quality standards through out the watershed

- **Likely that any actions that effectively eliminate or reduce current problems would also be effective in addressing future problems**

TMDL Simulation Results

- TMDL Simulations for WY2003
  - Actual Conditions
  - 100/200 Simulation (Part I)
  - 200/400 Simulation (Part II)
  - WY2003 Observed Data

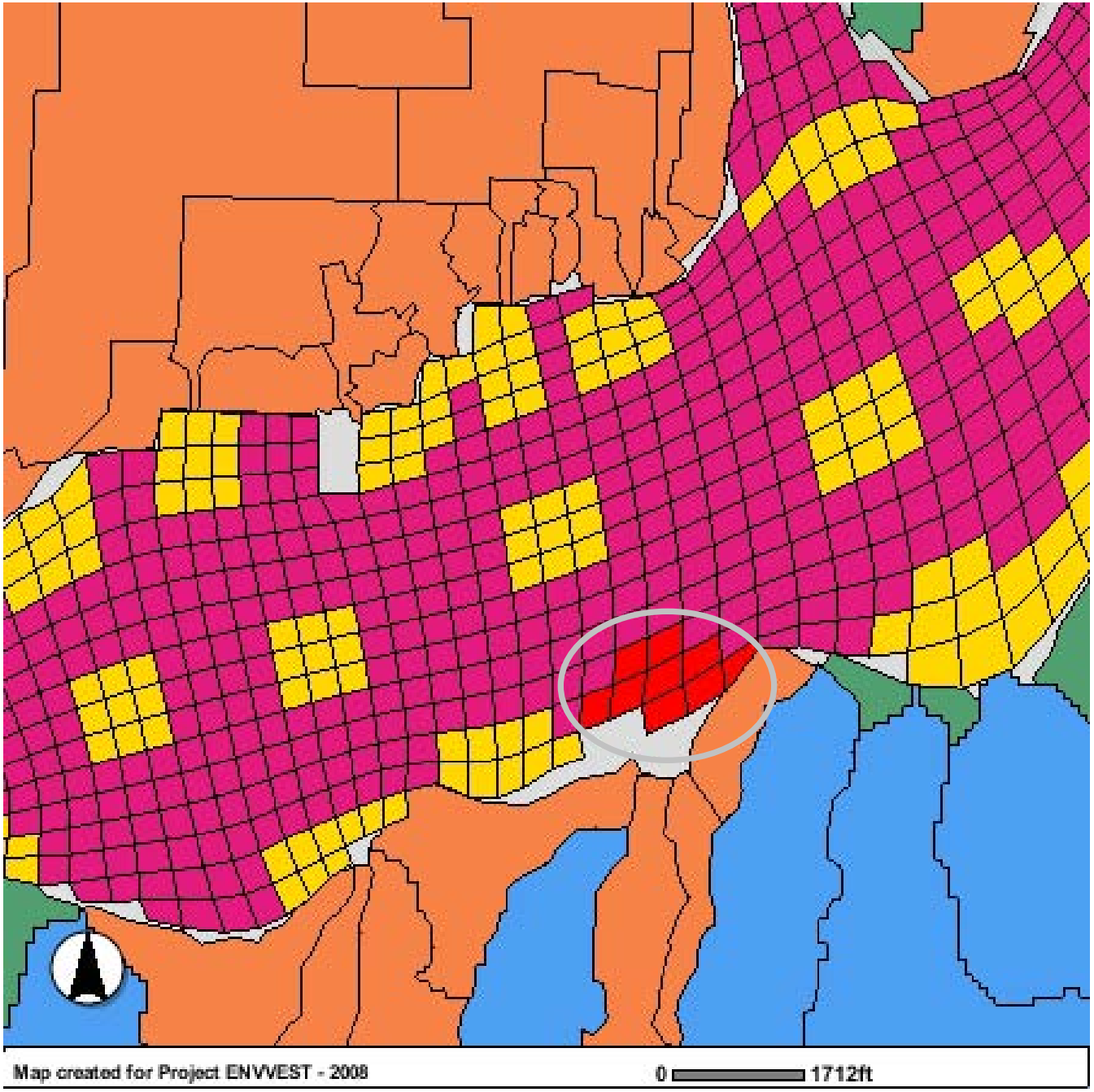
Performers: Drs. PF Wang, Woohee Choi, SSC-Pacific
Reviewers: Dr. Mindy Roberts and Sally Lawrence, Ecology
Mindy Fohn, Stan Olsen, Tom Ostrom, and
ENVVEST Working Group

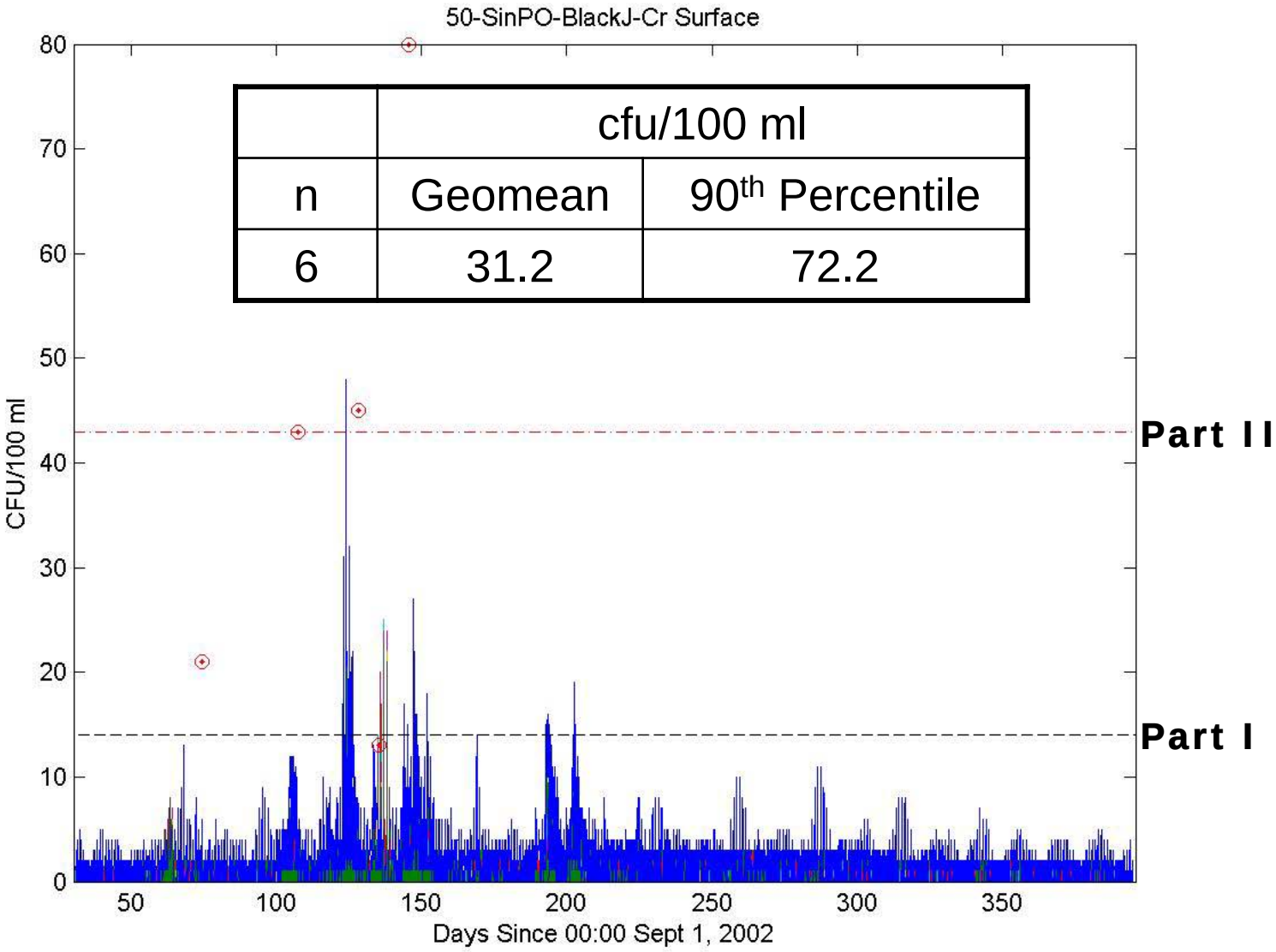
TMDL Simulation Results

- **Observed Data**
  Data Collected during WY2003
  Geomean and 90th Percentile
- **Actual Conditions (Critical Conditions)**
  “Best Estimate” of Loading
  30-day moving average of daily maximum
- **100/200 TMDL Simulation (Part I)**
  Streams and Stormwater set to 100 cfu/100 ml
  Treatment Plants set to 200 cfu/100 ml
  Compared to 14 cfu/100 ml (Geometric Mean)
- **200/400 TMDL Simulation (Part II)**
  Streams and Stormwater set to 200 cfu/100 ml
  Treatment Plants set to 400 cfu/100 ml
  Compared to 43 cfu/100 ml (90th Percentile)

Canary Nodes that Exceeded Standards

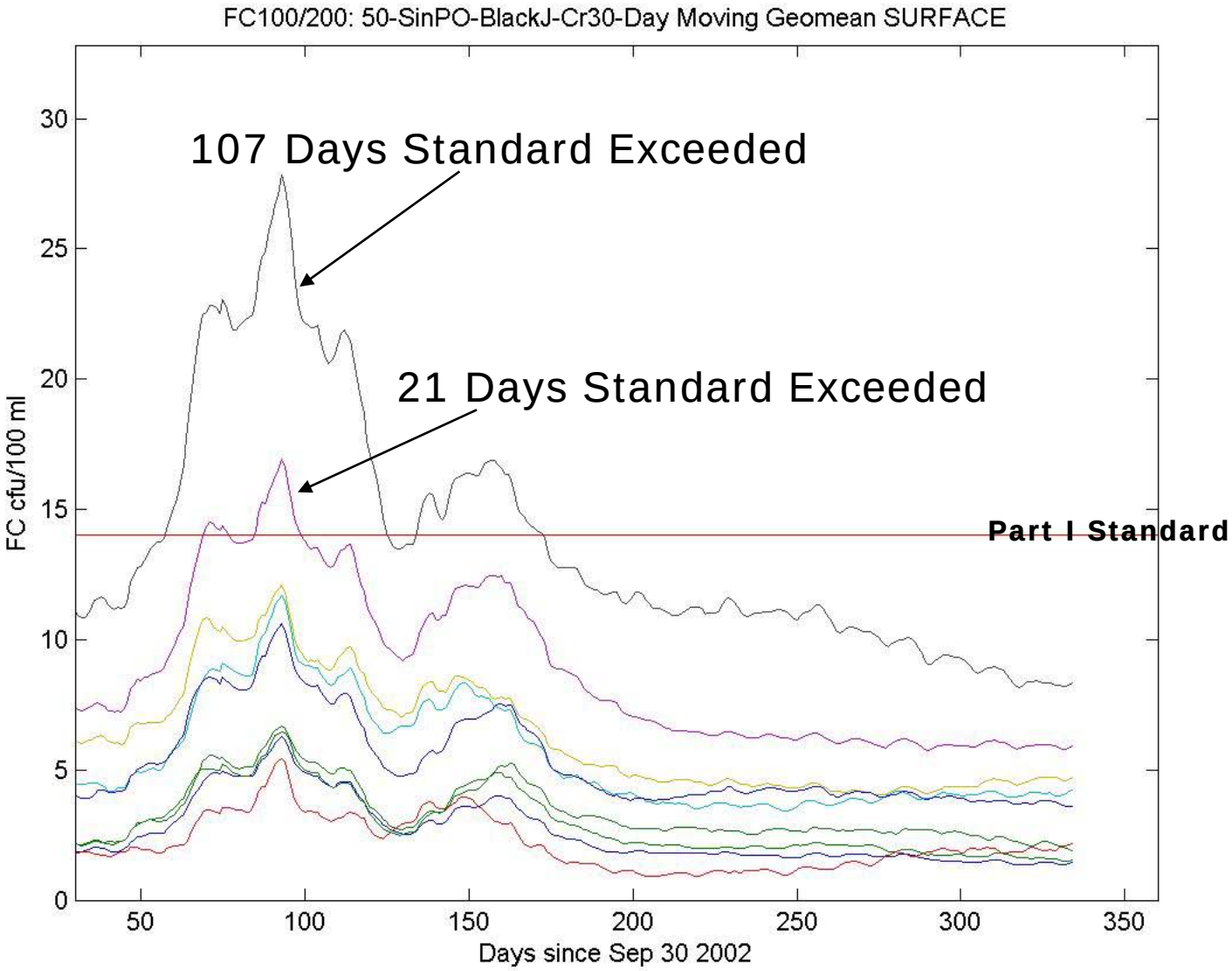
Canary Node	% Reduction Needed to Meet Standard			
	OBSERVED	SIMULATED		
		Actual	TMDL 100/200	TMDL 200/400
01-Dyes-Barker-Cr				8.40%
03-Dyes-Clear-Cr	69.30%	15.20%		9.9% - 30.6%
33-PWN-AnCov-PineR	37.50%			
35-RPass-FortWard	35.3% - 84.5%			
36-RPass-LynnwoodC	80.7% - 84.5%			
43-Sin-Gorst-Cr		24.70%	14.7% - 77.0%	14.6% - 78.5%
49-Sin-SNO3-PTOW			8.6% - 45.1%	0.2% - 37.3%
50-SinPO-BlackJ	40.4% - 55.1%	4.10%	1.9% - 49.7	14.9% - 47.4%
51-SinPO-KarcherC	15.00%			


Map created for Project ENVVEST - 2008
0
1712ft

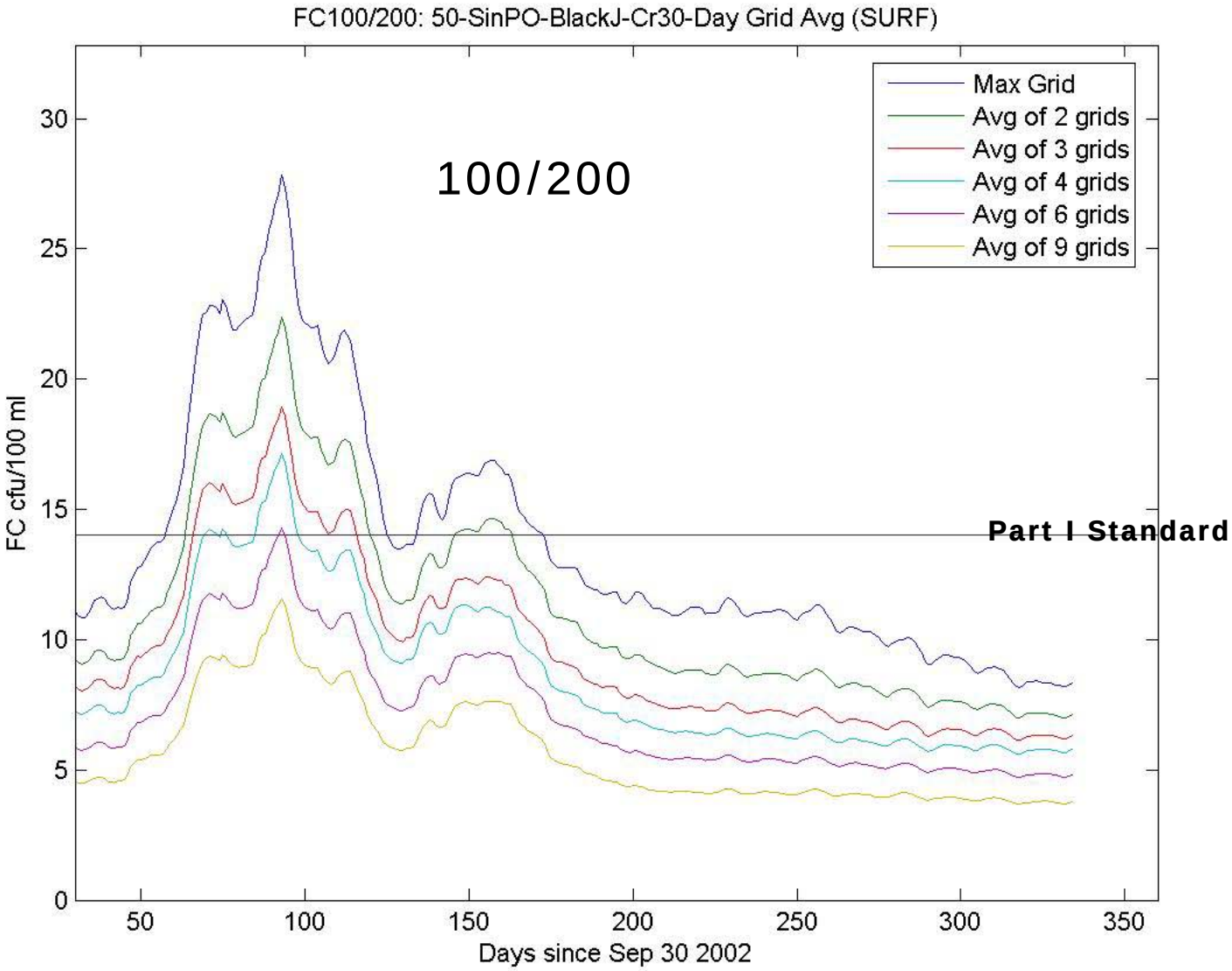


	cfu/100 ml	
n	Geomean	90th Percentile
6	31.2	72.2

Blackjack Cr. – 30 day moving average of daily max 100/200 Geomean



Blackjack Cr. – 30 day moving average of daily max Averaged by Grids

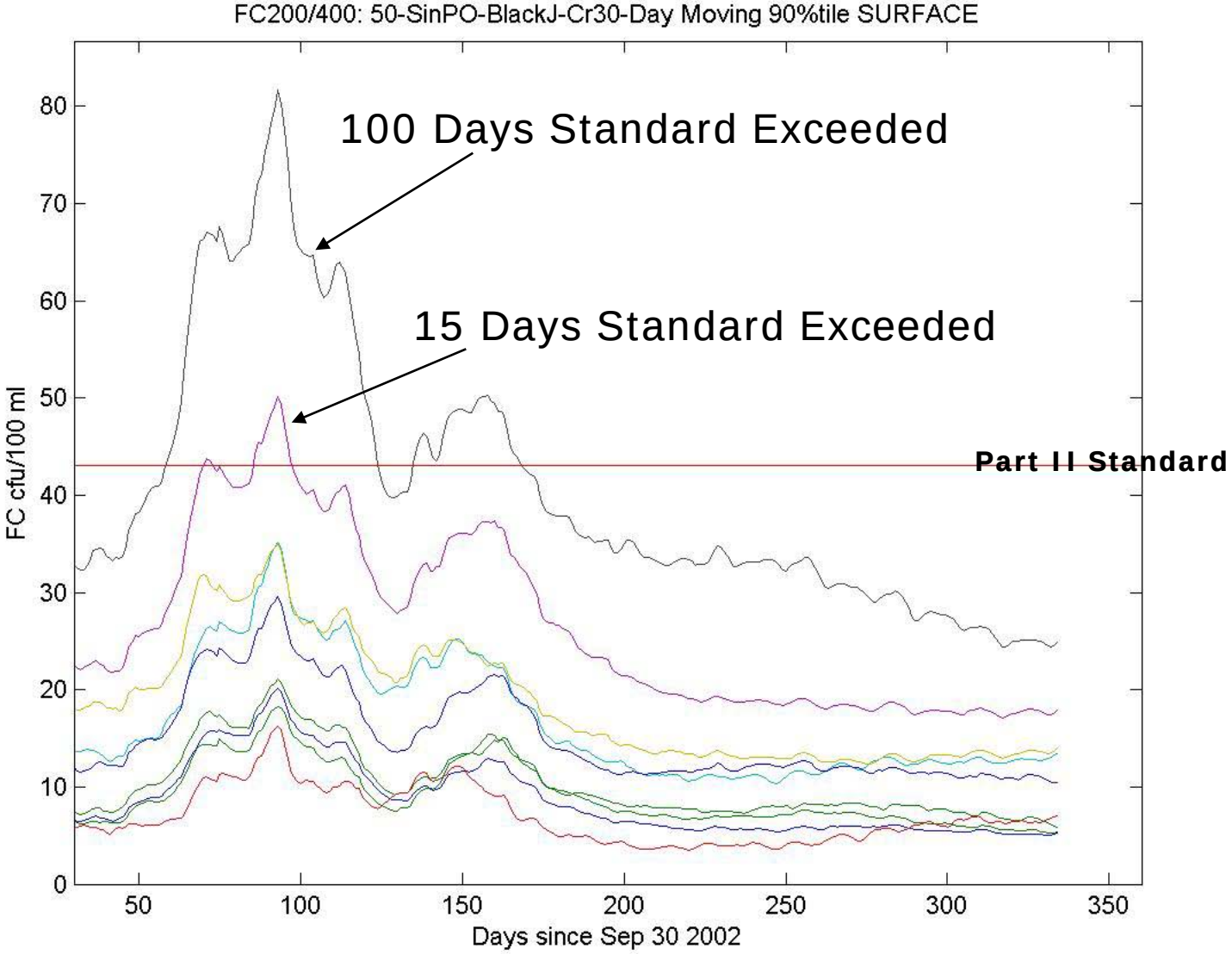


Reduction Required (Part I)

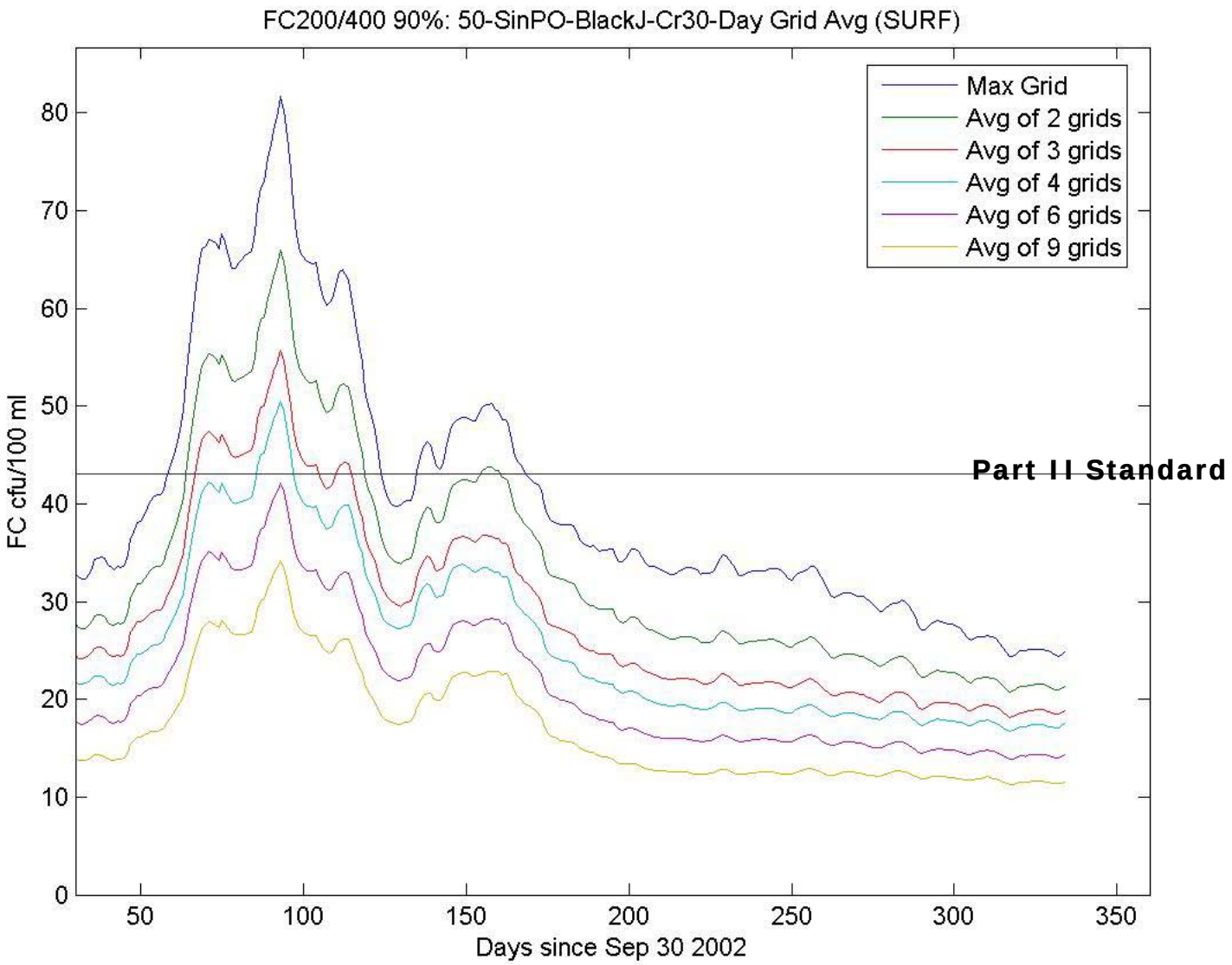
	Average of highest 1/2/3/4/6/9 grid cells 30-Day Moving GeoMean of Daily Max				50-SinPO-BlackJ-Cr	
	Average		Maximum		Reduction Needed	
	surface	depth-avg	surface	depth-avg	Average	Maximum
max grid	13.4	13.4	27.8	27.8	Meets Standard	49.7%
avg of 2 girds	11.0	11.0	22.4	22.4		37.4%
avg of 3 girds	9.4	9.4	19.0	19.0		26.1%
avg of 4 girds	8.4	8.4	17.1	17.1		18.3%
avg of 6 girds	7.0	7.0	14.3	14.3		1.9%
avg of 9 girds	5.5	5.2	11.6	10.6		OK

Target Reduction Needed to Meet Part I of Standard: 37.4%

Blackjack Cr. – 30 day moving average of daily max 200/400 90th Percentile



200/400 90th%


FC200/400 90%: 50-SinPO-BlackJ-Cr30-Day Grid Avg (SURF)
Max Grid
Avg of 2 grids
Avg of 3 grids
Avg of 4 grids
Avg of 6 grids
Avg of 9 grids
Part II Standard
FC cfu/100 ml
0
10
20
30
40
50
60
70
80
50
100
150
200
250
300
350
Days since Sep 30 2002

Reduction Required (Part II)

	Average of highest 1/2/3/4/6/9 grid cells 30-Day Moving 90th% of Daily Max				50-SinPO-BlackJ-Cr	
	Average		Maximum		Reduction Required	
	surface	depth-avg	surface	depth-avg	Average	Maximum
max grid	39.8	39.8	81.7	81.7	Meets Standard	47.4%
avg of 2 girds	32.9	32.9	65.9	65.9		34.8%
avg of 3 girds	28.1	28.1	55.6	55.6		22.7%
avg of 4 girds	25.2	25.2	50.5	50.5		14.9%
avg of 6 girds	20.9	20.9	42.1	41.7		OK
avg of 9 girds	16.7	15.4	34.2	31.2		OK

Target Reduction Needed to Meet Part II of Standard: 34.8%

Target Reduction Needed to Meet Part I of Standard: **37.4%**

Summary of TMDL Targets for Marine Waters

Canary Node	% Reduction Needed to Meet Standard				
	OBSERVED	SIMULATED			TMDL Target Reduction
		Actual	TMDL 100/200	TMDL 200/400	
01-Dyes-Barker-Cr				8.40%	
03-Dyes-Clear-Cr	69.30%	15.20%		9.9% - 30.6%	**27%**
33-PWN-AnCov-PineR	37.50%				
35-RPass-FortWard	35.3% - 84.5%				
36-RPass-LynnwoodC	80.7% - 84.5%				
43-Sin-Gorst-Cr		24.70%	14.7% - 77.0%	14.6% - 78.5%	**75%**
49-Sin-SNO3-PTOW			8.6% - 45.1%	0.2% - 37.3%	
50-SinPO-BlackJ	40.4% - 55.1%	4.10%	1.9% - 49.7	14.9% - 47.4%	**37%**
51-SinPO-KarcherC	15.00%				

Conclusions

Model Evaluation

– How good are the predictions?

- **Very High Confidence that the model is able to simulate watershed scale FC loading, fate, and transport in the Inlets**
- **Predictions are Acceptable within limitations and areas under predicted by model were identified**

Model Sensitivity and Uncertainty

– What are the most important factors?

- **FC Loading Concentration**
- **FC Die Off and Dispersion**

Simulations for TMDL

- **– Model can be used to define TMDL targets**

Acknowledgements

Thank You!

Brian Skahill, ERDC
Chris May & Valerie Cullinan, BMSL
PF Wang, Woohee Choi, Erin Carlson, Amy Blake, Ken Richter, Marissa Brand, & Chris Kyburg SSC-SD
Vickie Whitney, Dwight Leisle, Bruce Beckwith, & Jerry Sherrell PSNS&IMF
Mindy Roberts, Sally Lawrence Ecology
And other members of the ENVVEST Technical Working Group

Links

Link to CH3D-FC Simulation Results Page
http://environ.spawar.navy.mil/Projects/ENVVEST/index.html

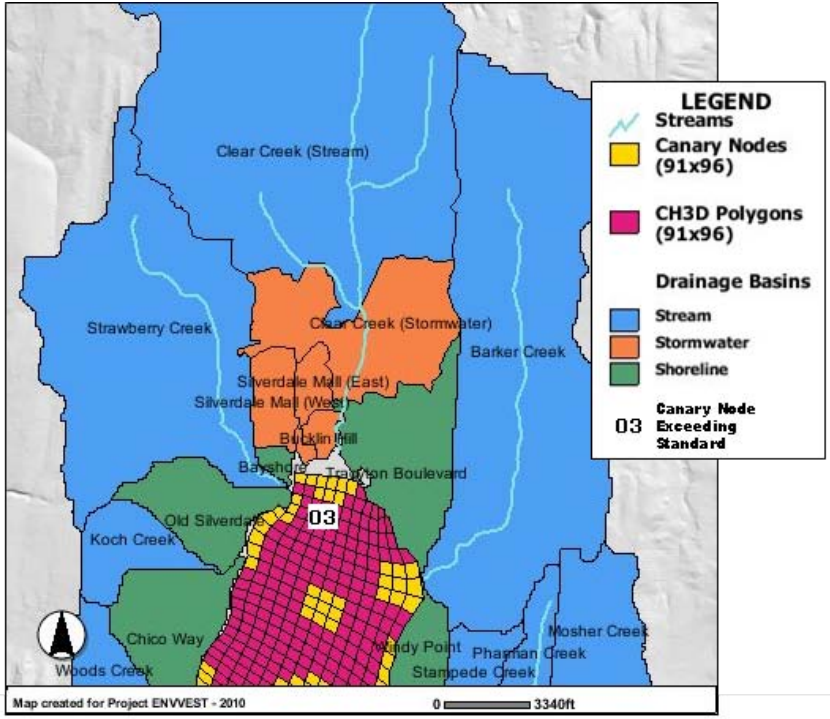
Link to ENVVEST Spatial Viewer
http://kairos.spawar.navy.mil/Website/spatialviewer

Link to Ecology's Sinclair/Dyes Inlet Web Site
http://www.ecy.wa.gov/programs/wq/tmdl/sinclair-dyes_inlets/index.html

Backup Slides

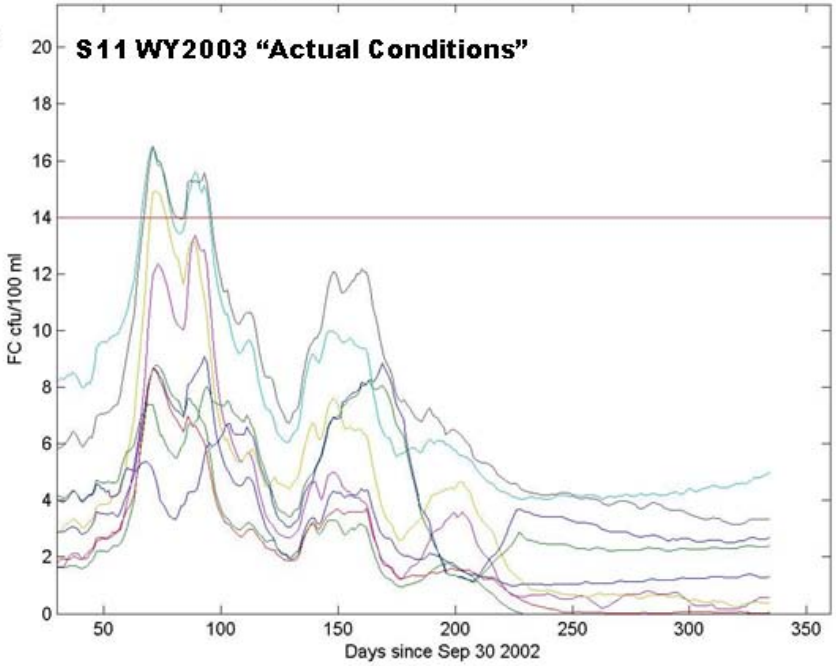
Clear/Strawberry Cr.

A.



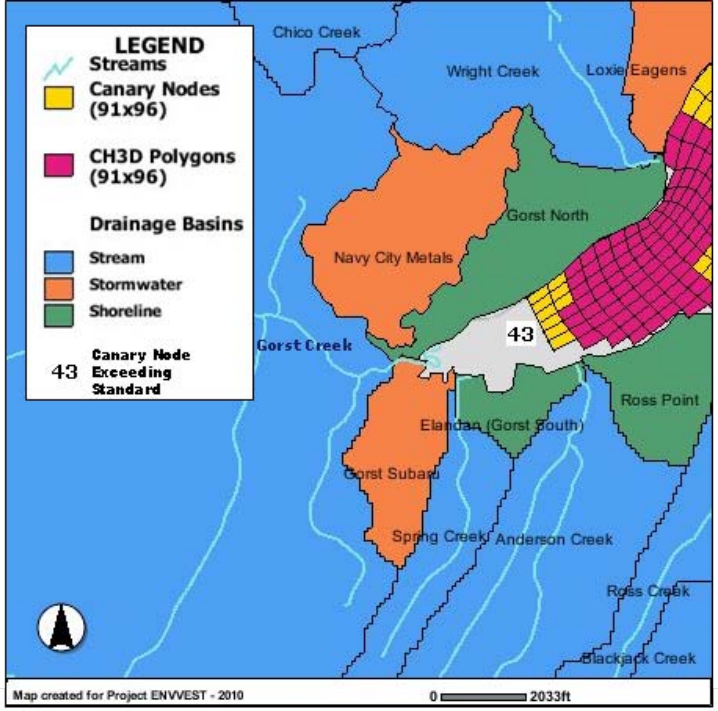
WY2003-91x96: 03-Dyes-Clear-Cr--30-Day Moving Geomean SURFACE

B.

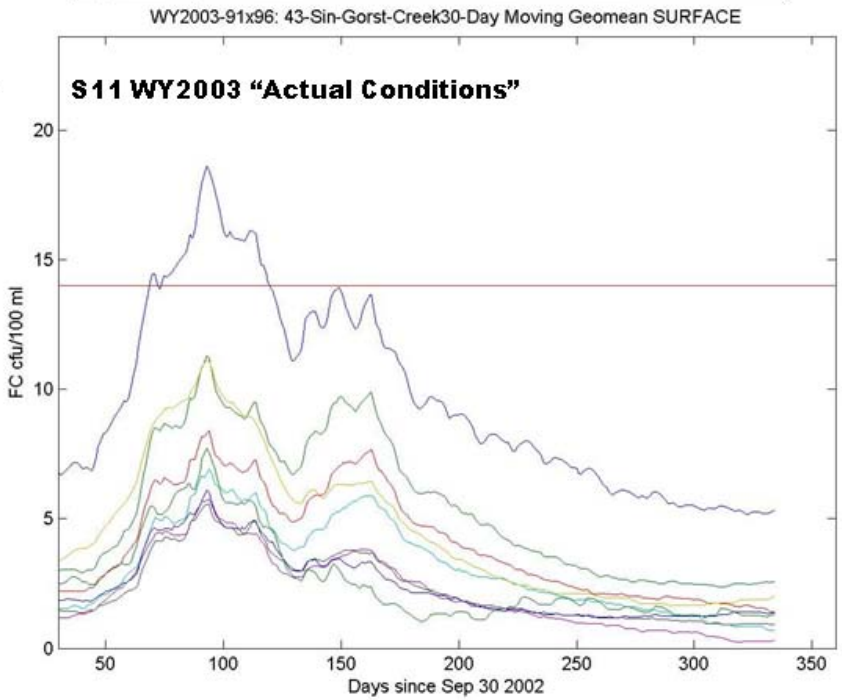


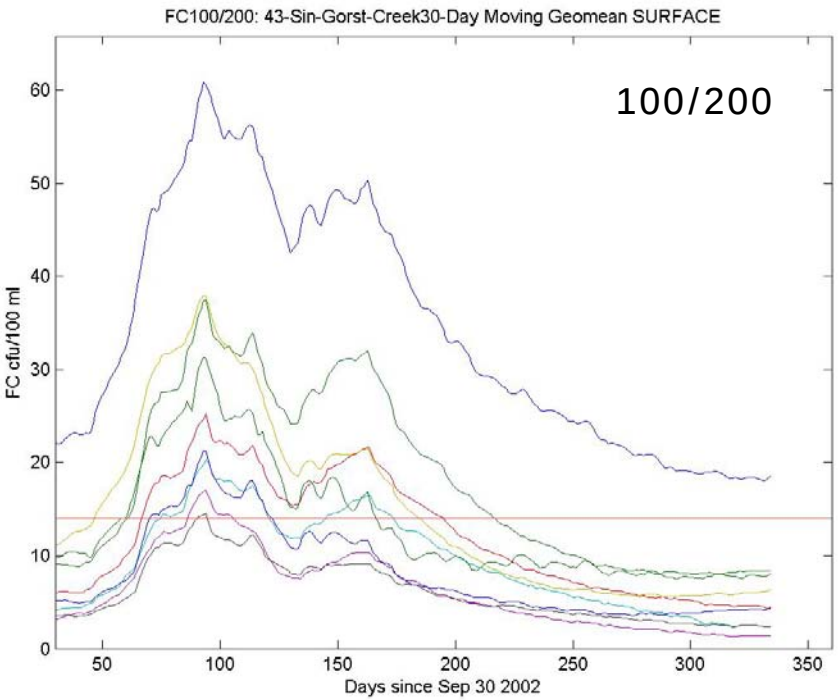
Gorst Creek

A.

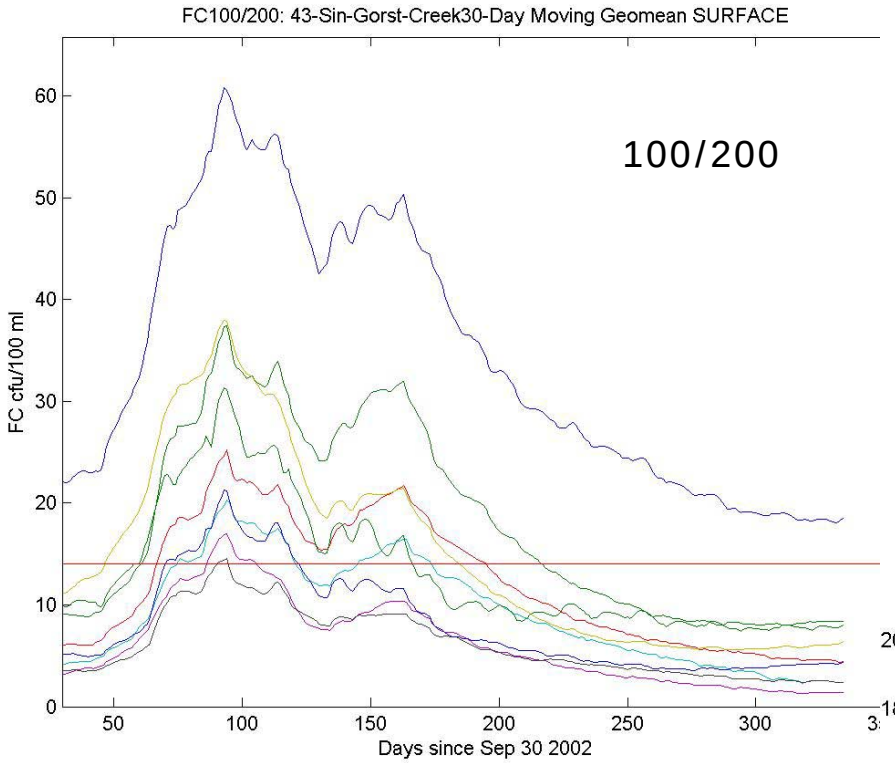


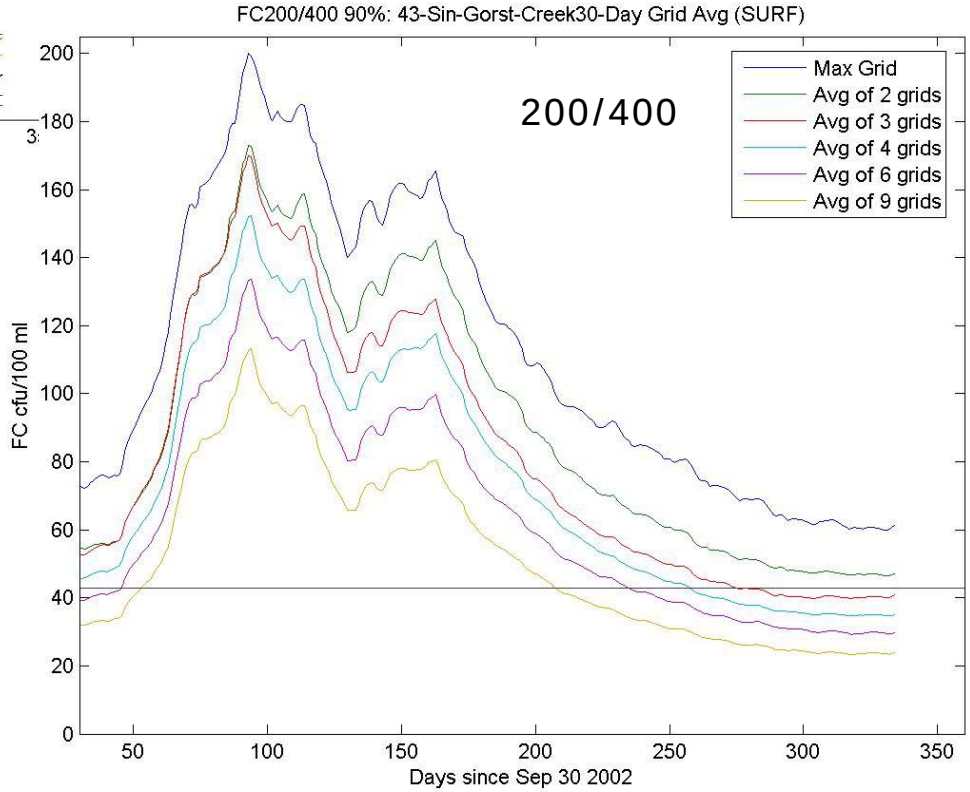
B.



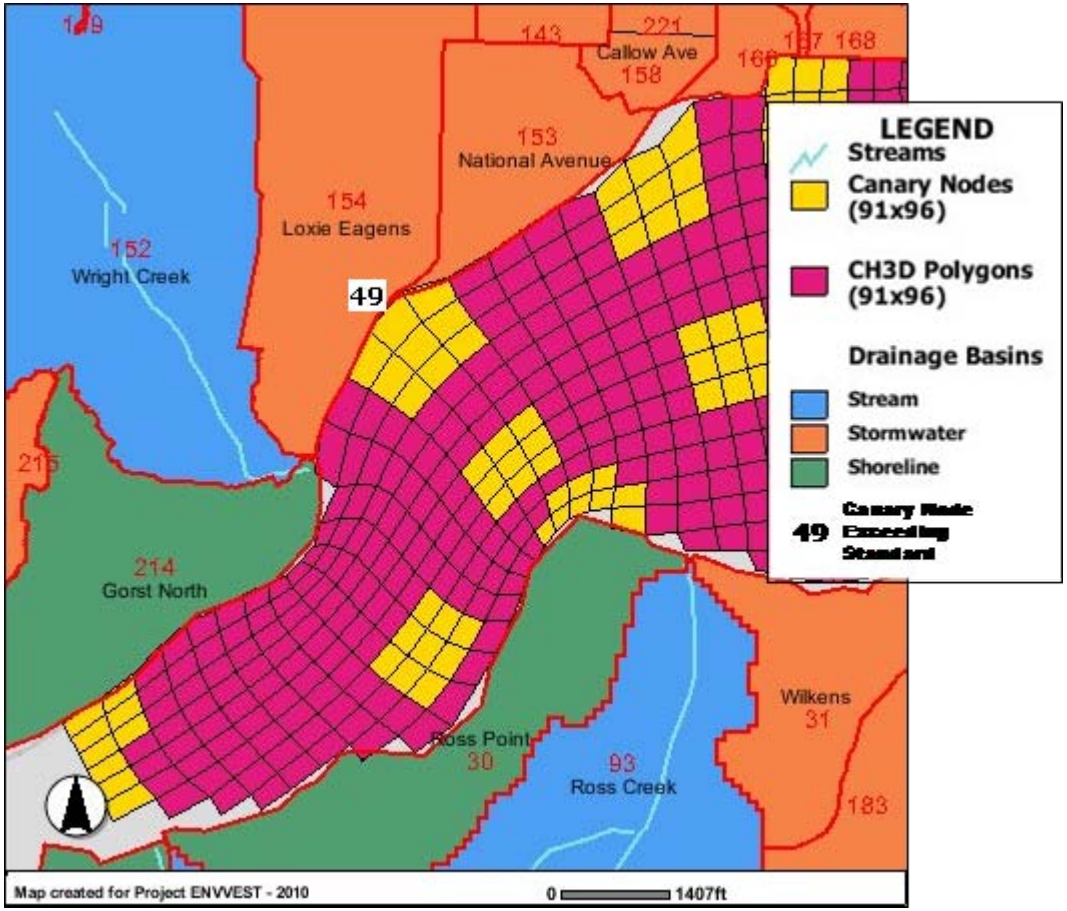


Gorst Creek

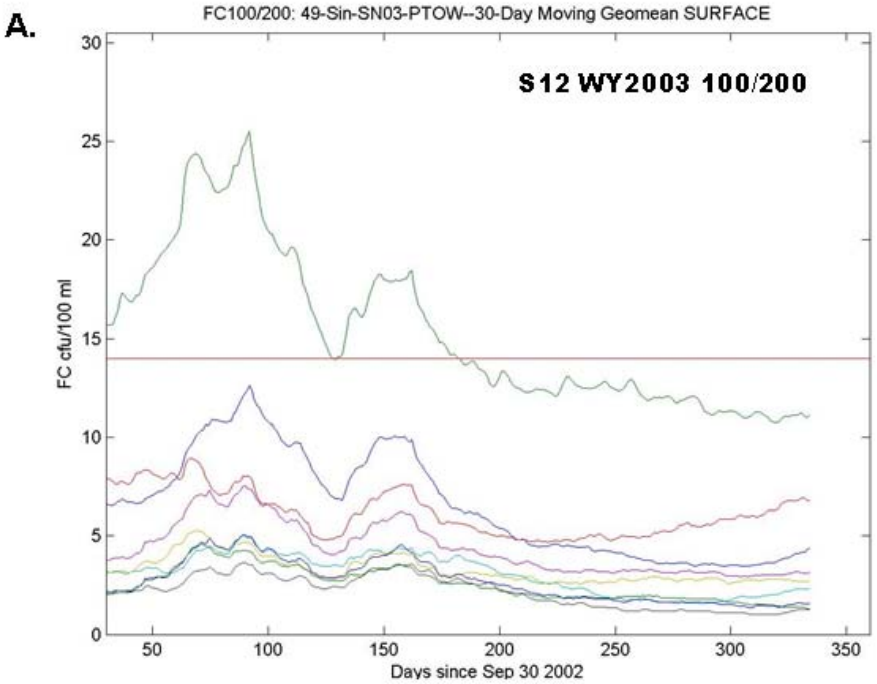

FC100/200: 43-Sin-Gorst-Creek30-Day Moving Geomean SURFACE
100/200
FC cfu/100 ml
Days since Sep 30 2002

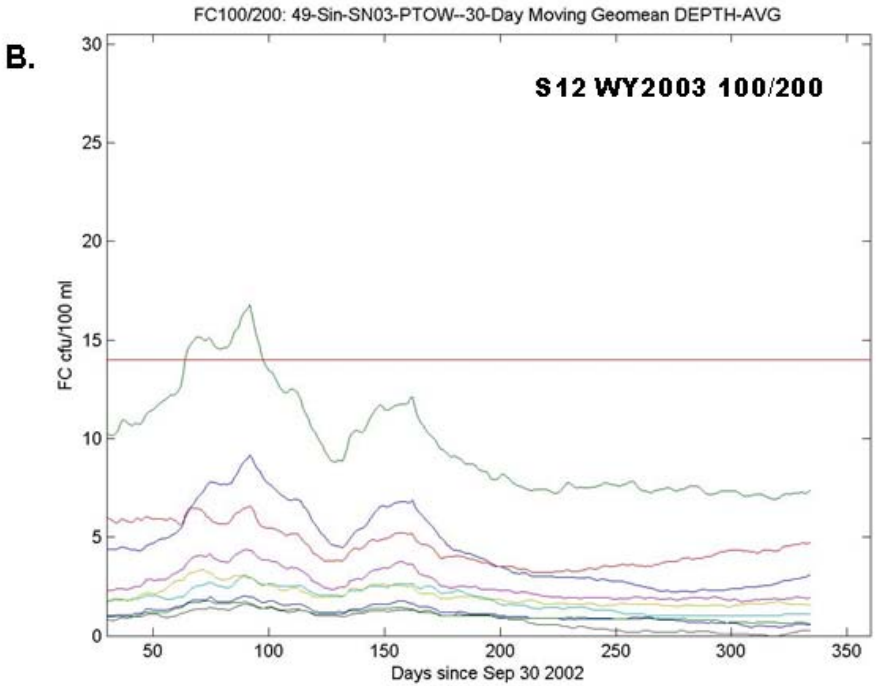

FC200/400 90%: 43-Sin-Gorst-Creek30-Day Grid Avg (SURF)
200/400
Max Grid
Avg of 2 grids
Avg of 3 grids
Avg of 4 grids
Avg of 6 grids
Avg of 9 grids
FC cfu/100 ml
Days since Sep 30 2002

SN03-POTW

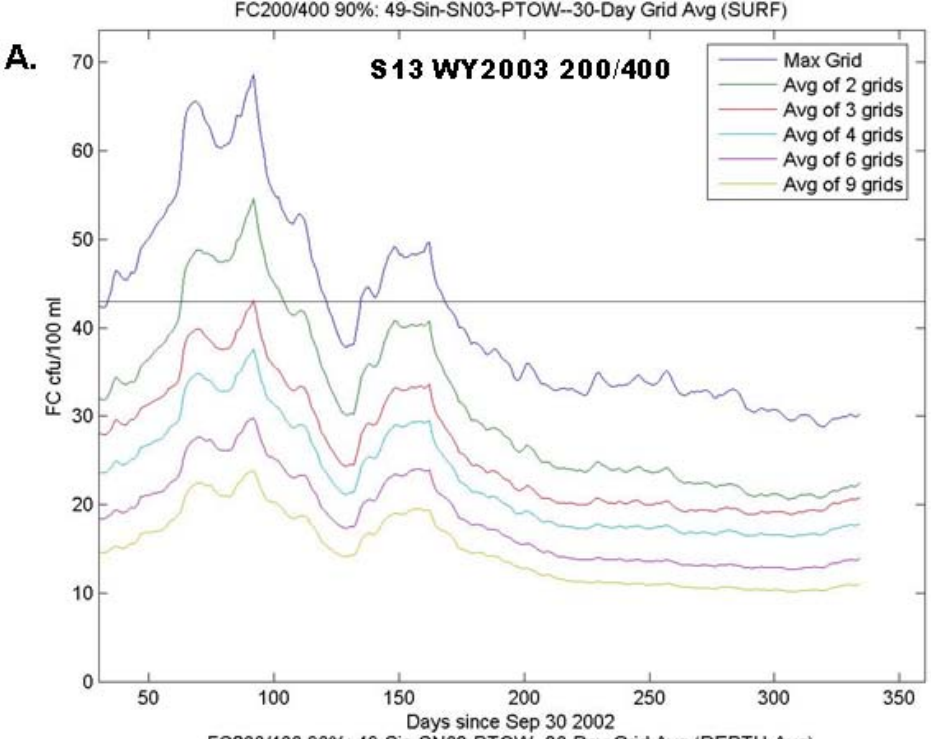

143
221
Callow Ave
158
168
153
National Avenue
154
Loxie Eagens
152
Wright Creek
49
215
214
Gorst North
Ross Point
30
93
Ross Creek
Wilkens
31
183
LEGEND
Streams
Canary Nodes (91x96)
CH3D Polygons (91x96)
Drainage Basins
Stream
Stormwater
Shoreline
49 Canary Node Exceeding Standard
Map created for Project ENVVEST - 2010
0
1407ft

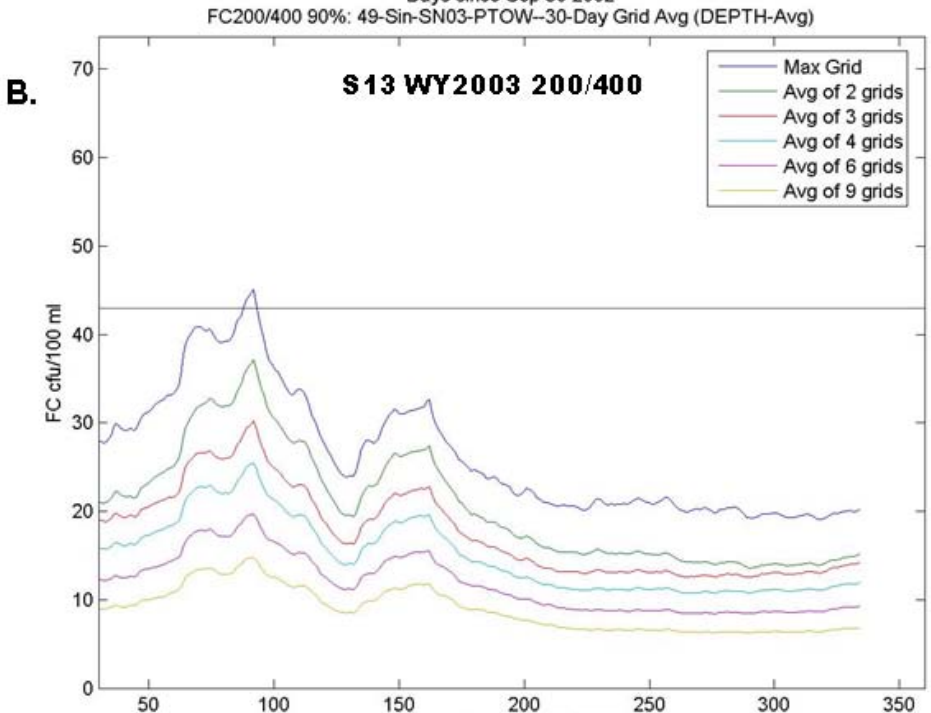
SN03-POTW


A.
FC100/200: 49-Sin-SN03-PTOW--30-Day Moving Geomean SURFACE
S12 WY2003 100/200
FC cfu/100 ml
Days since Sep 30 2002


B.
FC100/200: 49-Sin-SN03-PTOW--30-Day Moving Geomean DEPTH-AVG
S12 WY2003 100/200
FC cfu/100 ml
Days since Sep 30 2002

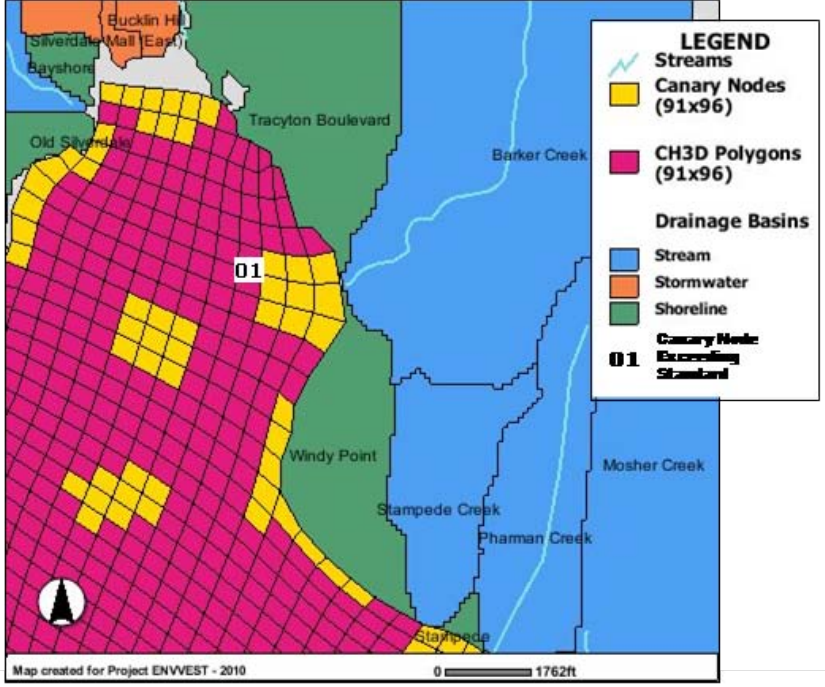
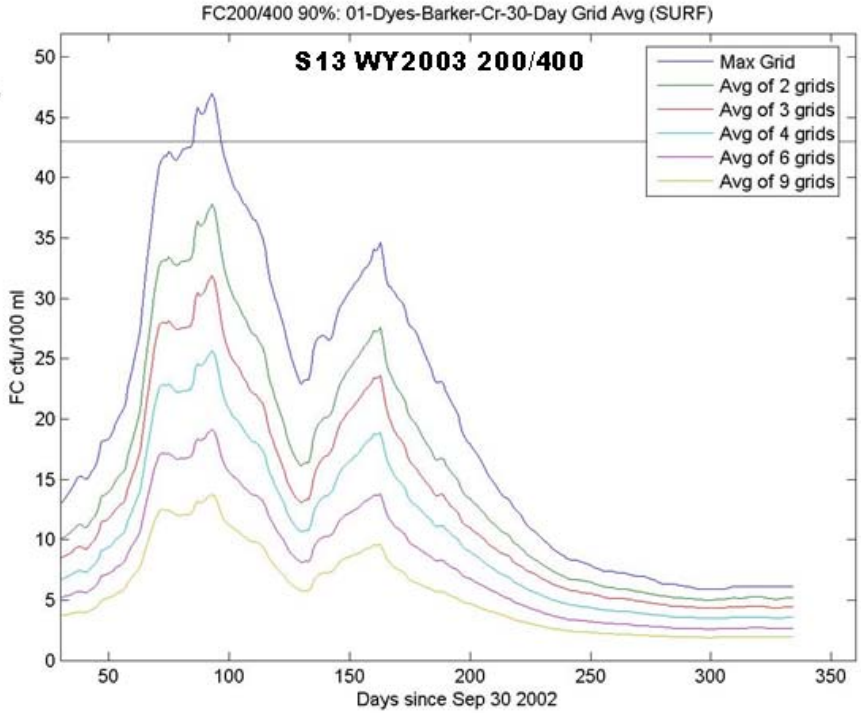
SN03-POTW


FC200/400 90%: 49-Sin-SN03-PTOW--30-Day Grid Avg (SURF)
A.
S13 WY2003 200/400
Max Grid
Avg of 2 grids
Avg of 3 grids
Avg of 4 grids
Avg of 6 grids
Avg of 9 grids
FC cfu/100 ml
0
10
20
30
40
50
60
70
50
100
150
200
250
300
350
Days since Sep 30 2002


FC200/400 90%: 49-Sin-SN03-PTOW--30-Day Grid Avg (DEPTH-Avg)
B.
S13 WY2003 200/400
Max Grid
Avg of 2 grids
Avg of 3 grids
Avg of 4 grids
Avg of 6 grids
Avg of 9 grids
FC cfu/100 ml
0
10
20
30
40
50
60
70
50
100
150
200
250
300
350

Barker Creek

A.



B.