REGRESSION MODELING APPROACH TO DRINKING WATER EXPOSURE ASSESSMENTS

Prepared for the Committee to Advise on Reassessment And Transition (CARAT)
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The Environmental Fate and Effects Division in OPP has been estimating pesticide concentrations in surface water through a combination of modeling and monitoring for the purposes of ecological risk assessment since the late 1980's. Since the passage of FQPA, the need has arisen to integrate risk posed by exposure to pesticides in drinking water with risk posed by exposure through other routes. In response to this need, new modeling scenarios have been developed which better represent pesticide concentrations in waters that might serve as drinking water sources for human consumption. During this process, the Agency has developed methods which can quite accurately predict the maximum pesticide concentration in surface water which may feed into a community water system (CWS). These methods are valuable as screening tools to cheaply and quickly separate out those chemicals not likely to pose a risk to human health. They are not useful, however, as tools for quantitatively assessing the risk potentially posed by chemicals which do not pass this screen. A method is therefore needed to estimate pesticide concentrations in drinking water at sites other than a single, high exposure site. This will allow a linkage to be made between population and the pesticide concentration in the water the consume.

OPP has been working with the US Geological Survey for a number of years in estimating pesticides concentrations in both surface and ground water for risk assessment purposes. In mid 1999, EFED began exploring two USGS projects aimed at estimating distributions of contaminants at the locations of drinking water intakes based on concentrations measured at other locations. The USGS methods are based on the premise that pesticide concentrations found in drinking water are not random but are in large part determined by the amount, method and location of pesticide application, by the physical characteristics of the watersheds in which the CWS's are located and by other environmental factors (such as rainfall) which cause the pesticide to move from the location where it was applied.

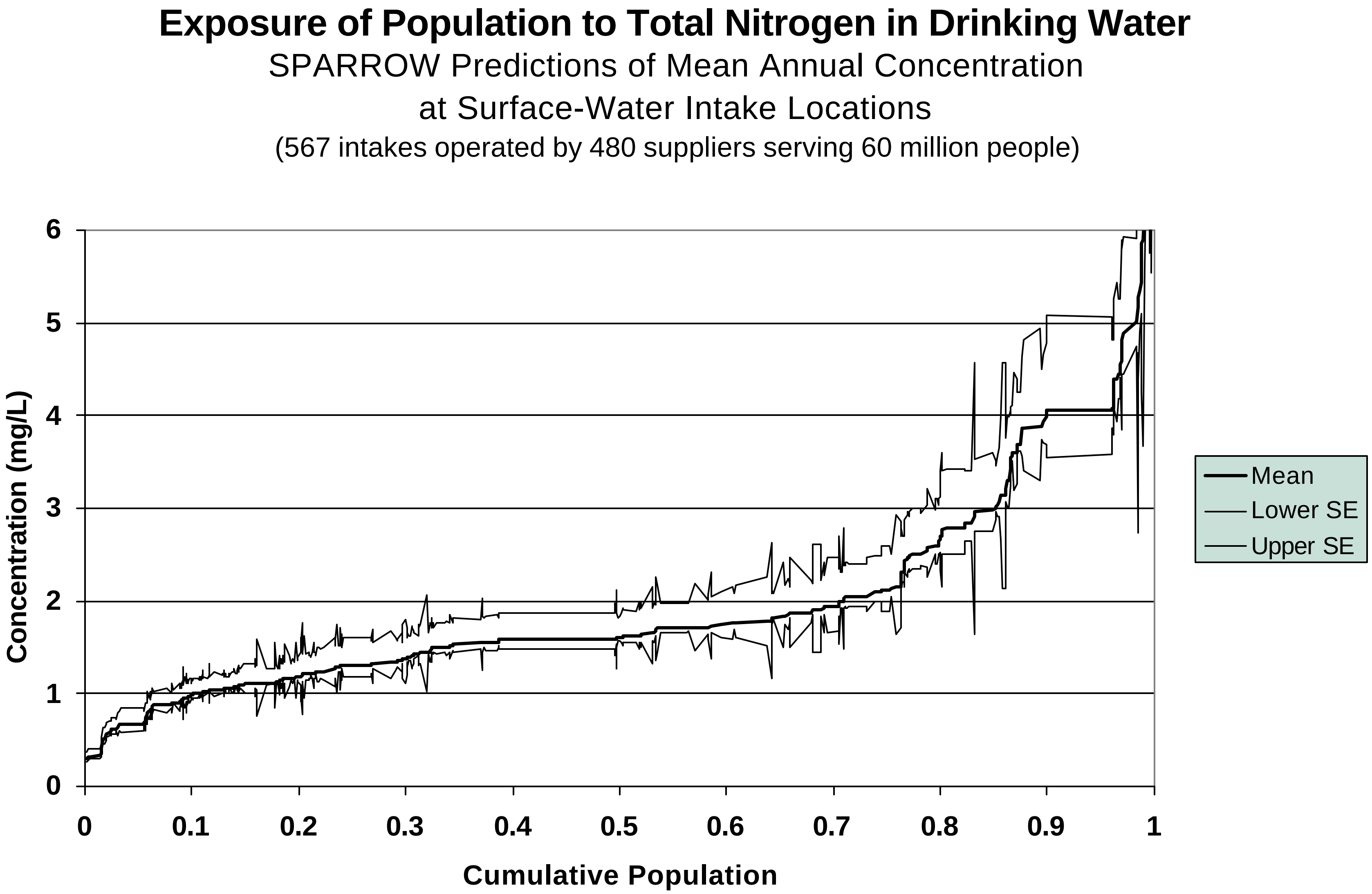
USGS scientists have investigated which of these factors are most important in estimating pesticide concentrations in the watersheds where monitoring data have been collected. They have then used this knowledge to develop equations that use these pesticide and environmental variables to predict concentrations at sites at which they have not made measurements. Figure 1 attached shows the results of this process for total nitrogen in 567 drinking water systems serving 60 million people. Risk managers can use this type of data and output on pesticides to assess the magnitude of the exposure across the country and identify regions deserving special attention. Up to this point, OPP has been able to estimate only the concentration in the upper right hand corner of this graph. Upper end exposure levels were estimable, but it was not possible to link this concentration with a specific site or region or with a specific number of individuals. Estimating the concentration separately at each intake location allows the population link to be established.

UGSG began this modeling approach by looking at nutrient concentrations but also had developed a plan to carry out the same work for pesticides at a future date. OPP asked the USGS to accelerate its investigation of pesticides by attempting to estimate the concentrations of atrazine at these same drinking water intake locations. This work was completed in late 1999 and the results were presented to a Science Advisory Panel (SAP) meeting in March 2000. Figures 2, 3 and 4 attached show the results of this work. Figure 2 shows the factors that were investigated as potential predictors of pesticide concentrations. Figure 3 shows the importance of each of the estimator variables in the equations that were established. Figure 4 shows the population-weighted distribution which was developed for atrazine. It should be noted that it is the form of this graph that is important and not the actual atrazine concentration values.

In response to OPP questions, the SAP agreed with OPP that the use of population-weighted distributions to represent pesticide concentrations in drinking water is very appropriate for use in FQPA risk assessments and further development is warranted. They also liked the idea of building a level of predictive capability into the regression approaches to allow estimation of distributions of concentrations for chemicals for which there is little or no measured data.

During the period since the March SAP presentation, additional work has been undertaken on both of the methods under development. The results of this development work were presented to another SAP meeting in late September. For both approaches, development work has included checking the model against new data sets of measured pesticide concentration values. A comparison of both the older and newer measured data to model estimated concentration values can be seen in Figure 5 attached. Based on these results and feedback from the latest SAP, it appears reasonable to expect to be within an order of magnitude for the peaks and annual average concentrations most of the time for single sites and much more accurate for the overall distribution of concentration values across all CWS locations.

Further development of both modeling approaches is ongoing. Availability of new data, collected specifically to enhance these models will greatly improve the scope and accuracy of the model predictions.



Exposure of Population to Total Nitrogen in Drinking Water
SPARROW Predictions of Mean Annual Concentration
at Surface-Water Intake Locations
(567 intakes operated by 480 suppliers serving 60 million people)
Concentration (mg/L)
0
1
2
3
4
5
6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Cumulative Population
Mean
Lower SE
Upper SE

Figure 1

ATRAZINE REGRESSION MODELS FOR STREAMS

Log(**C**) = *a* •Log(**use/area**) - *b* •**DOF** + *c* •**DA** + *d* •**AWC** - *e* •**HGB** + *f*

Concentration Percentile

Predictor	95th	90th	75th	50th	25th	10th	Annual mean
Use Intensity (kg/km2)	+	+	+	+	+	+	+
Dunne Overland Flow (%)	--	--	--	--	--	--	--
Drainage Area (km2)	+	+	+	+	+	+	+
Available water capacity (%)	+	+	+	+	(+)	(+)	+
Soil Hydro Group B (%)	--	--	(--)	--	--	(--)	--
R-squared (% Variance Explained)	88%	90%	87%	80%	83%	80%	91%

+ = positive coefficient in model

-- = negative coefficient in model

USGS

Figure 2

POTENTIAL PREDICTORS:

Explanatory Variables Evaluated

Pesticide Use

- **Use intensity**

Physical Basin Characteristics

- **Drainage area**
- Average slope
- Average annual runoff

Weather/Climate

- Average annual precipitation
- Average annual temperature
- Average storm intensity
- Average storm duration
- Average interstorm period

Soil Properties (STATSGO)

- **Available water capacity**
- Sand, silt, clay composition
- **Hydrologic group**
- Organic matter
- Permeability

Hydrologic Parameters (TOPMODEL)

- Total overland flow
- **Dunne overland flow**
- Horton overland flow
- Subsurface contact time

Agricultural Management Practices

- Irrigation
- Artificial drainage
- Conservation tillage

Figure 3

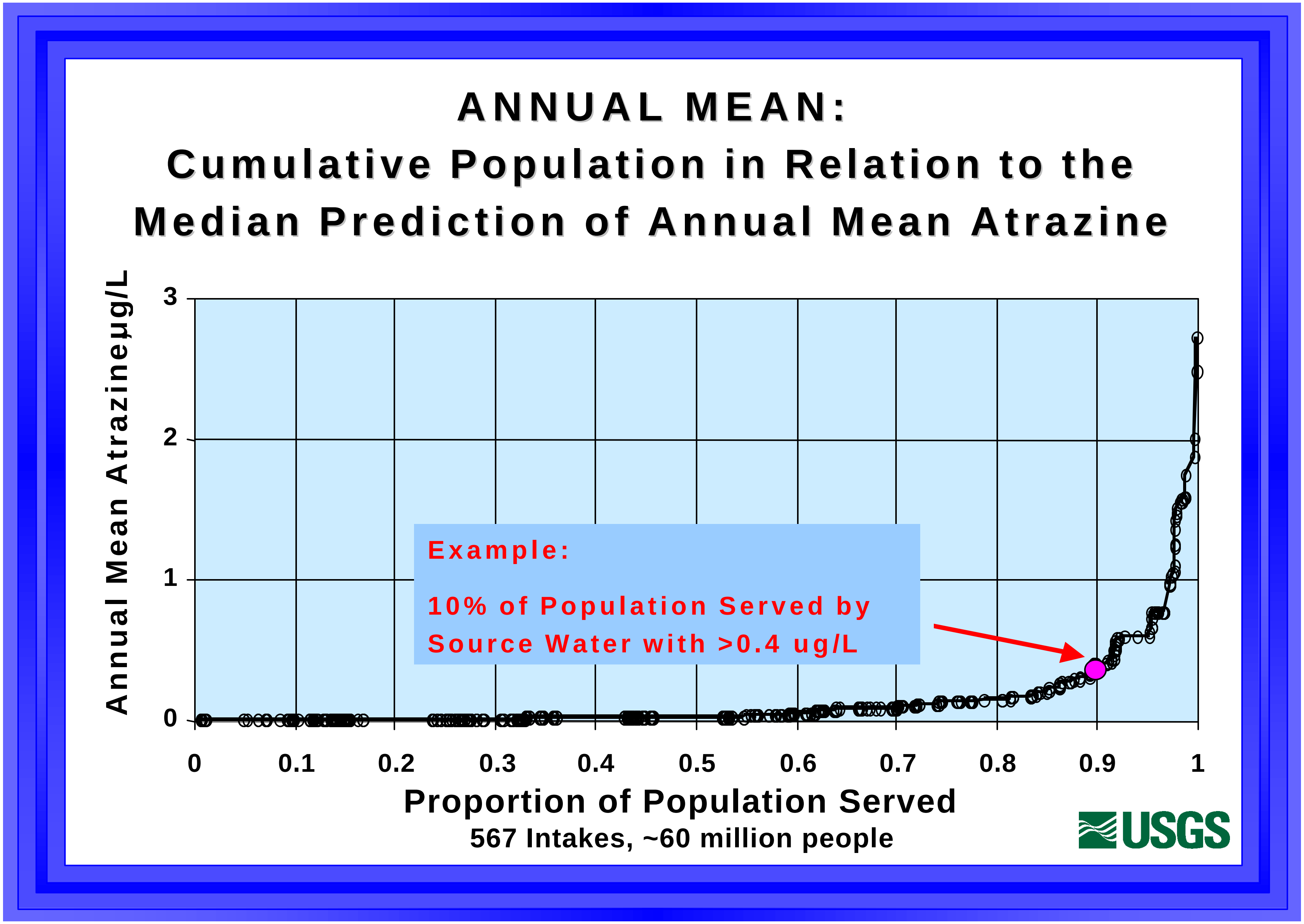
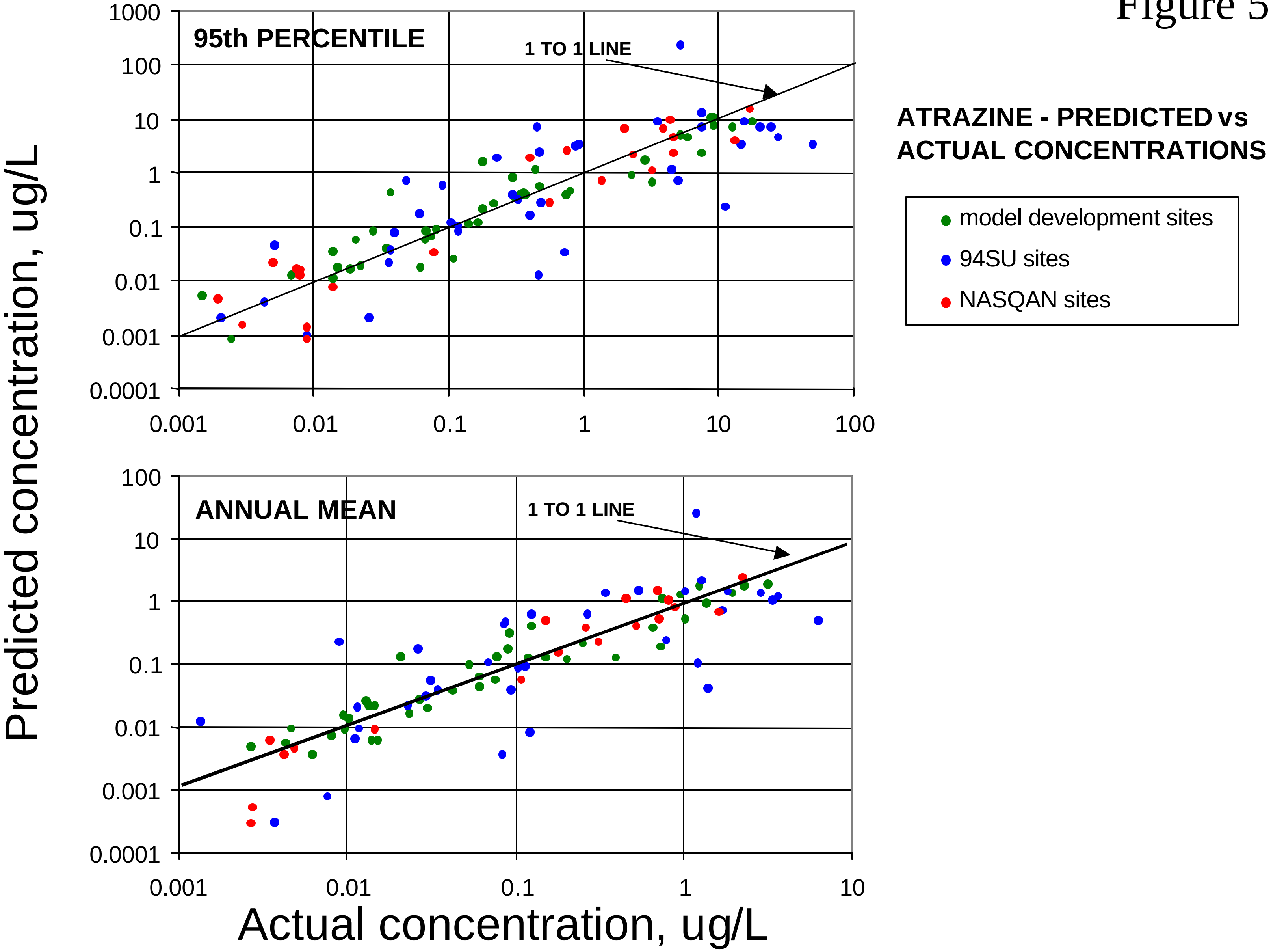

ANNUAL MEAN:
Cumulative Population in Relation to the
Median Prediction of Annual Mean Atrazine
Annual Mean Atrazine µg/L
3
2
1
0
Example:
10% of Population Served by
Source Water with >0.4 ug/L
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Proportion of Population Served
567 Intakes, ~60 million people
USGS

Figure 4

Figure 5


95th PERCENTILE
1 TO 1 LINE
1000
100
10
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10
100
ANNUAL MEAN
1 TO 1 LINE
100
10
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10
Predicted concentration, ug/L
Actual concentration, ug/L
ATRAZINE - PREDICTED vs
ACTUAL CONCENTRATIONS
model development sites
94SU sites
NASQAN sites