Integrating the National Hydrography Dataset Into RiverSpill

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The purpose of this project was to analyze the improvement in calculating the fate and transport of waterborne contaminants using the NHD with the RiverSpill modeling tool. The operational version of RiverSpill uses the Enhanced Reach File (ERF1), a 1:500,000-scale stream network. The value of ERF1 was that it contained, on a national scale, mean flow and velocity information that could be updated to reflect real-time conditions. In this pilot study, covering three hydrologic units, NHD was populated with mean flow and velocity values. This pilot data set was integrated into RiverSpill. Comparisons were made between ERF1 and NHD derived results.

Introduction

RiverSpill is a GIS based system that models the real-time transport of constituents within a river system. RiverSpill calculates time of travel and concentration based on real time stream flow measurements, decay, and dispersion of constituents introduced into surface waters. By selecting a location on a river to introduce a chemical or biological constituent, the model performs the following functions:

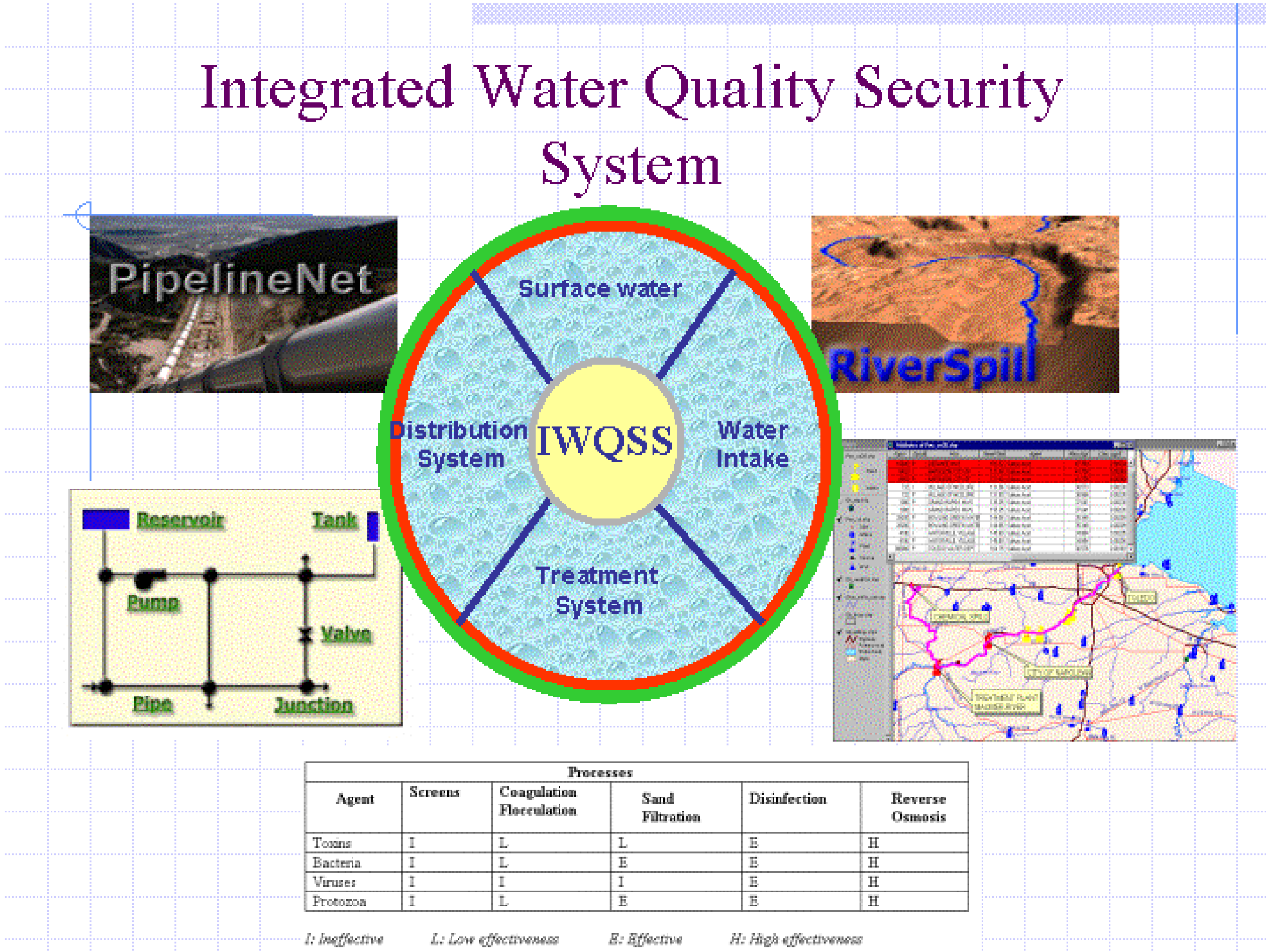
- Calculates the downstream distribution of contaminant concentrations and travel time using real-time stream flow data.
- Simulates the behavior of contaminants from instantaneous and continuous point sources.
- Tracks the chemical or biological constituent, under real time flow conditions, to a water supply intake.
- Associates an intake to a water treatment plant.
- Identifies the population served by the water treatment plant.
- Performs upstream tracing (by distance or time) to identify potential sources of contamination

Incident Command Information Tool

The US Forest Service (USFS), Environmental Protection Agency (EPA), Federal Emergency Management Agency (FEMA), Defense Threat Reduction Agency (DTRA) and the Technical Support Working Group (TSWG) have identified as a high priority, the need for protecting drinking water. An early detection of contamination and the need for information to enable incident commanders to evaluate the risks posed to the public will fulfill this need. For example, the Forest Service manages federally owned watersheds that are sources of drinking water for 3000 towns and cities nation-wide and serve a combined population of 60 million people. Forest Service employees, trained as incident commanders primarily for wildland fires, are tasked to lead the multi-agency responses to other emergencies, such as water contamination incidents, when they occur on federal land and elsewhere as needed.

Technical Description

RiverSpill is one of three components of the Integrated Water Quality Security System (IWQSS). The IWQSS (see figure 1) provides a comprehensive approach to assessing the consequences of threats to water supplies through its three modules: RiverSpill (source water), Water Treatment Processes (Filtration Plant) and PipelineNet (finished water in the distribution system).



Processes					
Agent	Screens	Coagulation Flocculation	Sand Filtration	Disinfection	Reverse Osmosis
Toxins	I	L	L	E	H
Bacteria	I	L	E	E	H
Viruses	I	I	I	E	H
Protozoa	I	L	E	E	H

I: Ineffective *L: Low effectiveness* *E: Effective* *H: High effectiveness*

Figure 1. Integrated Water Quality Security System (IWQSS)

The system contains the following models and databases:

- Stream flow and transport models
- USGS Enhanced Reach File version 1 database
- USEPA Public Water Supplies database (intakes and water treatment plants)
- USGS Real-Time Stream Flow Gauge database
- Sewage Treatment Plants
- Risk Management Plan Sites
- Dams
- Road and Railroad Stream Crossings
- Constituents of Concern

Databases

The databases required for this tool include the Enhanced River Reach File (ERF1), the USGS real-time stream flow measurements, and the EPA Safe Drinking Water Information System (SDWIS). The Arcview Network Analyst extension is used to integrate the databases and to provide the user with a tool to quickly assess the consequences of the introduction of a chemical or biological contaminant to the source waters (surface water) of a public water supply (see figure 1).

RiverSpill-NHD Pilot Study

The study area (see figure 2) for this project consisted of three hydrologic units (HUCs) in Ohio: Upper Scioto (05060001), Lower Scioto (05060002) and Paint (05060003). The increased number of river and stream segments represented in the NHD is apparent in figure 2. The three HUCs were chosen because they contained a widespread distribution of water supply intakes and USGS real-time stream flow stations that could be used for testing purposes. Four main tasks were carried out in this project: (1) assigning mean flows and velocities to NHD reaches (2) flow comparisons between ERF1, NHD and USGS Gage Measurements, (3) Time-of-Travel comparisons using flows from ERF1 and NHD and (4) Comparison of upstream tracing patterns using ERF1 and NHD.

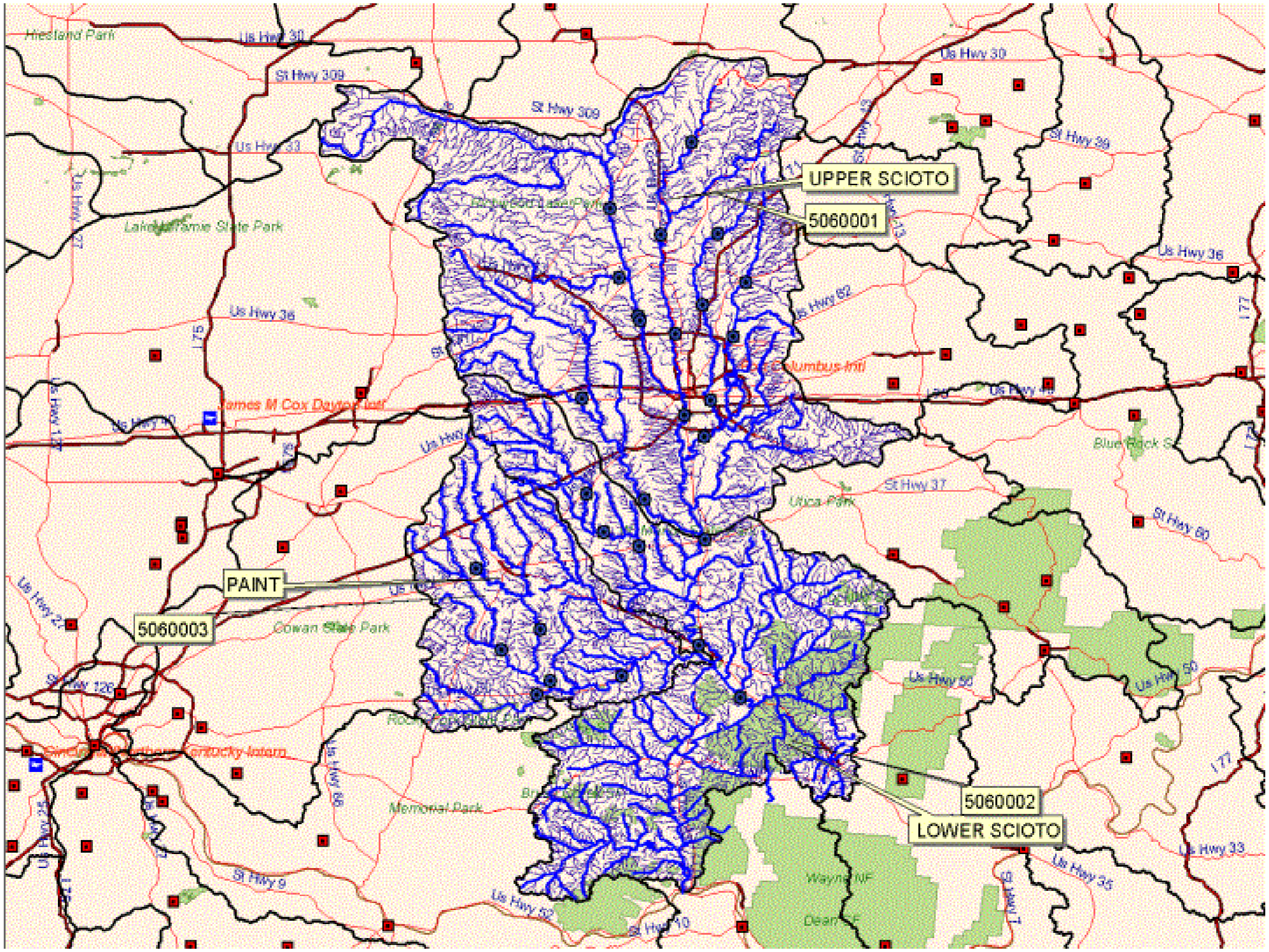


Figure 2. RiverSpill-NHD Pilot Study Area

Assigning mean flows and velocities to NHD reaches

This task was carried out by Tim Bondelid (Research Triangle Institute) and Cindy McKay (Horizon Systems) through their EPA sponsor, Tommy Dewald. The methods used and results of this work are reported in two papers in the ESRI Conference session titled, "Building National Hydrography Dataset (NHD) Derived and Complimentary Datasets". The first paper (McKay) is "Super-charging the National Hydrography Dataset with Computed Attributes" and the second paper (Bondelid) is " Making the NHD Flow: Adding Hydrology to the Hydrography".

Flow Comparisons

A total of 26 gages are present in the three HUCs comprising the pilot study area. Comparisons were made between the absolute difference between ERF1 mean flows vs. mean gage values and NHD mean flows vs. mean gage values. These results are shown in figure 3. For ERF1, 11 out of 26 comparisons showed flow differences greater than 50 cubic feet per second (cfs). For the NHD, 6 out of 26 comparisons showed a flow difference greater than 50 cfs.

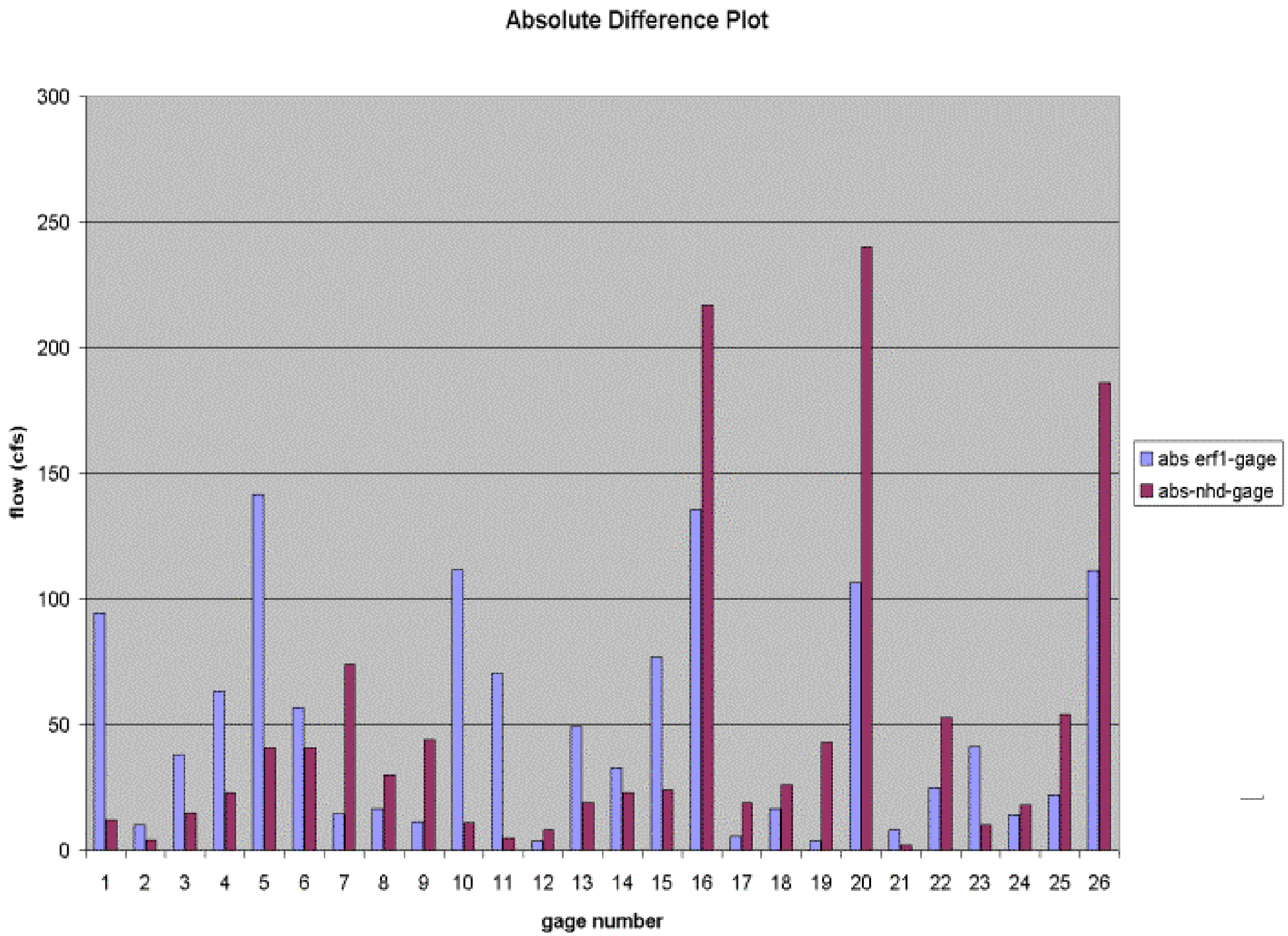


Figure 3. Flow comparisons: ERF1 and NHD vs. Gage flows

For the Olentangy River, figure 4 shows a comparison between mean flow for ERF1, NHD and two USGS gages on the river. Mean velocities for ERF1 and NHD are also shown. The difference in resolution between ERF1 and NHD is evidenced by the fact that NHD portrays this reach as 1 segment while NHD breaks it up into 55 segments. The mean flow from NHD compares more favorably to the gage values than does ERF1.

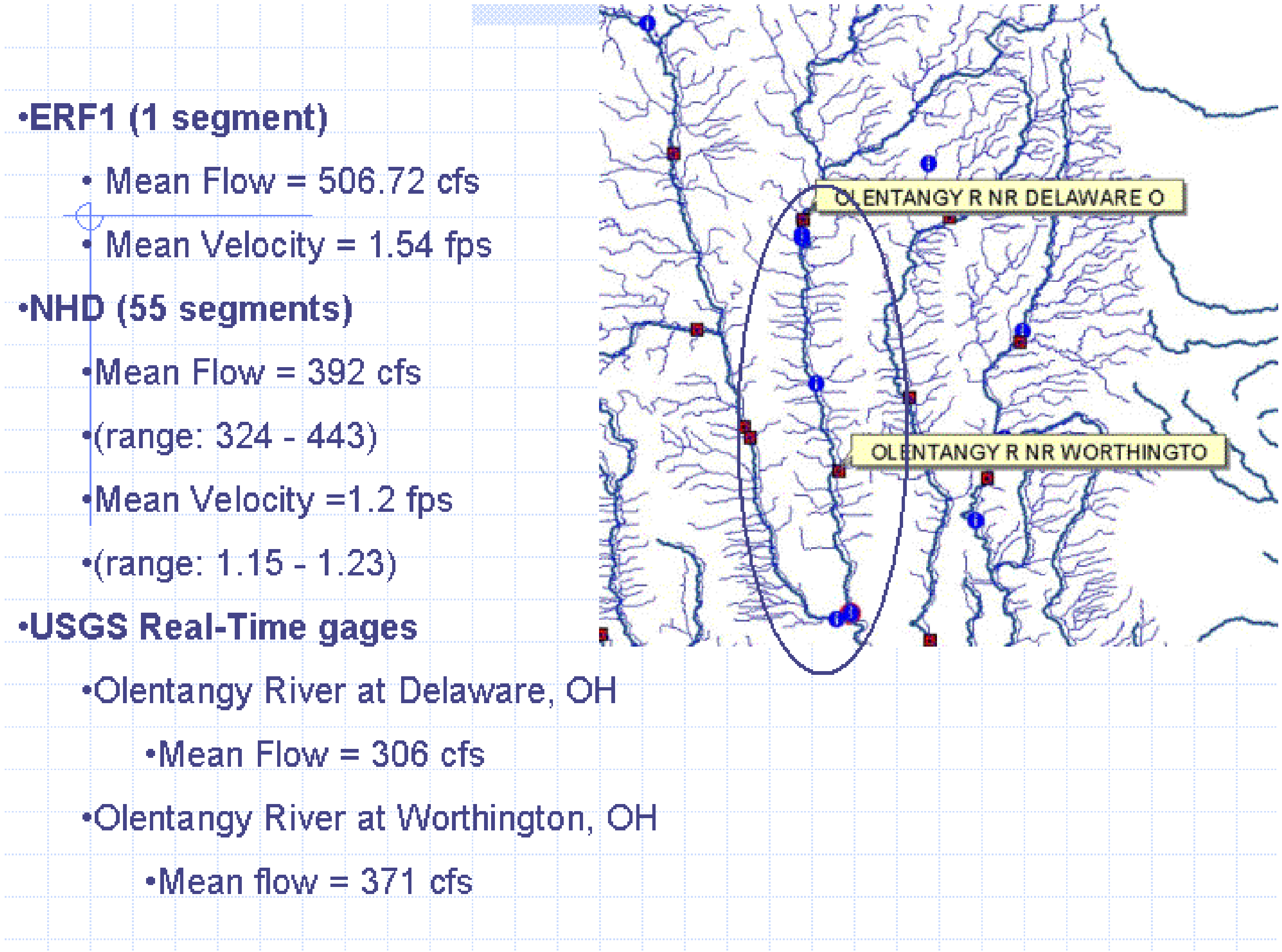


Figure 4. Flow comparisons for the Olentangy River

Time-of-Travel Comparisons

To compare travel times using ERF1 and NHD flows, a hypothetical spill was simulated at the upstream end of the Olentangy River and transported downstream using flows from both datasets. Figure 5 shows a map of the scenario. There are four intakes downstream of the spill site. The first two intakes are less than one mile downstream. The thrird and fourth intakes are respectively 13 and 30 miles downstream. The overlay of ERF1 and NHD in figure 5 shows an offset between these two data sets. This is due to a scale difference (ERF1 is 1:500,000 and NHD is 1:100,000) as well as a difference in the source of the data.

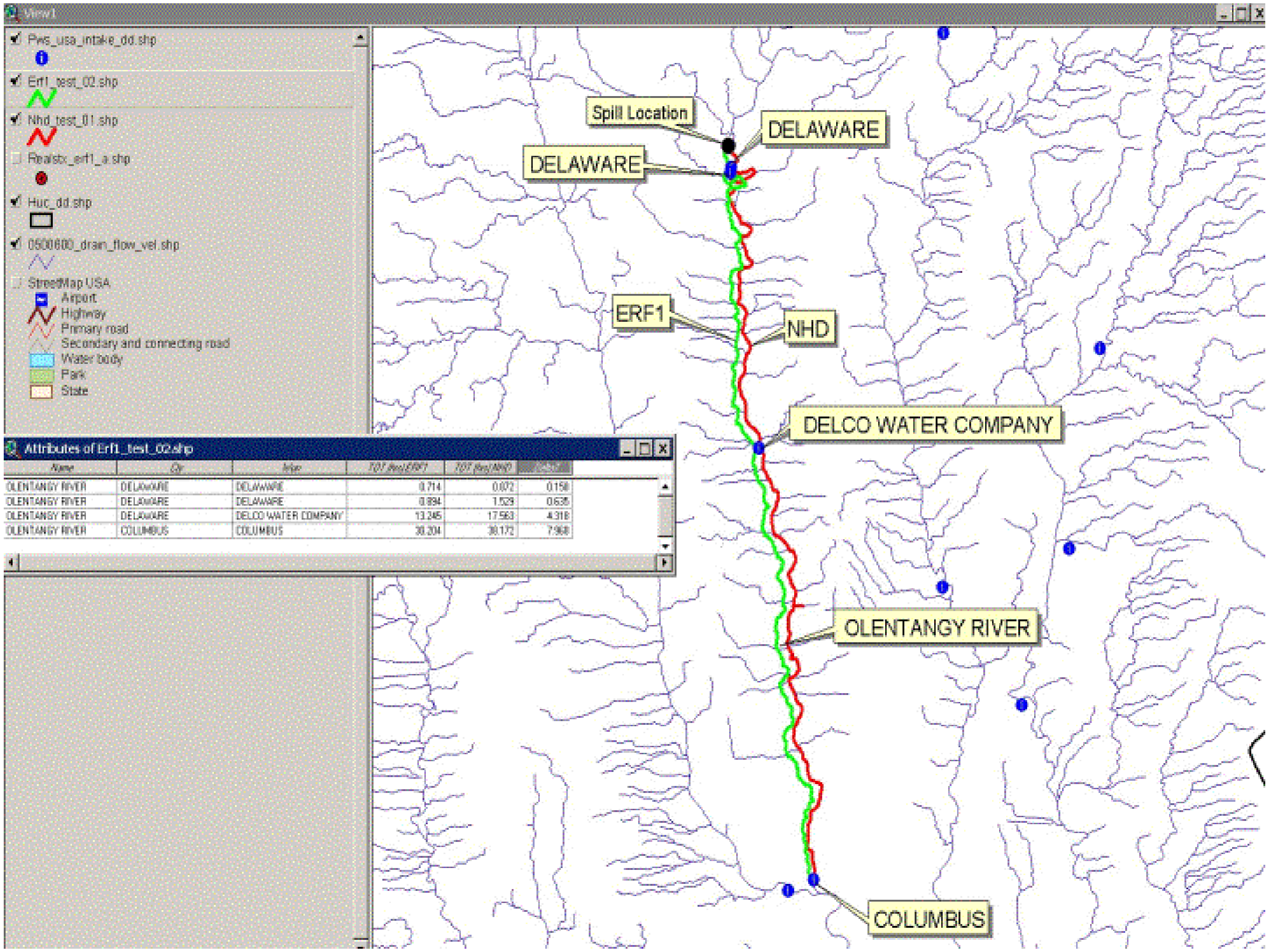


Figure 5. ERF1 and NHD Time-of-Travel Path

Figure 6 shows a comparison of the travel time results for the four downstream intakes. The distance to the intakes were essentially the same using either ERF1 or NHD to perform the navigation. Travel times were always longer when NHD flows were used in the calculation. At the farthest intake (30 miles downstream), the NHD travel time was 38 hours while the ERF1 travel time was 30 hours.

Stream	City	Water Utility	TOT (hrs) ERF1	TOT (hrs) NHD	Delta T (hrs)	Distance (Mi) NHD	Distance (Mi) EFF1
OLENTANGY RIVER	DELAWARE	DELAWARE intake 1	0.714	0.872	0.158	0.733	0.841
OLENTANGY RIVER	DELAWARE	DELAWARE intake 2	0.894	1.529	0.635	1.247	1.030
OLENTANGY RIVER	DELAWARE	DELCO WATER COMPANY	13.245	17.563	4.318	14.094	13.955
OLENTANGY RIVER	COLUMBUS	COLUMBUS	30.204	38.172	7.968	31.287	31.703

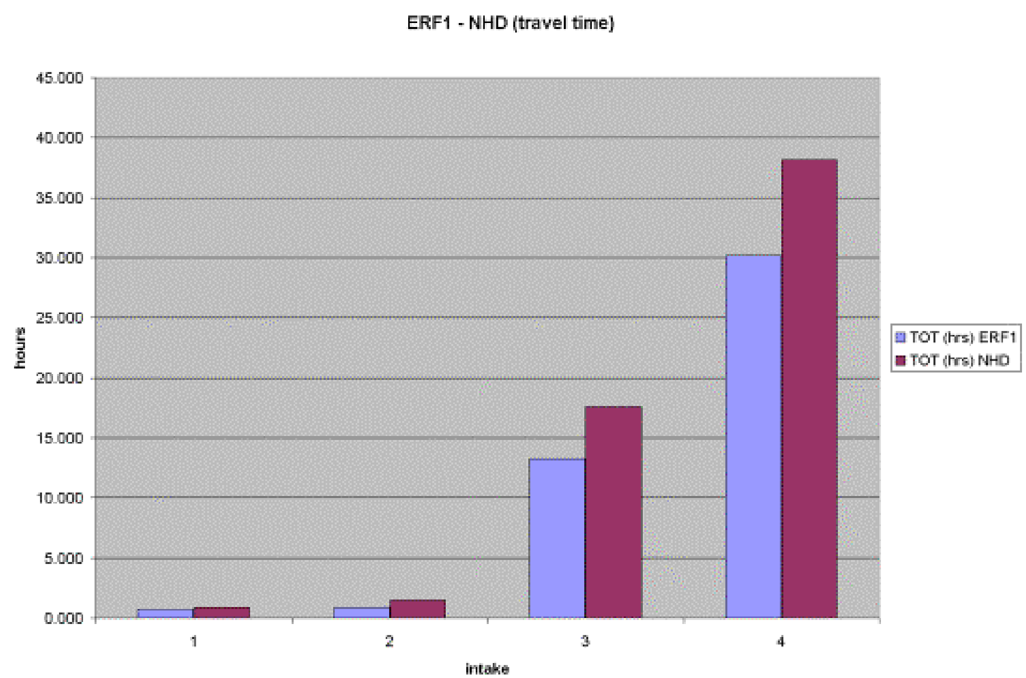


Figure 6. ERF1 and NHD Time-of-Travel Comparison

Comparison of Upstream Tracing

RiverSpill also has the capability to trace upstream to locate potential sources of contamination within distance or travel-time windows. A comparison was made of the uptream areas delinated by ERF1 and NHD for a 100 hour travel-time window (see figure 7). In figure 7, the NHD upstream area is show by the blue reaches and the ERF1 upstream area is shown by the red reaches. The ERF1 upstream area extends further to the north than does NHD, however, in the eastern direction, the NHD extends further than ERF1. Clearly, the greater speeds in the ERF1 dataset observed along the Olentangy River (1.54 fps vs. 1.2 fps) are not indicative of a systematic difference between the data sets.

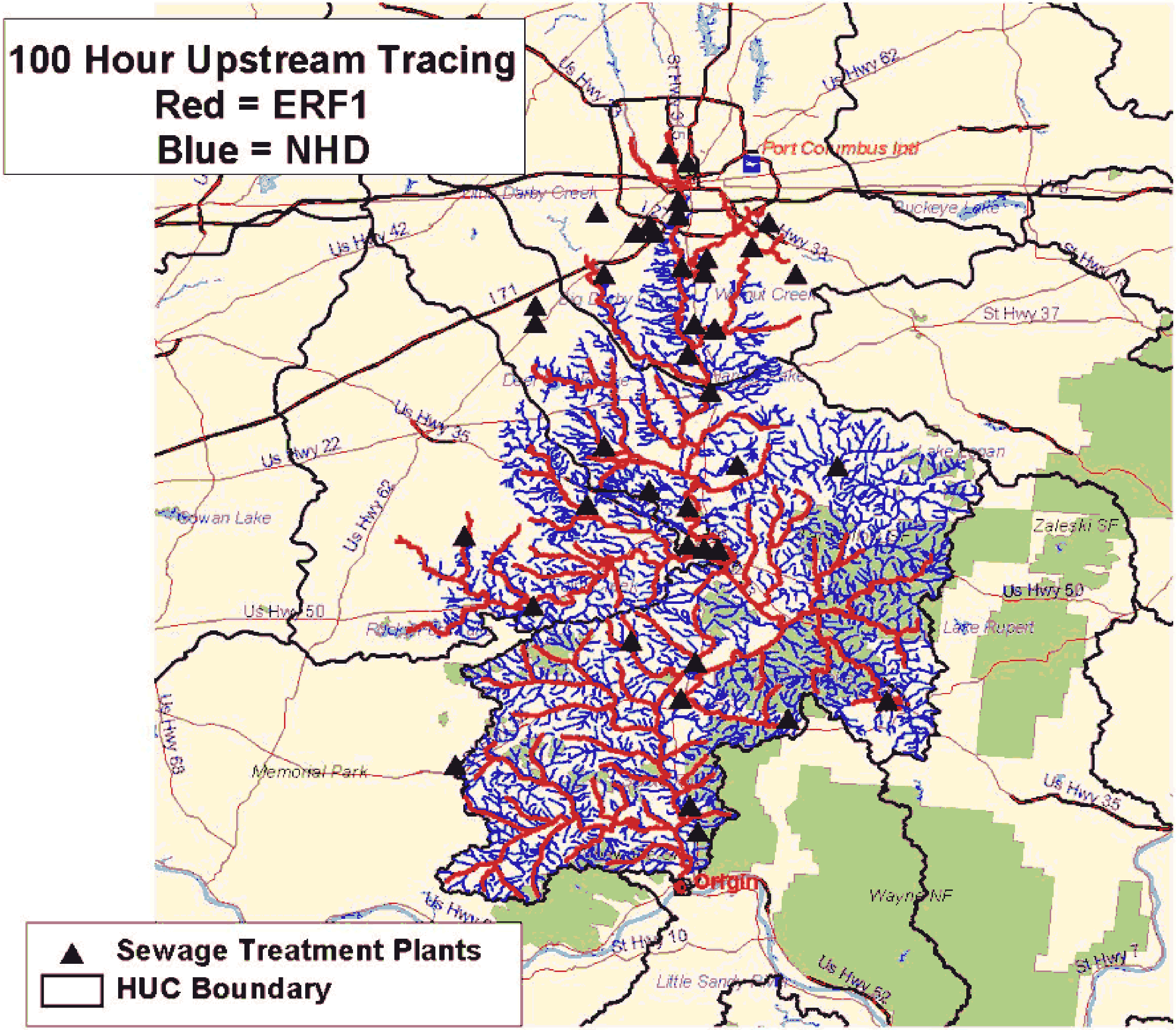

100 Hour Upstream Tracing
Red = ERF1
Blue = NHD
Sewage Treatment Plants
HUC Boundary
Port Columbus Intl
Little Darby Creek
Buckeye Lake
Us Hwy 62
Us Hwy 42
Hwy 33
I 70
I 71
St Hwy 37
Walnut Creek
Us Hwy 35
Us Hwy 22
Lake Logan
Cowan Lake
Us Hwy 62
Zaleski SF
Us Hwy 50
Us Hwy 50
Lake Rupert
Us Hwy 68
Memorial Park
Us Hwy 35
Origin
Wayne NF
St Hwy 10
St Hwy 7
Us Hwy 52
Little Sandy River

Figure 7. ERF1 and NHD Upstream Tracing Comparison

Conclusions

The operational version of RiverSpill is a stand-alone Arcview 3.2 application that currently works with the Enhanced Reach File, version 1 (ERF1). A new project, the Incident Command Information Tool (ICIT) for drinking water protection, managed by the US Forest Service and the Technical Support Working Group (TSWG), will re-engineer RiverSpill by: (1) integrating a higher resolution surface water network, the National Hydrography Dataset (NHD), (2) building interfaces to field sensors and reports, (3) web-enabling the application, and (4) expanding its tracking capabilities to include human pathogens, and radioactive substances. As part of the ground-work for this new project, a pilot study was conducted to test the integration of the NHD into RiverSpill.

Replacing ERF1 with NHD in RiverSpill is a significant upgrade to the system's downstream travel-time and upstream tracing capabilities. The population of NHD with mean flows and velocities is critical to making this upgrade. The downstream travel-time capability will improve because of the increase in stream resolution and velocity profile along the navigation pathway. The upstream tracing capabilty will improve due to the fact that additional reaches will be portrayed in the upstream trace and that potential sources of contamination associated with reaches in NHD will appear on the map.

References and Acknowledgements

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