
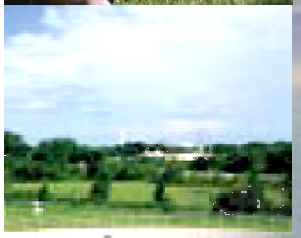
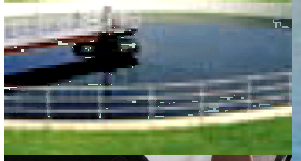

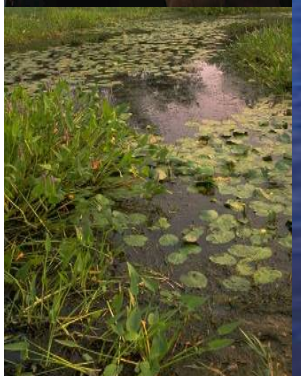

Technical Issues and Tools for Source Water Protection

Conservation Authority Roundtable

Presented by:
Edward J. Kent, PhD., P.E.

January 18th, 2006

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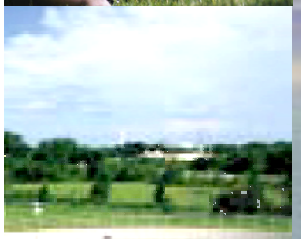
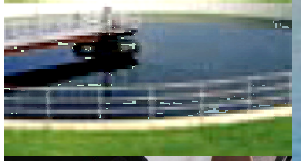
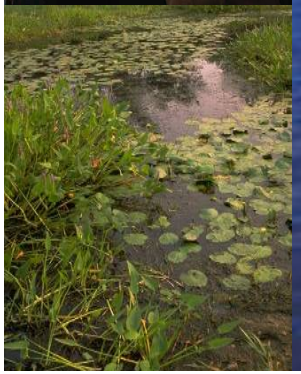
Historic Perspective

- **Source Water Protection has been in regulations for over 25 years in the U.S.**
- **Many issues encountered and addressed:**
  - Technical methods
  - Land use controls
  - Inter-municipal agreements
  - Funding
- **Ontario - Proposed Clean Water Act**



Outline

- Ontario Water Supply Overview
- Getting it Done - Source Water Protection Tools
- Massachusetts Experience - I 495, Rapid Growth Area

Source Water Protection Objective

- ✓ **Safeguard Human Health**
- ✓ **Identify potential water supply needs and sources**
- ✓ **Protect existing and future water supply sources forever**

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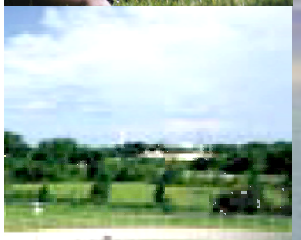
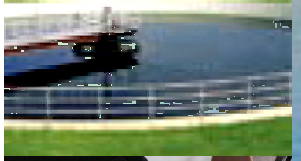
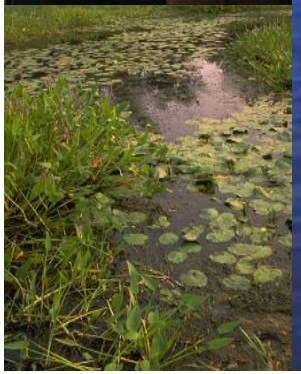
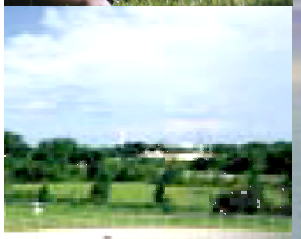
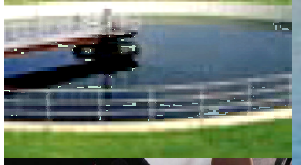



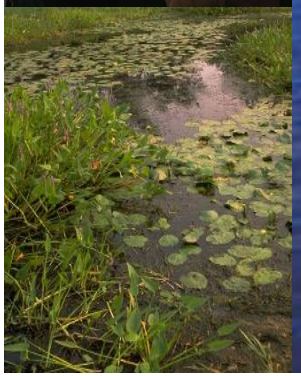


Ontario Water Supply Overview

- 12 million people in Ontario
- 250,000 lakes, 1/3 of world's fresh water
- Water Sources
  - Great Lakes - 75%
  - Private Wells - 2 million people

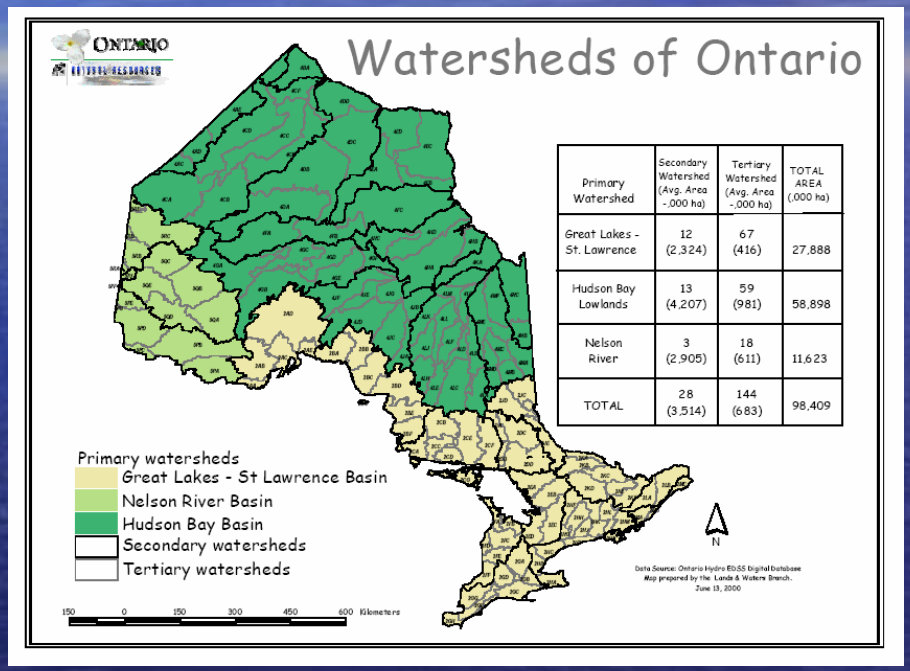






Ontario Watersheds

- **Basic Units for SWPP**
- **Growth in Great Lakes - St. Lawrence**



Primary Watershed	Secondary Watershed (Avg. Area - ,000 ha)	Tertiary Watershed (Avg. Area - ,000 ha)	TOTAL AREA (,000 ha)
Great Lakes - St. Lawrence	12 (2,324)	67 (416)	27,888
Hudson Bay Lowlands	13 (4,207)	59 (981)	58,898
Nelson River	3 (2,905)	18 (611)	11,623
TOTAL	28 (3,514)	144 (683)	98,409

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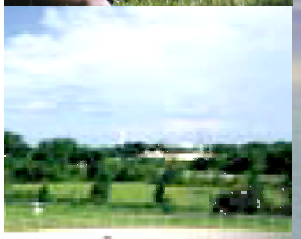
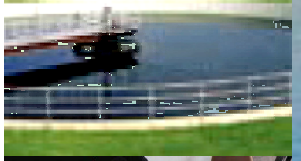
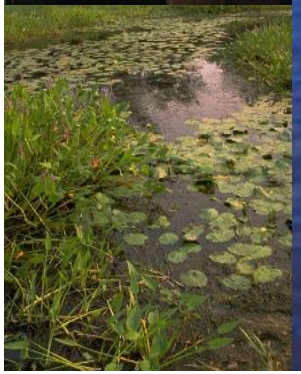
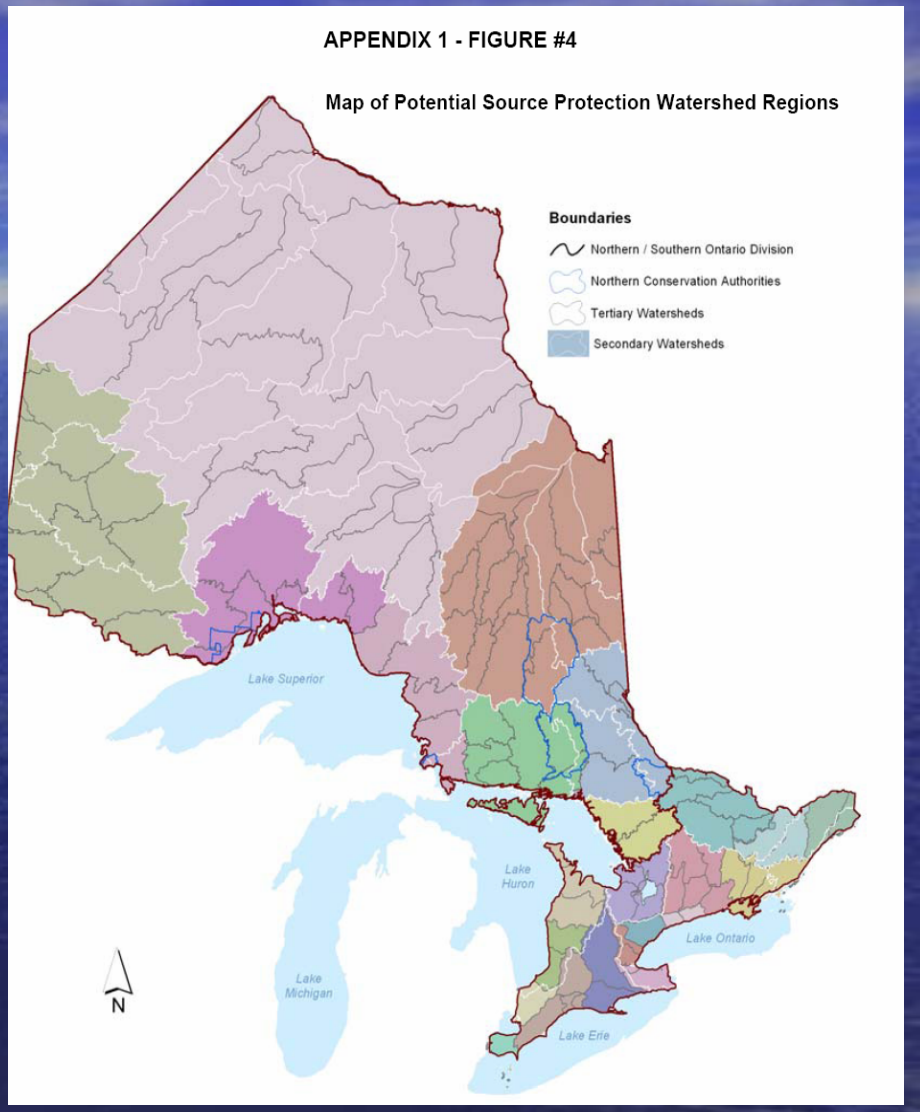






- **Groups of watersheds**
- **Similar characteristics relative to SWPP**
- **Most refined in urbanizing areas**



Source: Ministry of the Environment 2004

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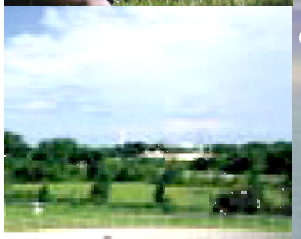
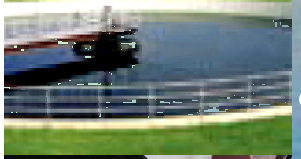
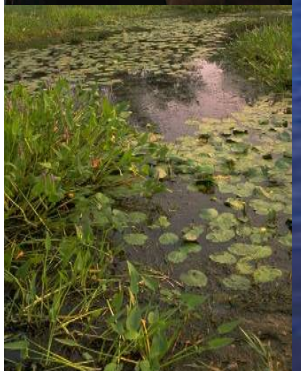
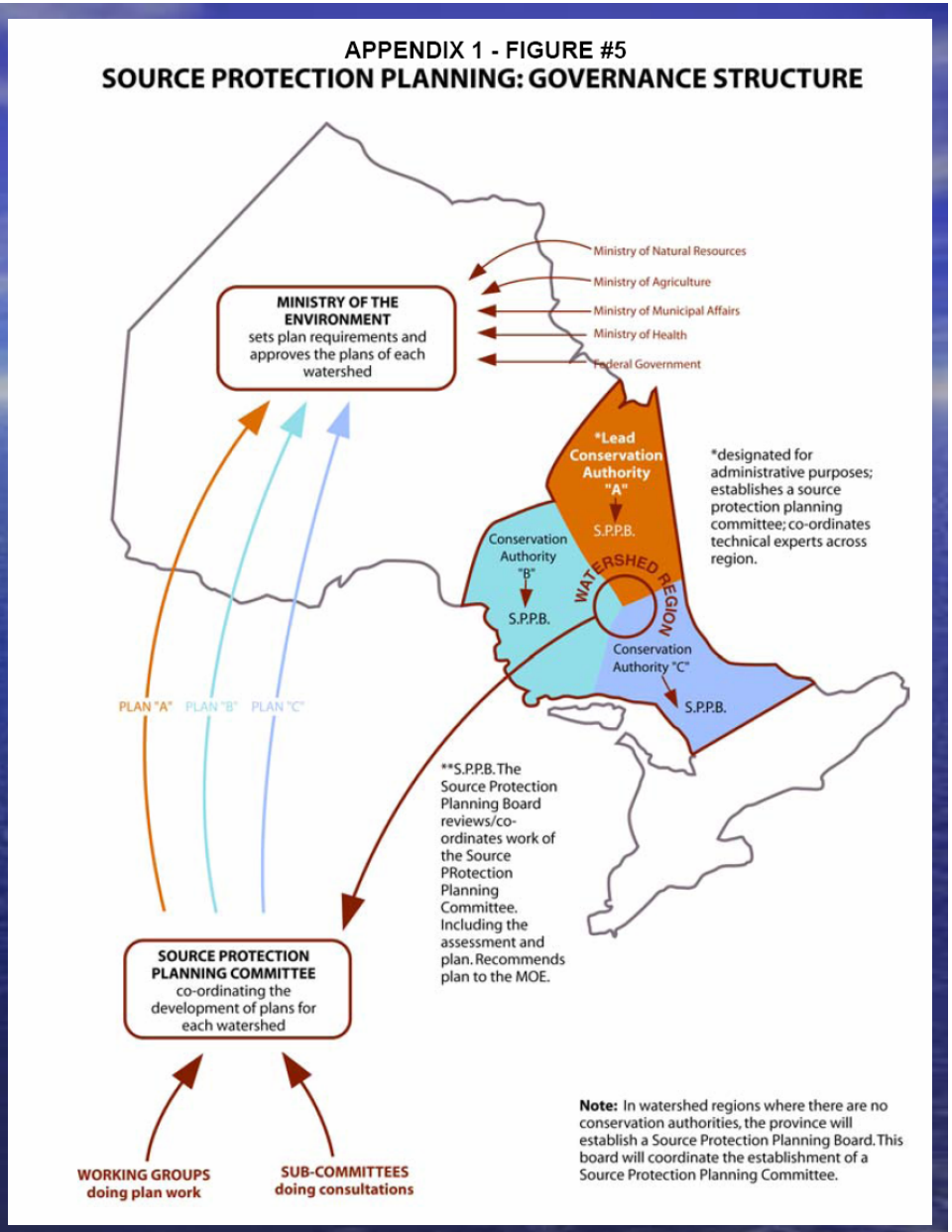






- **Watershed Region Basis**
- **Conservation Authorities/SPPBs lead Program**
- **Diverse SPPC coordinates work**
- **MOE provides guidance and oversight**



Source: Ministry of the Environment 2004

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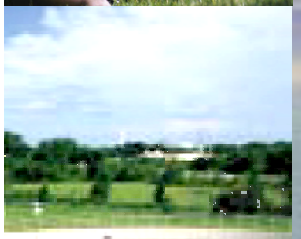
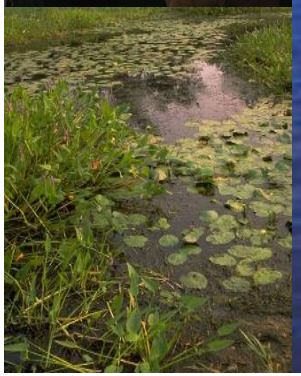
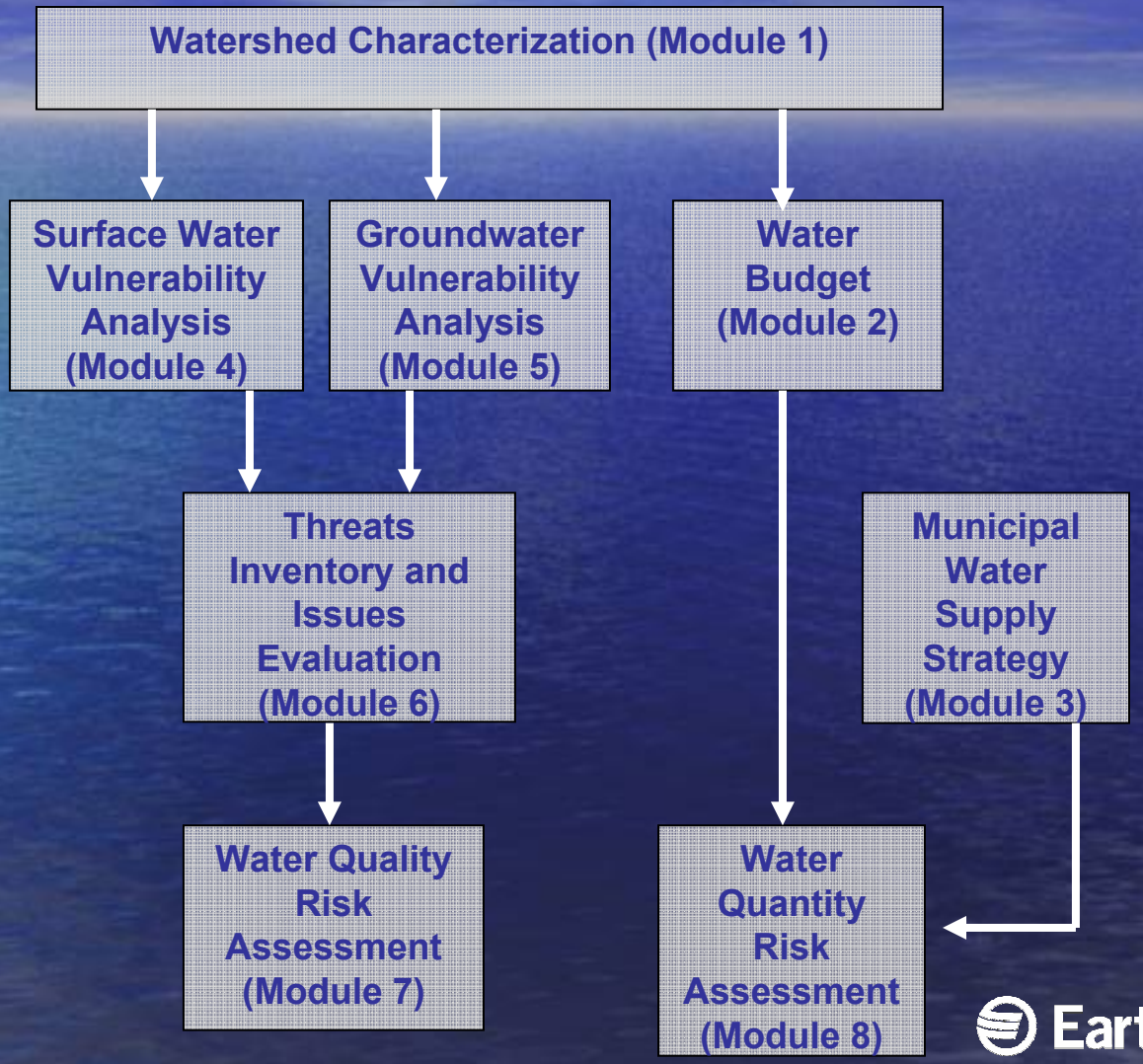
Source Water Protection Process

- Assessment
- Source Water Protection Plan
- Implementation



SWPP Assessment Process Modules



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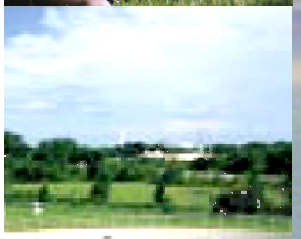
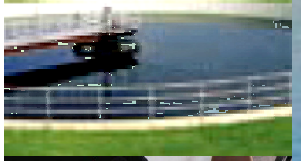

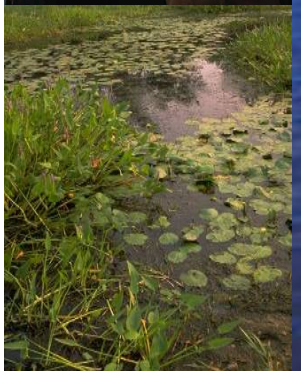

The SWPP Toolbox

- Water Supply Plan
- Watershed Data
- GIS
- Groundwater Flow “Models”
- Surface Water Flow “Models”
- Surface Water Quality
- Field Exploration

Water Supply Plan

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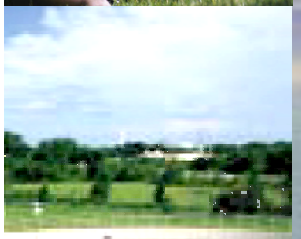
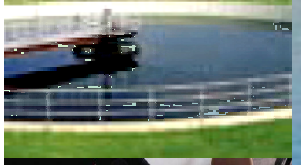
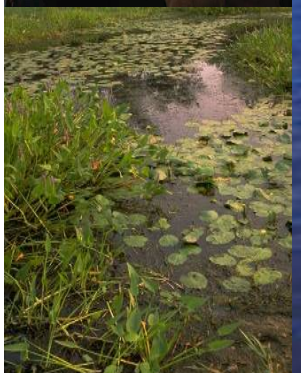
Water Supply Plan

- Defines Water Supply Needs and Sources
- Planning Horizon
- May Include SWPP Components
  - Population Projections
  - Hydrologic/Hydrogeologic Investigations
  - ID Future Sources and Phasing
  - Treatment, Storage and Distribution
  - GIS/Mapping



Watershed Data

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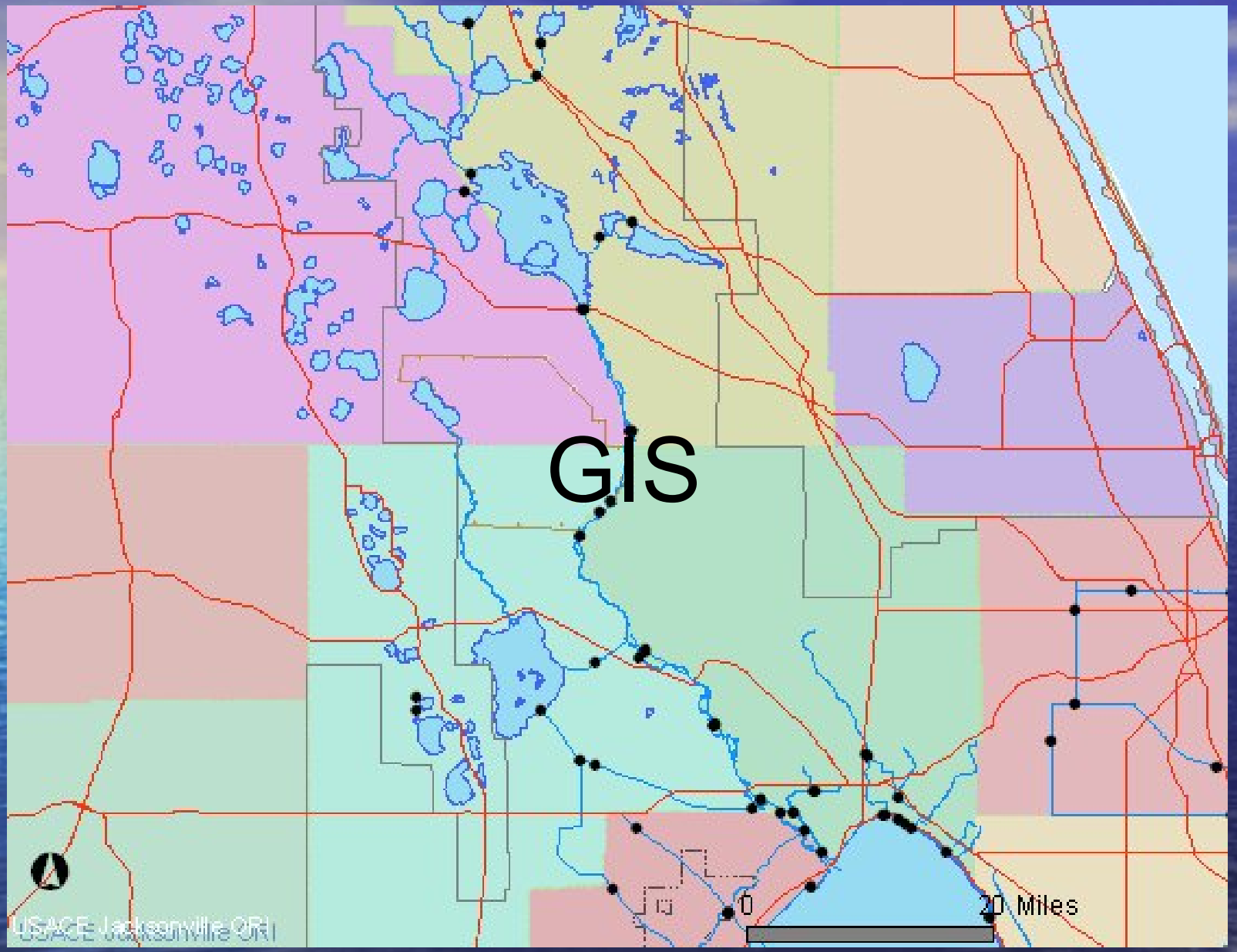
Watershed Data

- Various Sources
- MNR-Land Information Ontario
  - http://www.lio.mnr.gov.on.ca/informationdirectory.cfm
- Source Protection Data Matrix
  - http://www.ene.gov.on.ca/envision/water/swpdata_jan10_2006.xls
- Data Types - Quality/Quantity, Physical
- Format/Conversions
- Timely Accessibility
- Data Quality
- Agency Labor Availability



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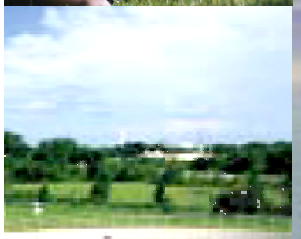
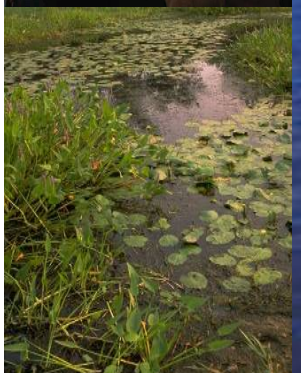
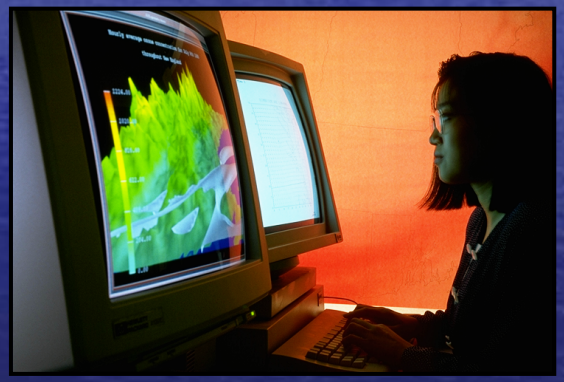




GIS for Watershed Assessment

- GIS is the primary tool
- Watershed Characteristics
  - **Boundaries**
  - **Soils, aquifer locations and properties**
  - **Land use-present and future**
  - **Existing wells, surface water withdrawals**
  - **Potential contamination sources***
  - **Surface water and ground water levels and flows**
  - **Water quality**



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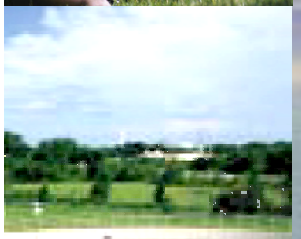
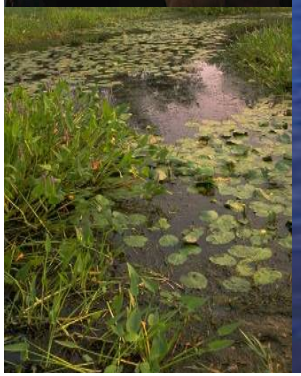
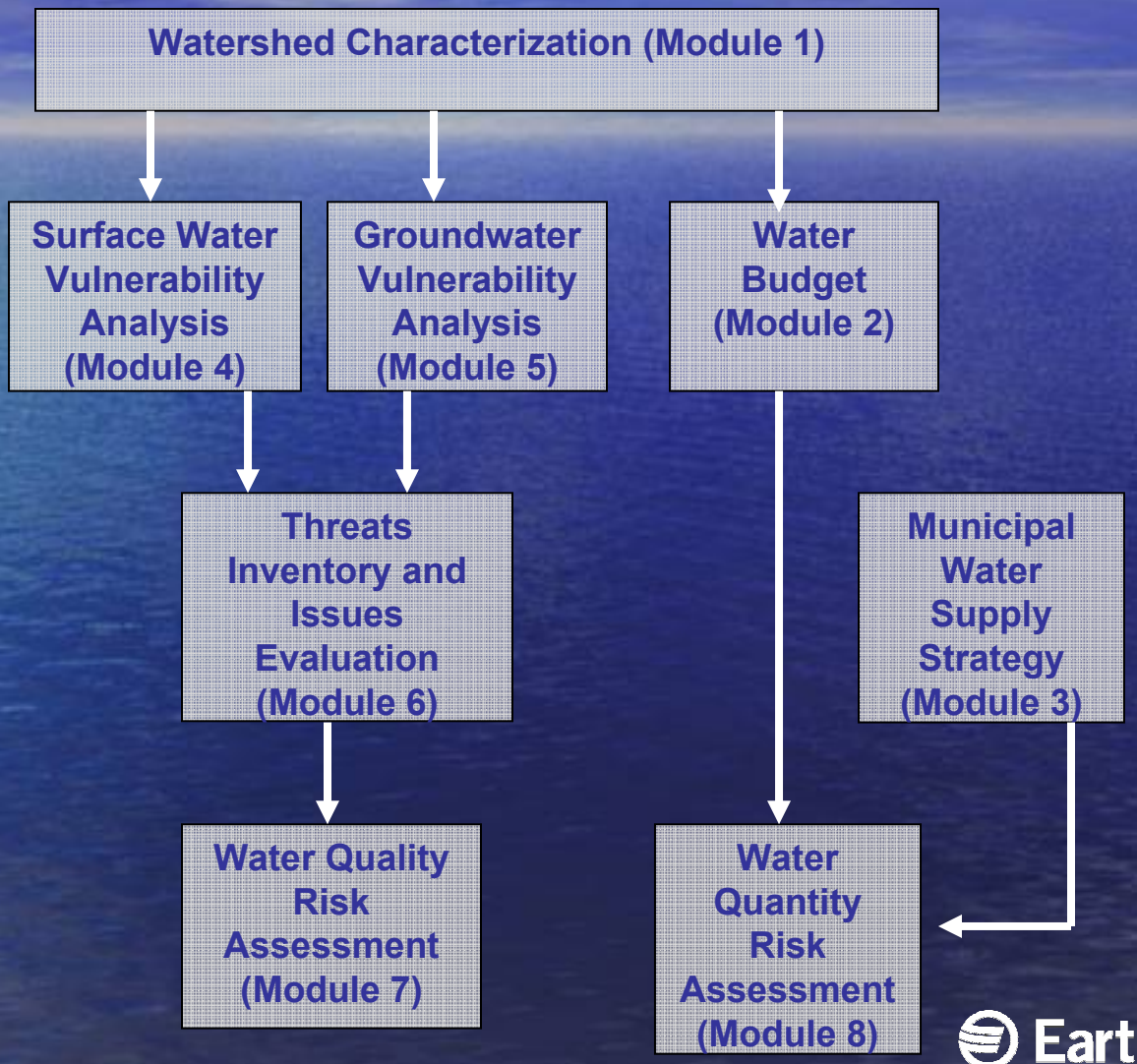
Comprehensive Role of GIS

- Repository for watershed data
- Tool for spatial analysis of data
- Production of Maps
- Automated production of reports for watersheds, sub-watersheds, municipalities



SWPP Assessment Information Modules



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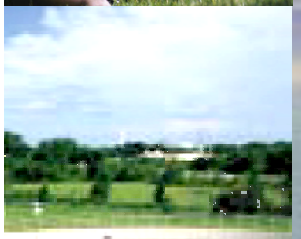

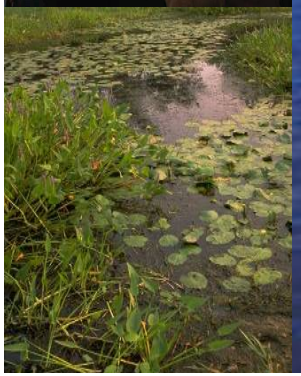

Groundwater Flow "Models"

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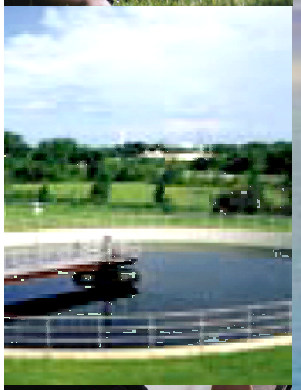

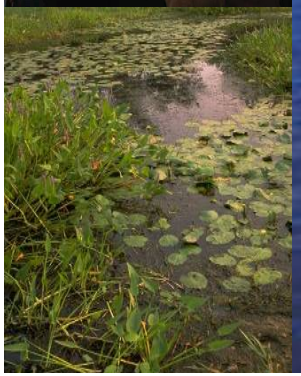

Groundwater Modeling

Range from simple analytical models to computer-based fully three-dimensional

- Uniform Flow
- Topographic Analysis
- Digital Models
  - MODFLOW
  - MOD-HMS
  - MIKE-SHE
  - Others

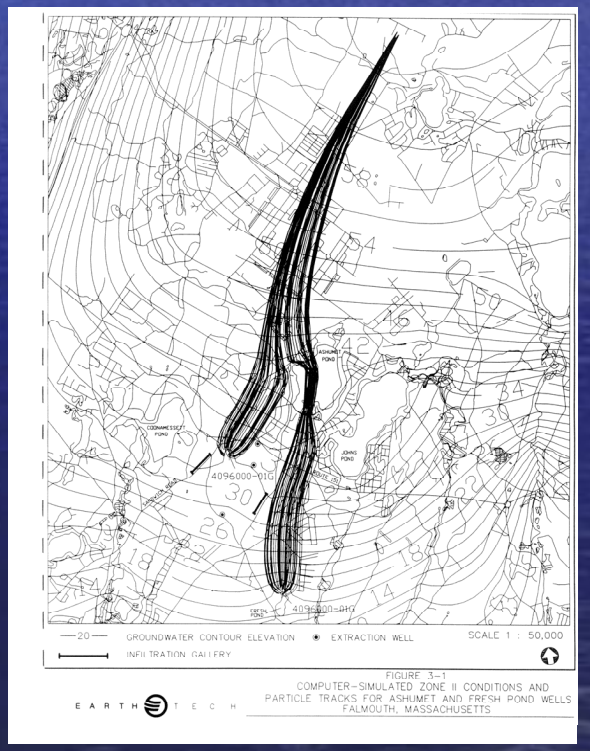

FIGURE 3-1
COMPUTER-SIMULATED ZONE II CONDITIONS AND PARTICLE TRACKS FOR ASHUMET AND FRESH POND WELLS FALMOUTH, MASSACHUSETTS

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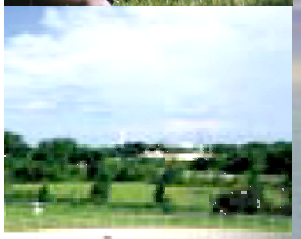


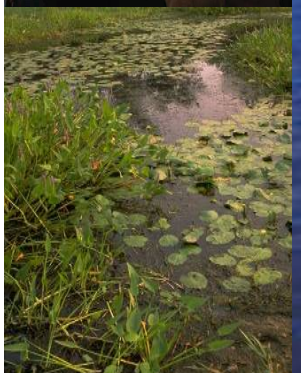

Surface Water Flow "Models"

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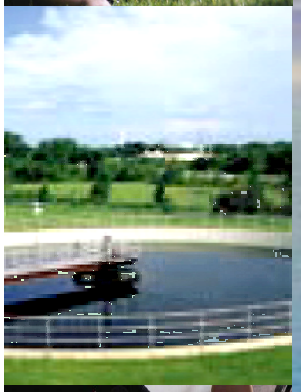
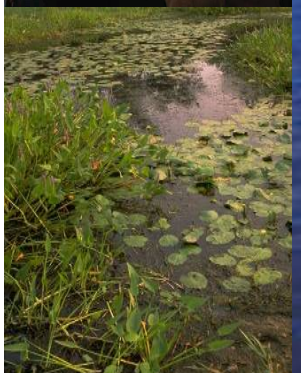
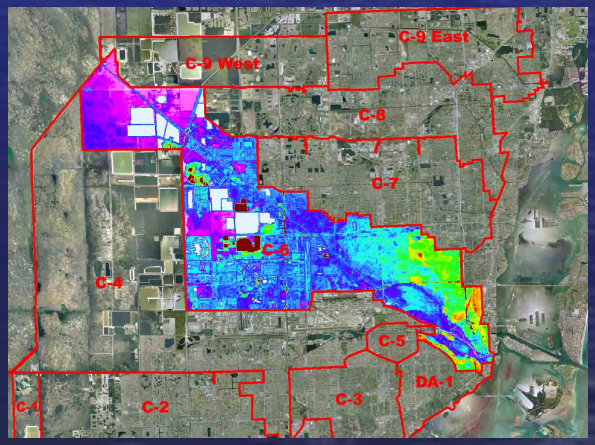




Surface Water Models

- Delineate contributing watersheds from maps
- Spreadsheet models useful for water budget analysis
- Watershed models- HSPF, SWAT, HMS, SWMM
- Instream Flow Models
  - RMA2
  - Flow3D
  - ADCIRC



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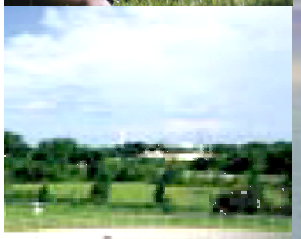
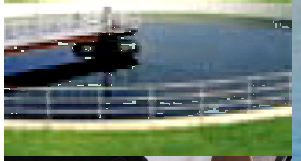

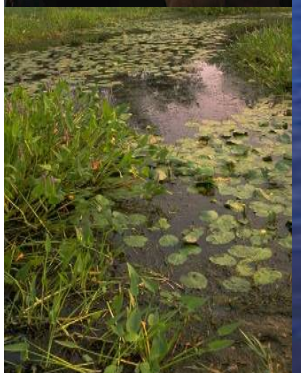

Surface Water Quality "Models"

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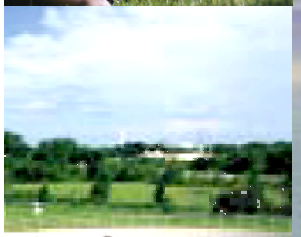
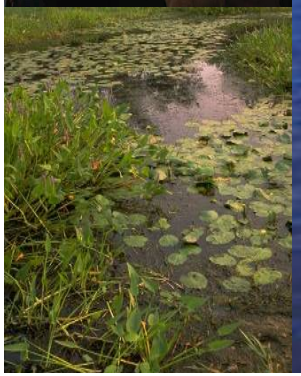
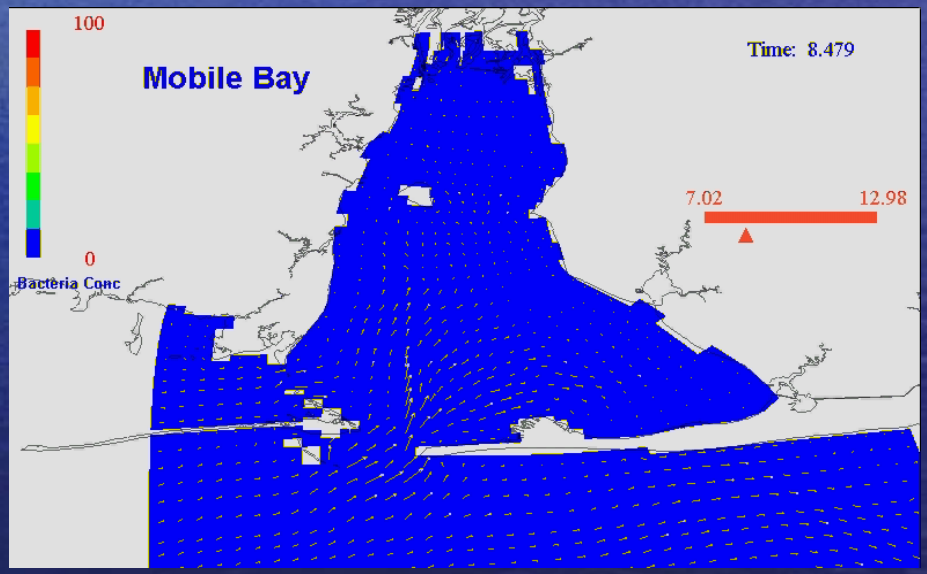




Surface Water Quality Models

- Delineate Intake Protection Zones
- Great Lakes - winds, waves, currents
- Examples:
  - QUAL2K
  - CORMIX
  - WASP
  - ADCIRC
  - ECOMSED
  - Other



- Hydrodynamic and pathogen model (3D/TV) by Limno -Tech shown

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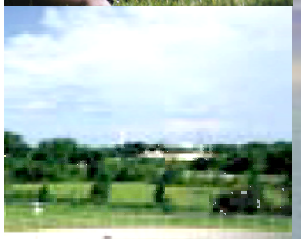
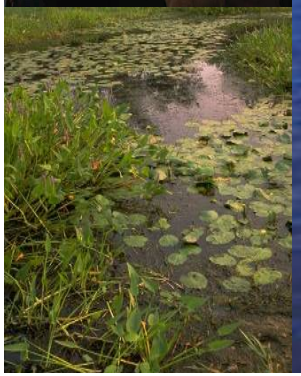
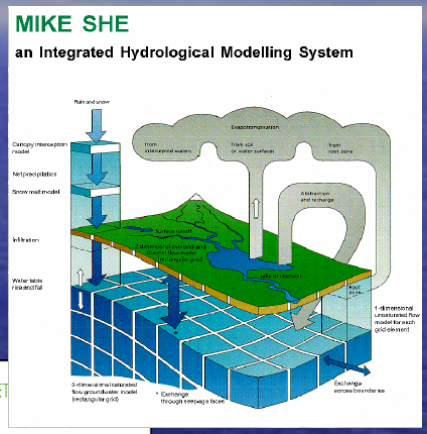
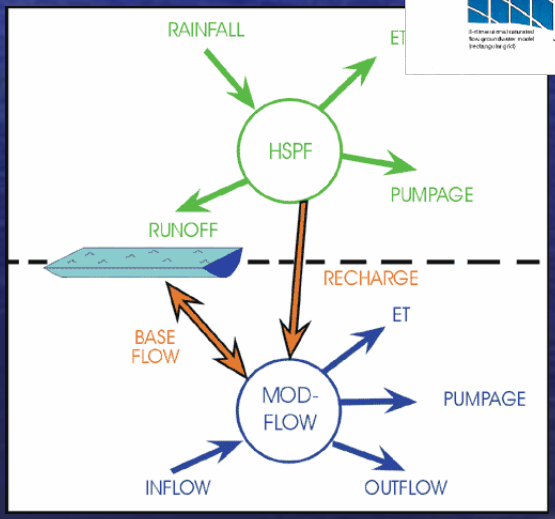




Integrated Groundwater Surface Water Models

- **Applications**
  - Surface water/groundwater interactions are significant
  - Highly developed or developing areas
- **Examples**
  - MIKE-SHE
  - MODHMS
  - Hydrogeosphere





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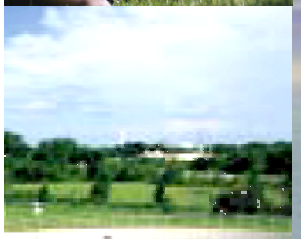
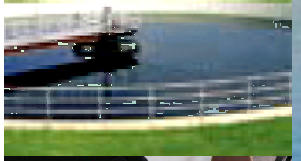

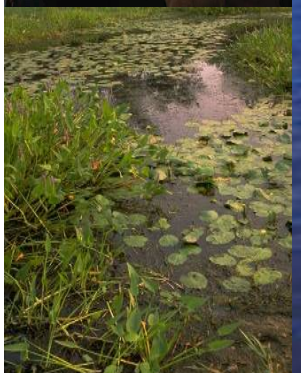

Field Investigations

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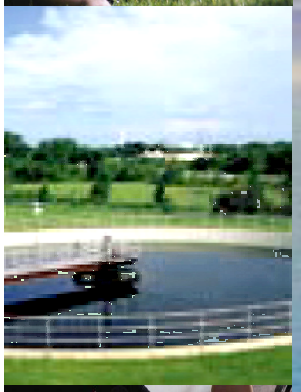
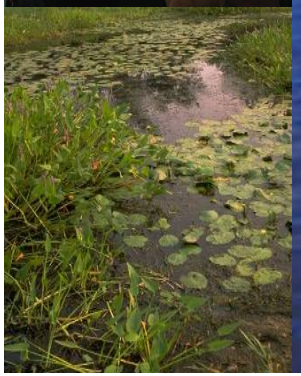
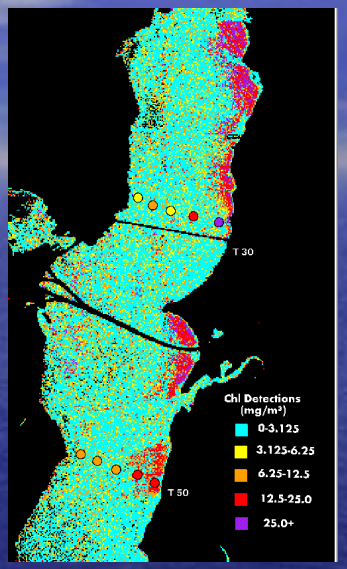




Field Investigations

- Water Supply Test Well Programs
  - Exploratory Wells
  - Monitoring Wells
  - Aquifer Performance Testing
- Flow Gauging Stations
- Water Quality Monitoring
- Surveys of Potential Contamination Threats



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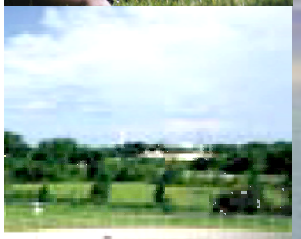
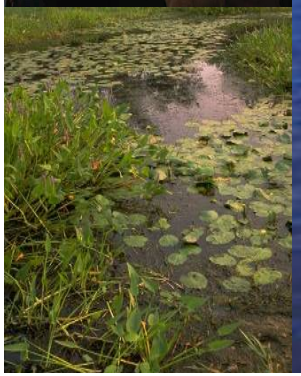


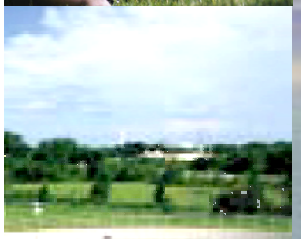


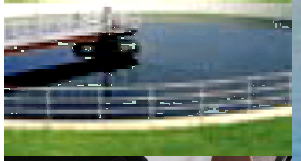
Observations

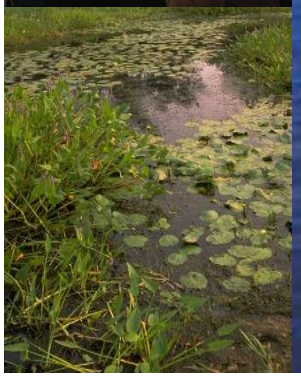
- **Municipalities/Agencies with data will need additional staffing to support data requests**
- **Need water supply master plans or updates**

Observations

- Transportation corridors can be a risk
- Rural assessments-simplified but conservative
- Role of industry and volunteer watershed groups
- If funding is too limited
  - Simple and conservative methods now
  - More detailed analyses later

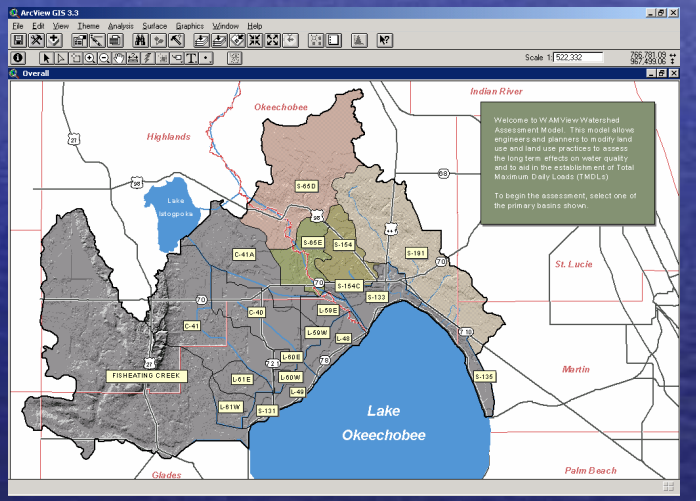






Observations

- Water Use Conflicts Identified
- Agriculture - major potential pollutant source
  - Lake Okeechobee a good case study
  - www.sfwmd.gov
- SWP process (GIS) improves communication in municipalities



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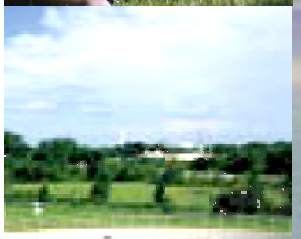


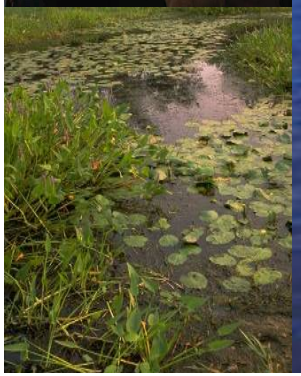

Case Study: Massachusetts

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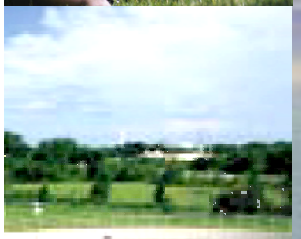
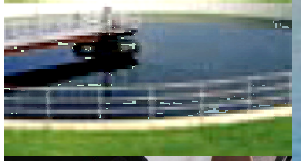

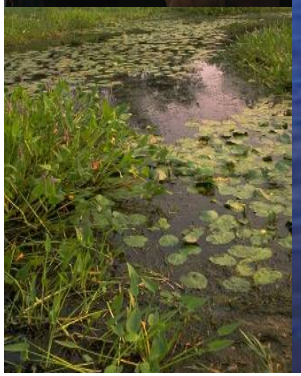

Existing Regulations

- **Ground Water**
  - Zone I – 400’ Radius
  - Zone II- Zone of Contribution in Drought
  - Zone III- Zone draining into Zone II
- **Surface Water**
  - Zone A- 400’ from supply and 200’ from tributaries
  - Zone B- 0.5 miles from source
  - Zone C- remainder of watershed

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Activities Restricted in Wellhead Zones

- **Zone I**
  - **Owned and controlled by water supplier**
  - **Only water supply activities**
- **Zones II and III**
  - Prohibited uses and activities examples
    - **Landfills, chemical storage,**
    - **Snow with deicing chemicals from areas outside of Zone II**
    - **Large hazardous waste generators**
    - **Impervious areas exceeding 15% unless mitigated**

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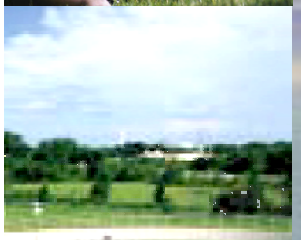
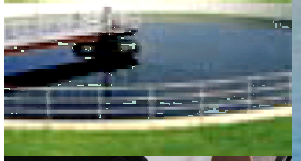

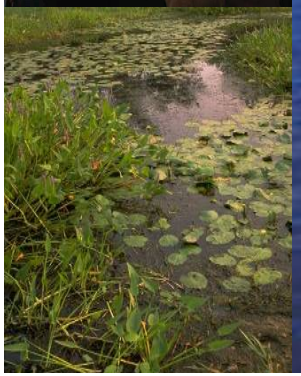

Activities Restricted in Surface Water Reservoir Zones

- Zone A
  - Major roads, commercial, and industrial development
  - Landfills and chemical use or storage
  - Agriculture
  - Etc.

- Zones B and C
  - Activities that will degrade the surface water and cannot be reliably controlled- similar to groundwater Zones II and III

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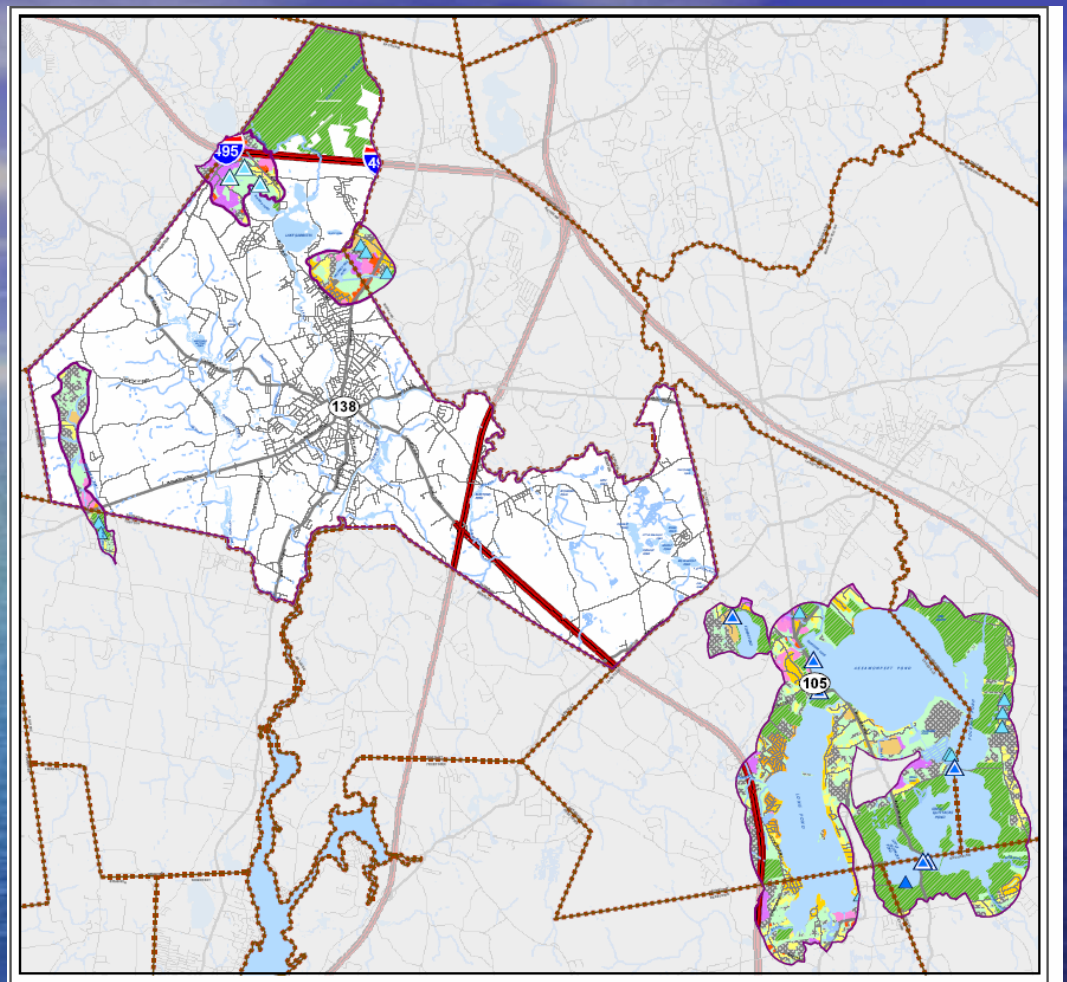
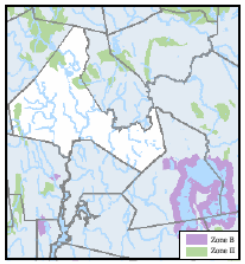
Land Use Analysis Example

- Current & Potential Land Use in Existing Public Water Supply Protection Areas
- Land Available for Future Groundwater Supplies
- Current & Potential Land Use in Potential Public Water Supply Protection Areas





0 2 Miles
0 1 2 Kilometers

Water Supply Protection Area (Zone II or Zone B)

Developable Land

Undevelopable Land

Criteria that may constrain land from development include slope, wetlands, River Protection Act buffers, 100-year flood zones, certain zoning overlays and rights-of-way, and restrictions outlined in an existing development plan.

Protected Open Space within or contiguous with Zone IIs or Zone Bs

Municipal Boundary

Water Features

River or Stream

Intermittent Stream

Lake or Pond

Current Land Use in developed areas

Multi-Family and High Density Residential

Medium Density Residential

Low Density Residential

Commercial

Industrial/Transportation/ Mining

Urban open/Recreational

Subdivisions (from EOEA Buildout Analysis)

Land Use Data Not Available

Public Water Supplies

Taunton Supplies	Other Towns
Ground Water	
Surface Water	
Proposed Well	

Map 1

Current Land Uses in Existing Public Water Supply Protection Areas

Taunton

This project is funded by the Executive Office of Environmental Affairs (EOEA).
Maps prepared by Earth Tech, Concord Massachusetts.

June 2004

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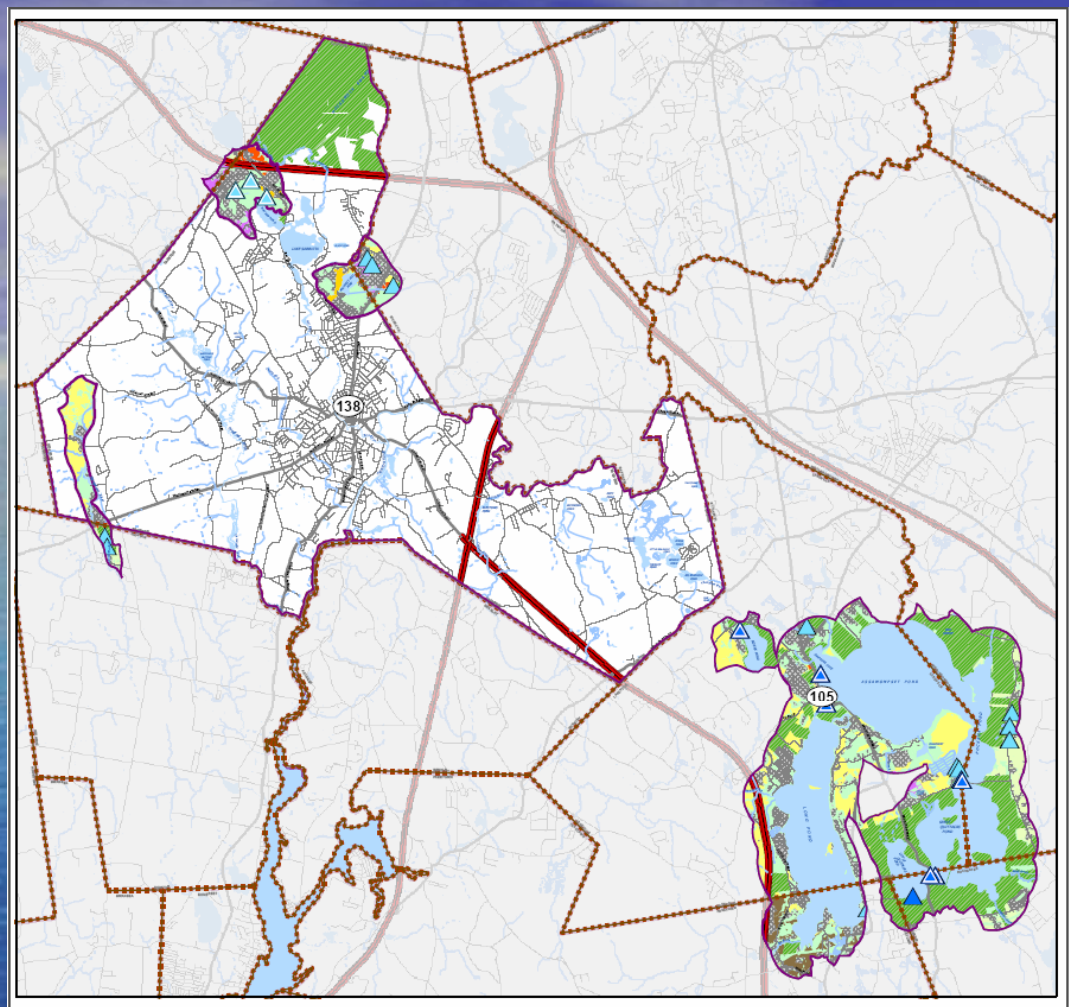

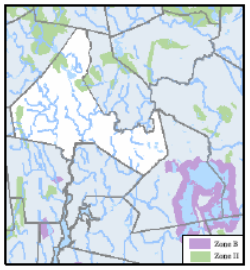

Water Supply (Zone II or Zone B) Protection Area
Water Supply Protection Overlay District
Developed Land
Undevelopable Land

Criteria that may constrain land from development include slope, wetlands, River Protection Act buffers, 100-year flood zones, certain zoning overlays and rights-of-way, and restrictions outlined in an existing development plan.

Protected Open Space within or contiguous with Zone IIs or Zone Bs

Public Water Supplies

Taunton Supplies	*Other Towns*
Ground Water	
Surface Water	
Proposed Well	

Potential Future Land Use in undeveloped areas, derived from zoning by-laws

- Agriculture
- Very Low Density Residential
- Low Density Residential
- Medium Density Residential
- Higher Density Residential
- Mixed Use
- Commercial
- Industrial/Transportation/Mining
- Urban open/Institutional/ Recreation
- Natural Land/ Undisturbed Vegetation
- No Zoning or Unknown
- Municipal Boundary

Water Features

- River or Stream
- Intermittent Stream
- Lake or Pond

0 2 Miles
0 1 2 Kilometers

Map 2

Potential Land Uses in Existing Public Water Supply Protection Areas

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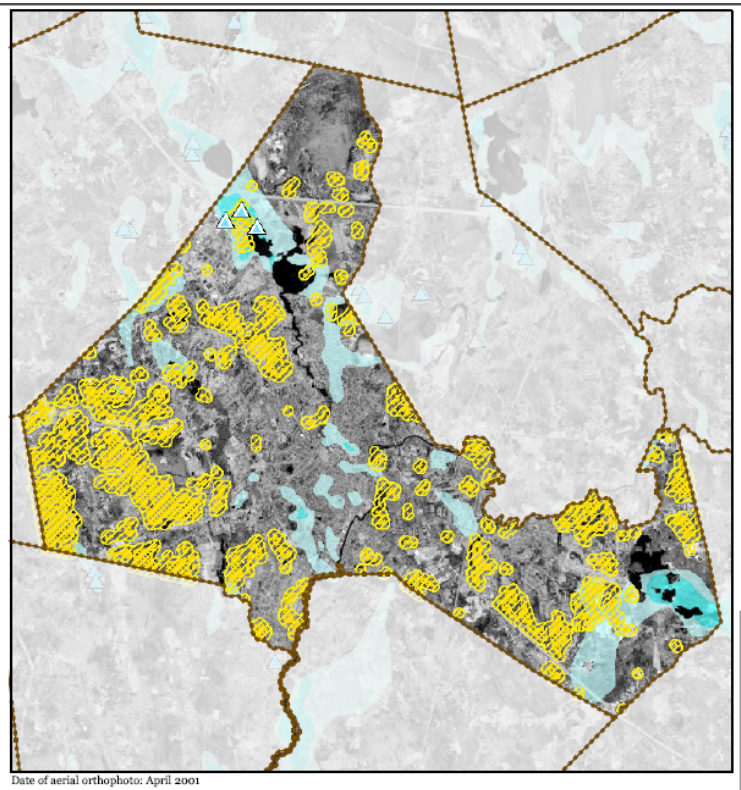
Map 3

Land Potentially Available for Future Groundwater Supplies

Taunton



Potential groundwater supply location

Note: This analysis is based strictly on land use and land cover. These sites are not evaluated in this report for their potential to yield water.

Potential public water supply protection area (Zone I)

Aquifers

- High Yield
- Medium Yield

Public Water Supplies

Taunton Supplies	*Other Supplies*
Ground Water	
Surface Water	
Proposed Well	

The following restrictions were used to identify potential areas for future public water supply:

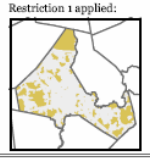
1. No residential, commercial, industrial, transportation or waste disposal land use, or Tier 1A or true Tier 1B 21E sites; and no land within 400 feet of any of the above.
2. No wetlands or land within 100 feet of a wetland.
3. No land under the control of a municipal conservation commission, no permanently protected state- or privately-owned open space, no federally-owned open space other than land owned by the Army Corps of Engineers, and no land within 400 feet of any of the above.

These restrictions are based on the best available data at the time of project completion.

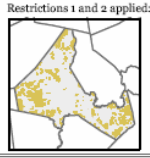
Date of aerial orthophoto: April 2001

Taunton

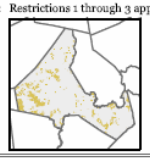
Restriction 1 applied:

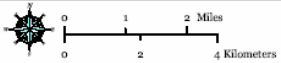


Restrictions 1 and 2 applied:



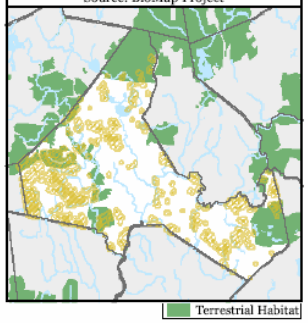
Restrictions 1 through 3 applied:





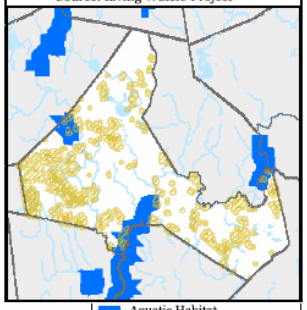
Natural Heritage and Endangered Species Program

Terrestrial Core Habitat
Source: BioMap Project



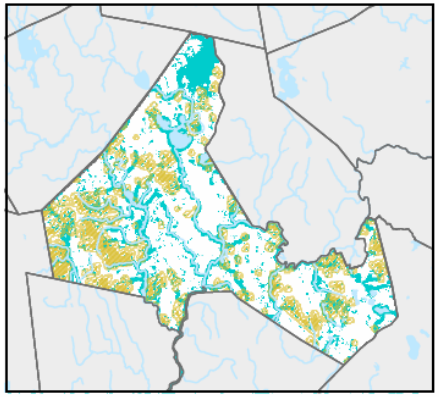
Terrestrial Habitat

Aquatic Core Habitat
Source: Living Waters Project



Aquatic Habitat
(Linear features are widened for display)

Wetlands and Riparian Corridors



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Maps were prepared by Earth Tech, Concord Massachusetts.

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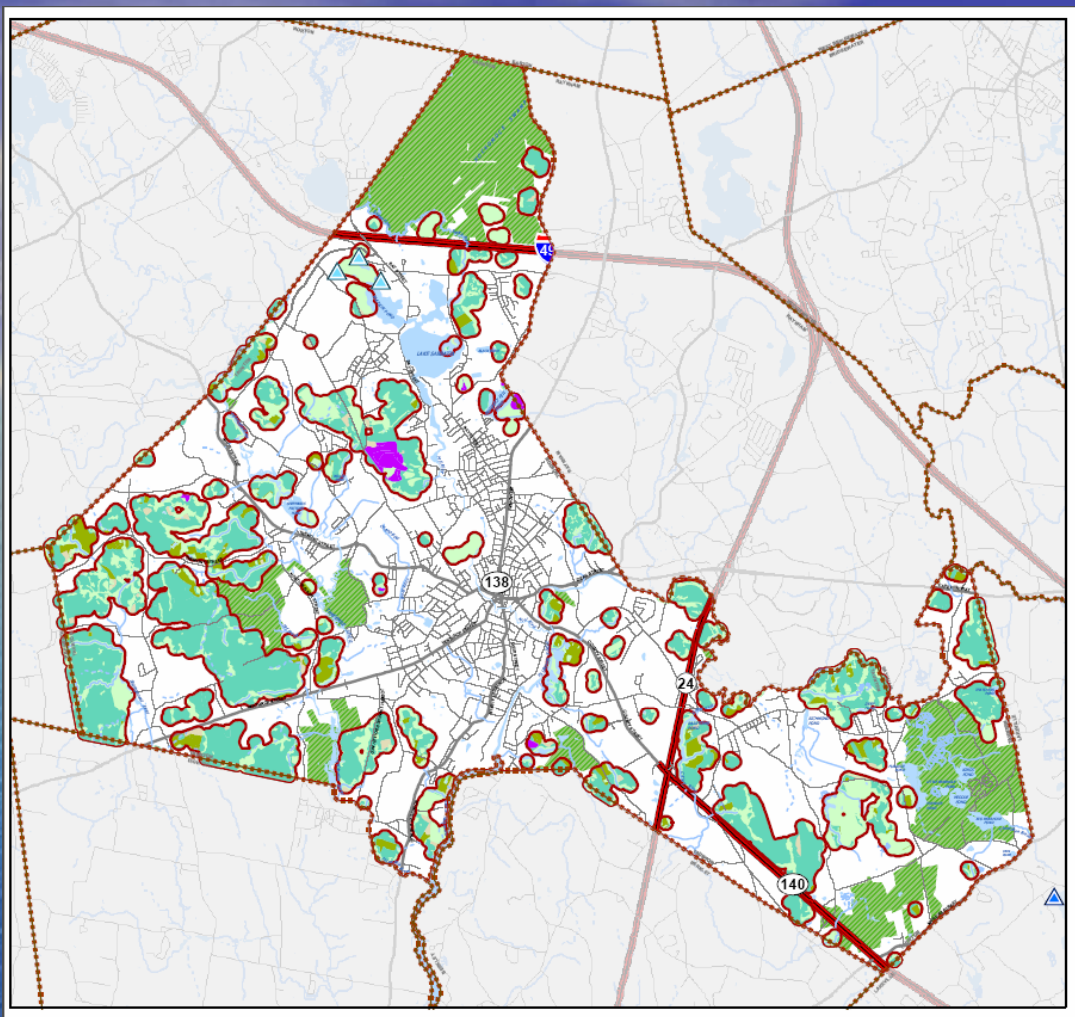
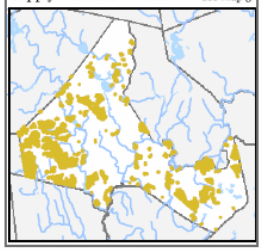


Potential Future Zone I Public Water Supply Protection Areas see Map 3



Potential Future Water Supply Protection Area (Zone I)

Undevelopable Land

Criteria that may constrain land from development include slope, wetlands, River Protection Act buffers, 100-year flood zones, certain zoning overlays and rights-of-way, and restrictions outlined in an existing development plan.

Protected Open Space within or contiguous with potential future Zone I

other than federally-owned, permanently protected state- or privately-owned, or under the control of a municipal conservation commission (see Map 3).

Municipal Boundary

Water features

River or Stream
Intermittent Stream
Lake or Pond

0 1.25 2.5 Miles

0 0.45 0.9 Kilometers

Current Land Use

Agriculture
Natural Land/ Undisturbed
Urban open/ Institutional/Recreation
Mining
Open Undeveloped Land

Public Water Supplies

Taunton Supplies	*Other Towns*
Ground Water	
Surface Water	
Proposed Well	

Map 4

Current Land Use

in

Potential Public Water Supply Protection Areas

Taunton

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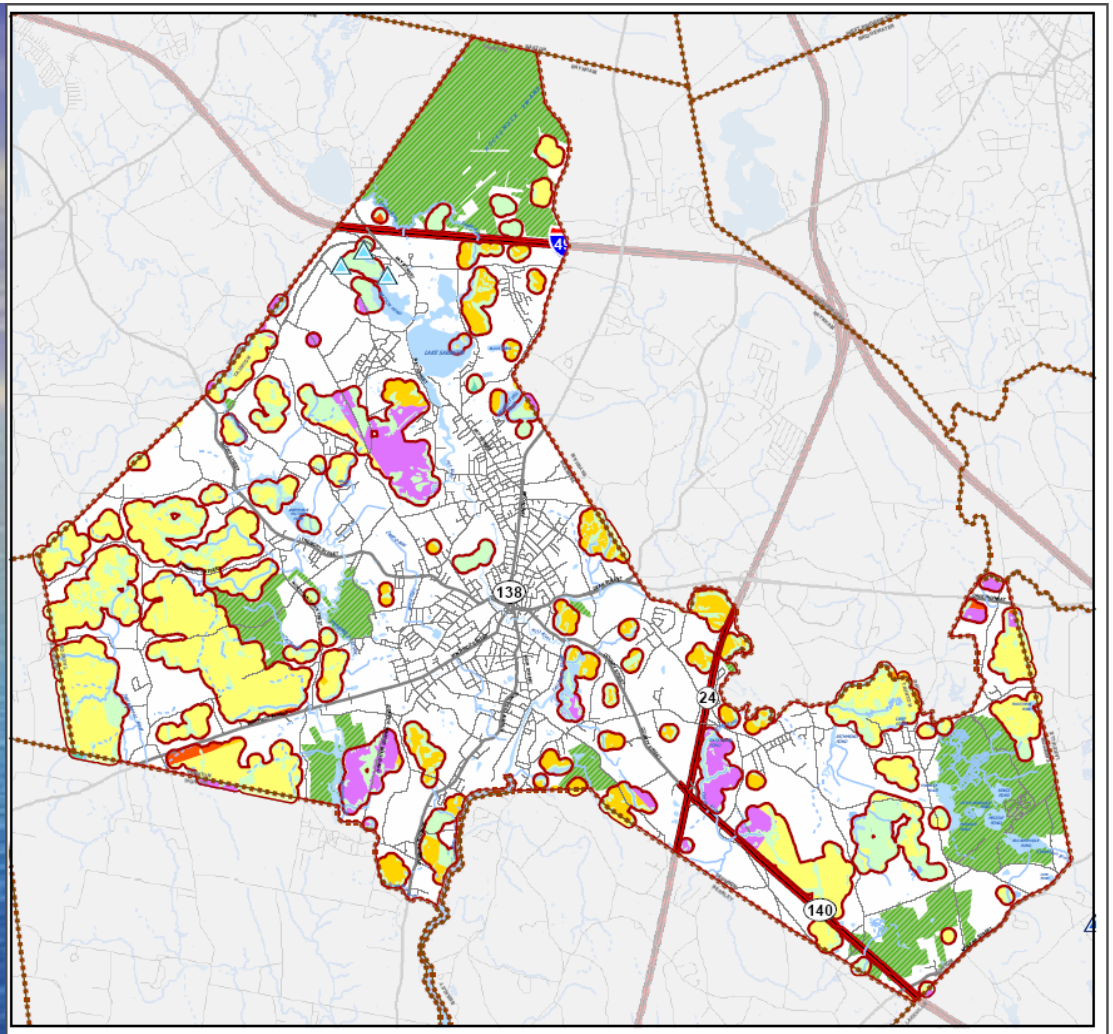
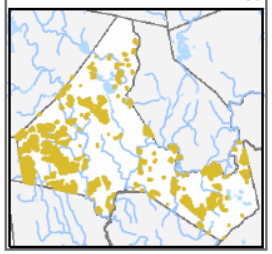


Potential Future Zone I Public Water Supply Protection Areas
see Map 3



0 0.5 1 Miles
0 0.5 1 Kilometers

Potential Future Water Supply Protection Area (Zone I)

Undevelopable Land

Criteria that may constrain land from development include slope, wetlands, River Protection Act buffers, 100-year flood zones, certain zoning overlays and rights-of-way, and restrictions outlined in an existing development plan.

Protected Open Space within or contiguous with potential future Zone I other than federally-owned, permanently protected state- or privately-owned, or under the control of a municipal conservation commission (see Map 3).

Municipal Boundary

Public Water Supplies

Taunton Suppliers / Other Towns
Ground Water
Surface Water
Proposed Well

Potential Future Land Use in potential Zone I areas, derived from zoning by-laws

- Agriculture
- Very Low Density Residential
- Low Density Residential
- Medium Density Residential
- Higher Density Residential
- Mixed Use
- Commercial
- Industrial/Transportation/ Mining
- Urban Open/Institutional/ Recreation
- Natural Land/ Undisturbed Vegetation
- No Zoning or Unknown

Water features

- River or Stream
- Intermittent Stream
- Lake or Pond

Map 5
Potential Land Use
in
Potential Public Water Supply Protection Areas

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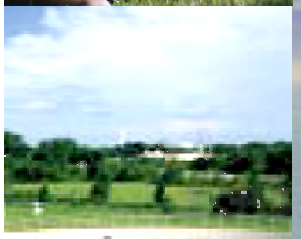

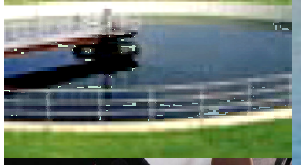

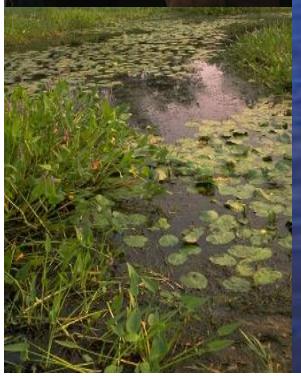

Massachusetts Case Study:

Source Water Protection Delineations

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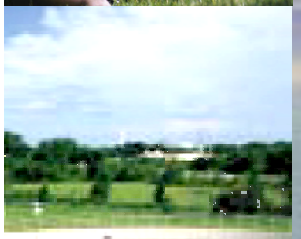
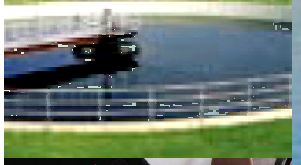
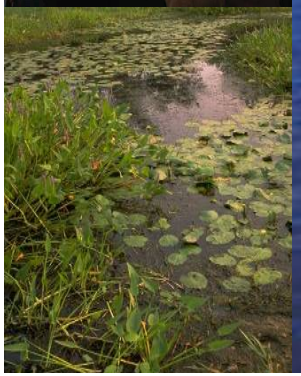
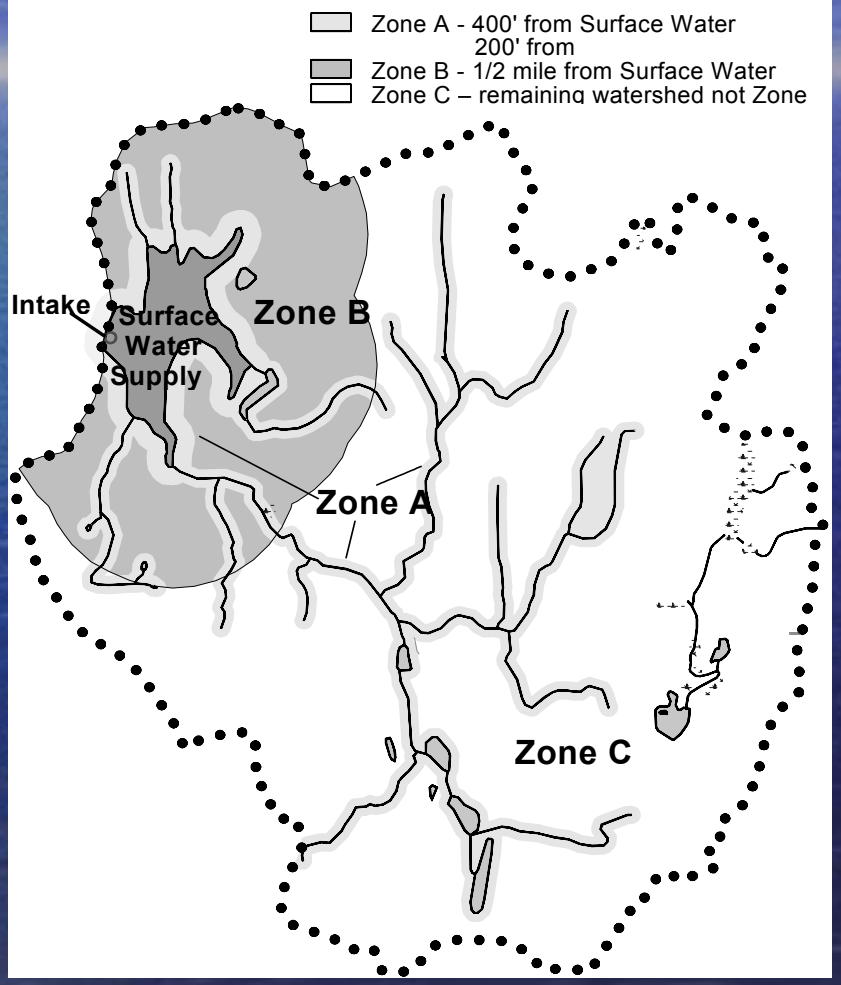






Surface Water Protection Zones

Figure 1. **Surface Water Supply Protection Areas**



Source: Massachusetts DEP

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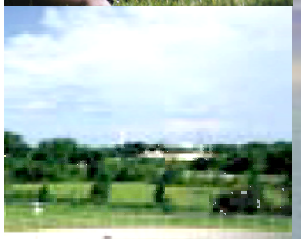

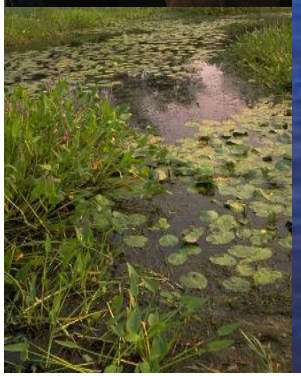

Massachusetts Case Study: Groundwater Source Water Protection Delineations

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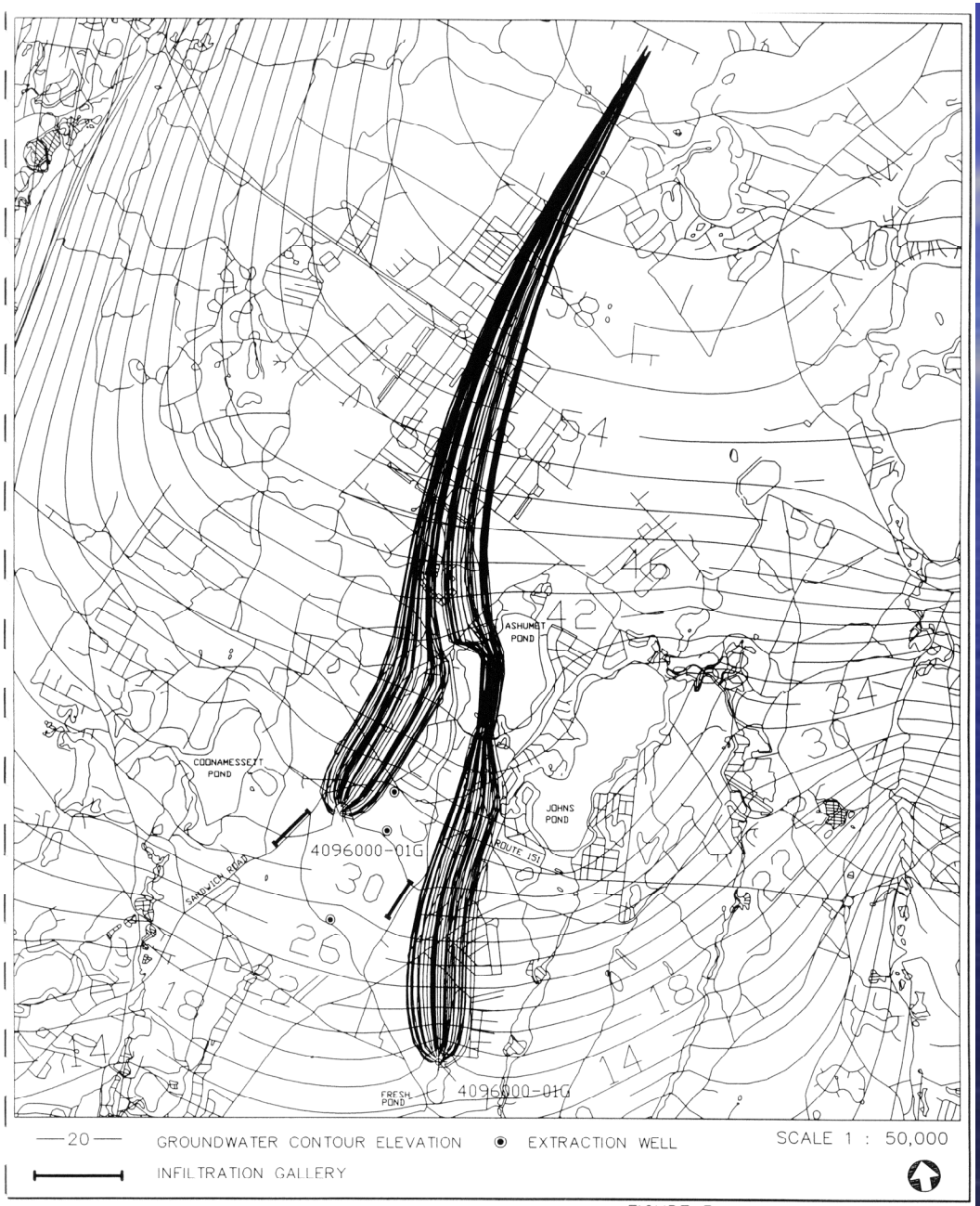

FIGURE 3-1
COMPUTER-SIMULATED ZONE II CONDITIONS AND
PARTICLE TRACKS FOR ASHUMET AND FRESH POND WELLS
FALMOUTH, MASSACHUSETTS

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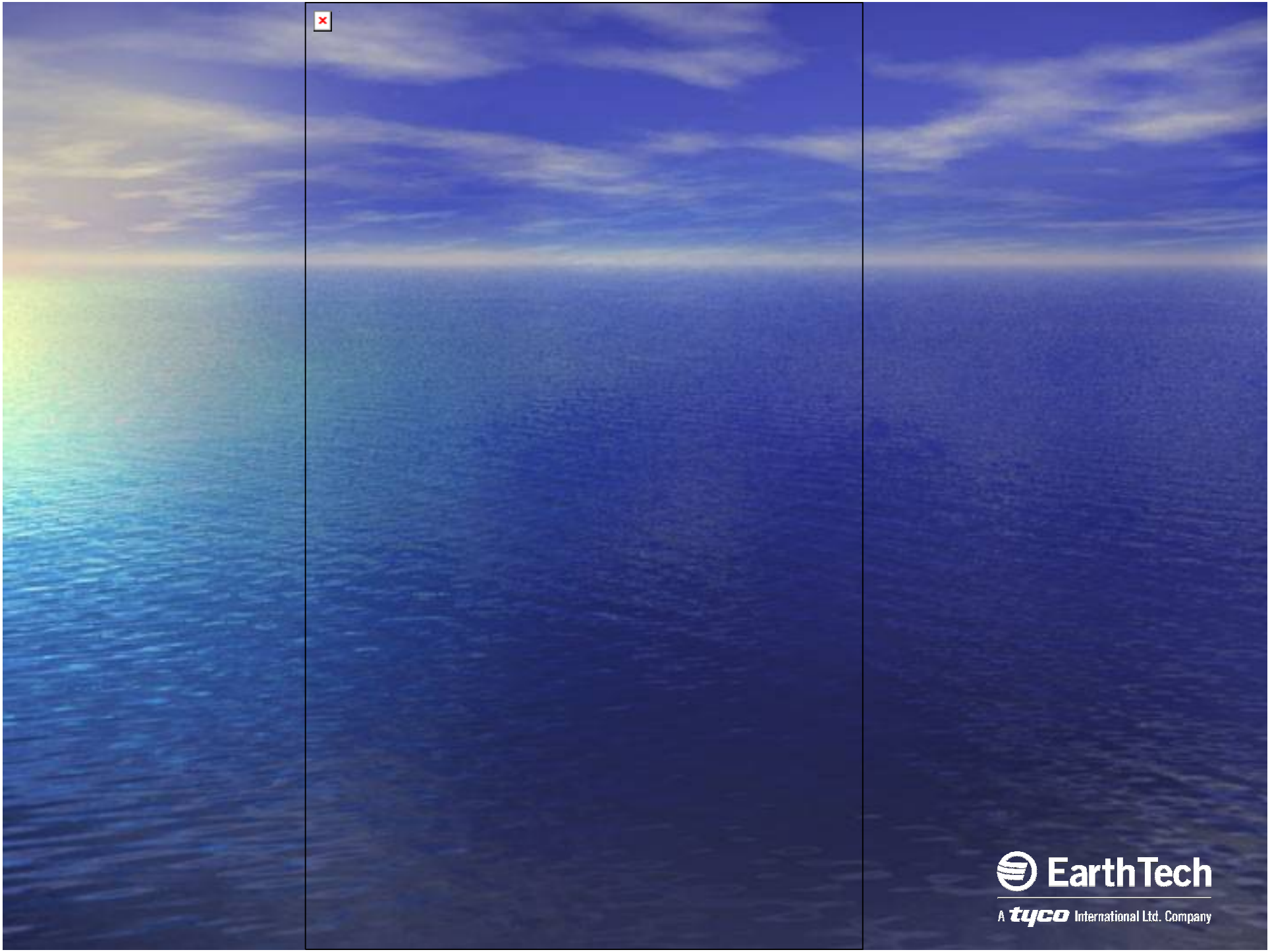
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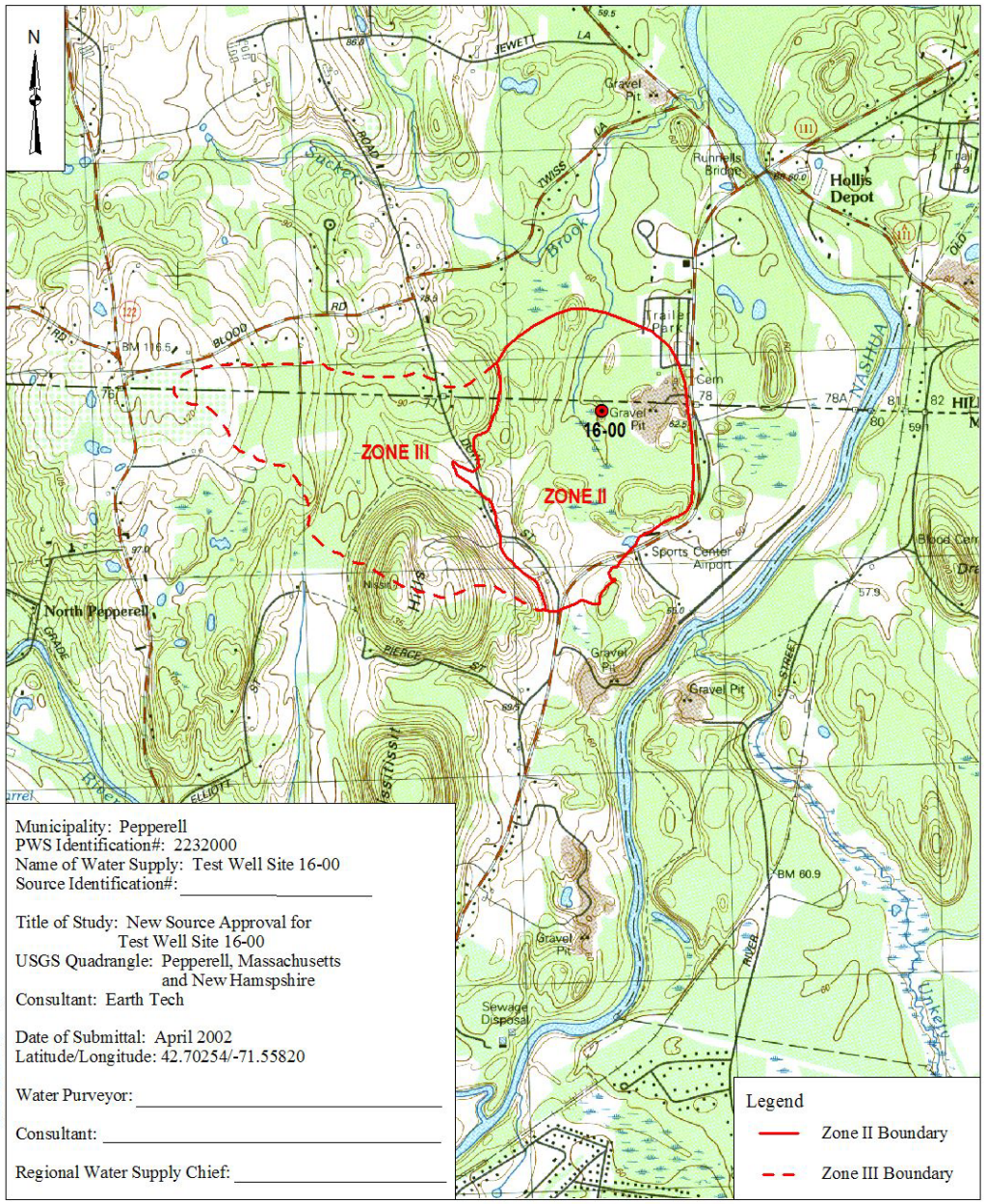

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SOURCE:Scanned USGS Quadrangles from MassGIS

Scale 1:25,000
April 2002

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FIGURE 5-2
ZONE II and ZONE III
TEST WELL SITE 16-00
PEPPERELL, MASSACHUSETTS

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Conclusions

- Source Water Protection (SWP) can assure future water supplies-quality and quantity
- Requires extensive watershed data/GIS
- Hydrologic models can be simple to complex
- Monitoring - quality, quantity, conflict resolution

Conclusions

- **Success requires permanent regulation/monitoring of activities within identified SWP areas-model regulation developed by Massachusetts**
- **Planning/Zoning goals must be in sync with SWP**

Conclusions

- SWP safeguards human health and is more economical than remediation
- GIS will provide new valuable product in the public domain

Thank You
for Attending
Today's Roundtable

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