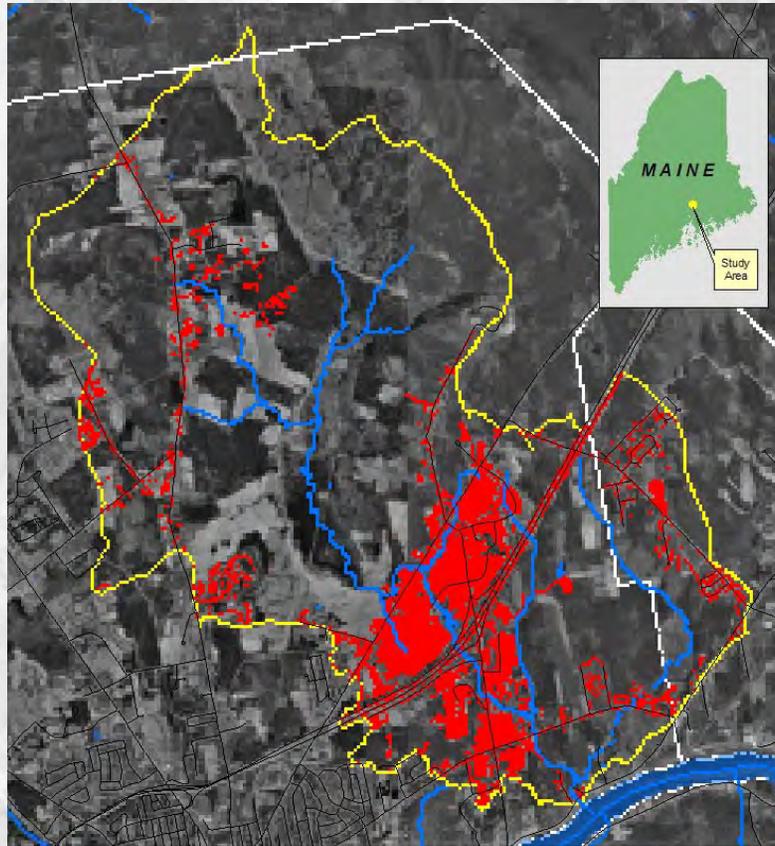


Penjajwoc Watershed ~ Bangor, ME

Impervious Cover Buildout Analysis



February 2007

Fred Dillon ~ FB Environmental



Study Questions

- To determine current extent of impervious cover in Penjajawoc watershed and;
- To estimate increase in watershed impervious cover under full buildout conditions as defined by current zoning.

The Problems with Imperviousness

Increased Imperviousness Leads to:	Resulting Impacts				
	Flooding	Habitat loss	Erosion	Channel Widening	Stream bed Alteration
Increased Volume	✓	✓	✓	✓	✓
Increased Peak Flow	✓	✓	✓	✓	✓
Increased Peak Duration	✓	✓	✓	✓	✓
Increased Stream Temp.		✓			
Decreased Base Flow		✓			
Changes in Sediment Loading	✓	✓	✓	✓	✓

What it Looks Like...

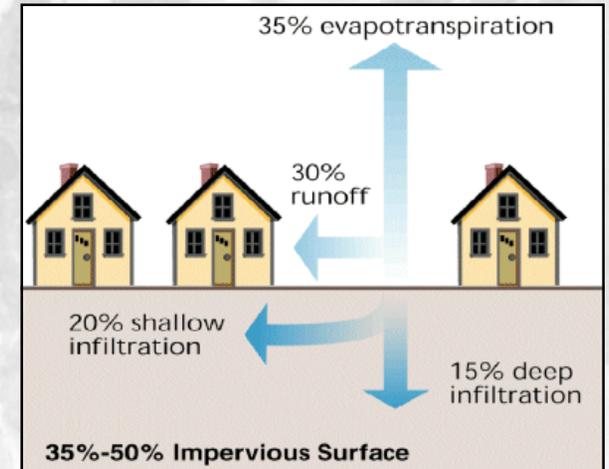
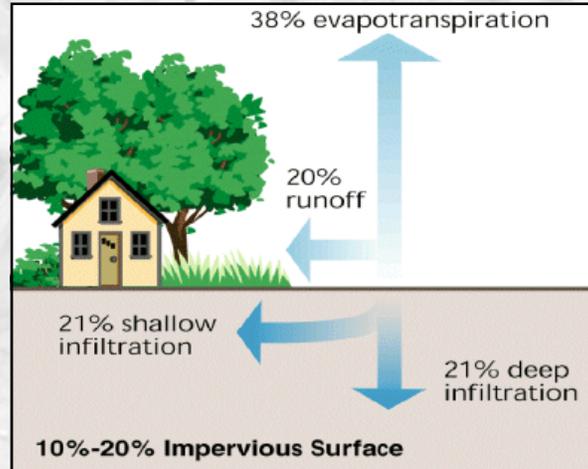
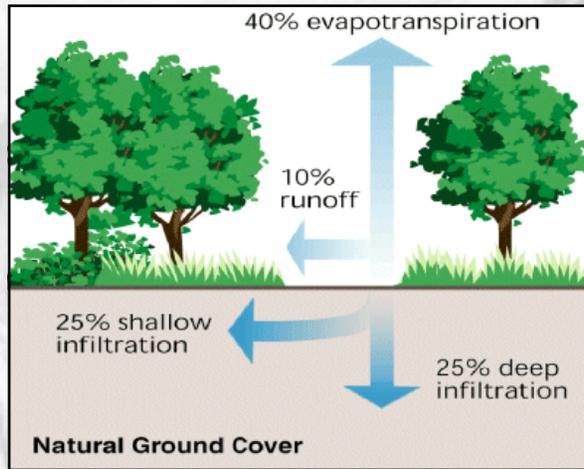
Commercial "Big Box" Sprawl



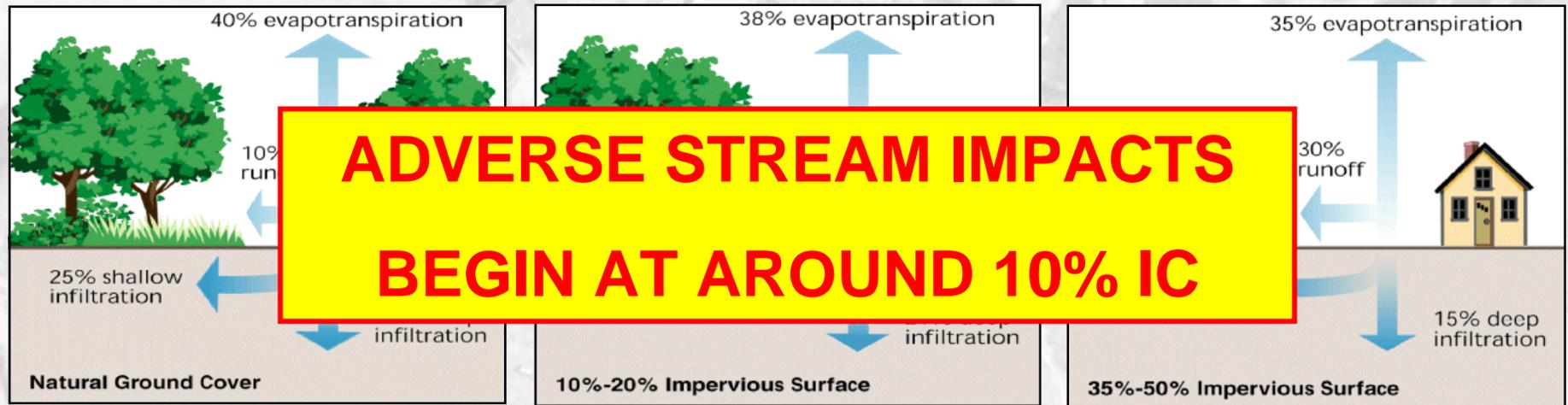
Residential Sprawl



Imperviousness & Surface Water Quality



Imperviousness & Surface Water Quality



- <10 % IC streams are generally protected, although sensitive streams may begin to be stressed.
- 11-25 % IC streams are most likely impacted; mitigation may be successful.
- > 25 % IC streams are most likely degraded; mitigation difficult.

Stormwater Runoff

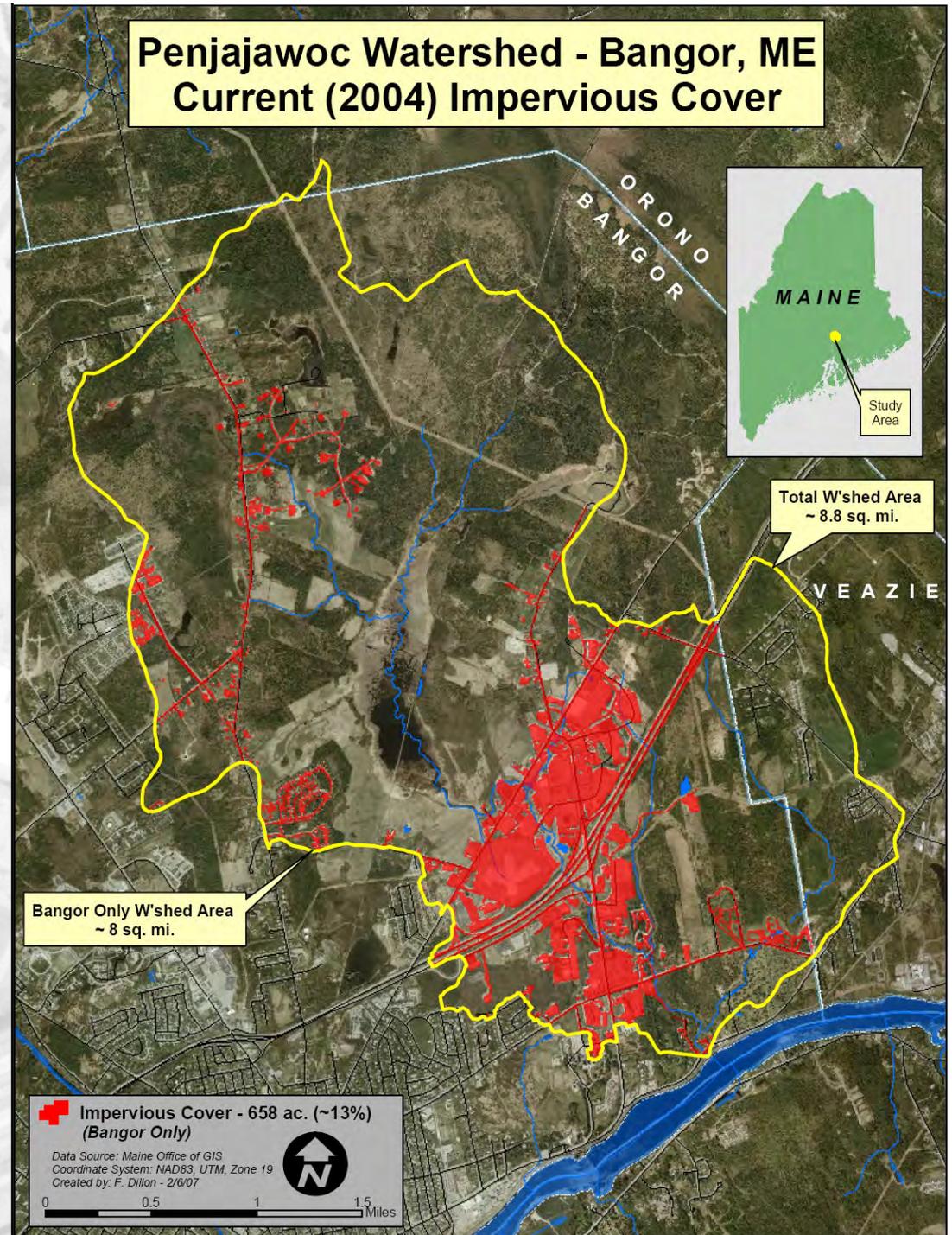
Contaminant	Contaminant Sources
Sediment and Floatables	Streets, lawns, driveways, roads, construction activities, atmospheric deposition, drainage channel erosion
Pesticides and Herbicides	Residential lawns and gardens, roadsides, utility right-of-ways, commercial and industrial landscaped areas, soil wash-off
Organic Materials	Residential lawns and gardens, commercial landscaping, animal wastes
Metals	Automobiles, bridges, atmospheric deposition, industrial areas, soil erosion, corroding metal surfaces, combustion processes
Oil and Grease/ Hydrocarbons	Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains
Bacteria and Viruses	Lawns, roads, leaky sanitary sewer lines, sanitary sewer cross-connections, animal waste, septic systems
Nitrogen and Phosphorus	Lawn fertilizers, atmospheric deposition, automobile exhaust, soil erosion, animal waste, detergents



Current IC Determination for Penjajawoc Watershed

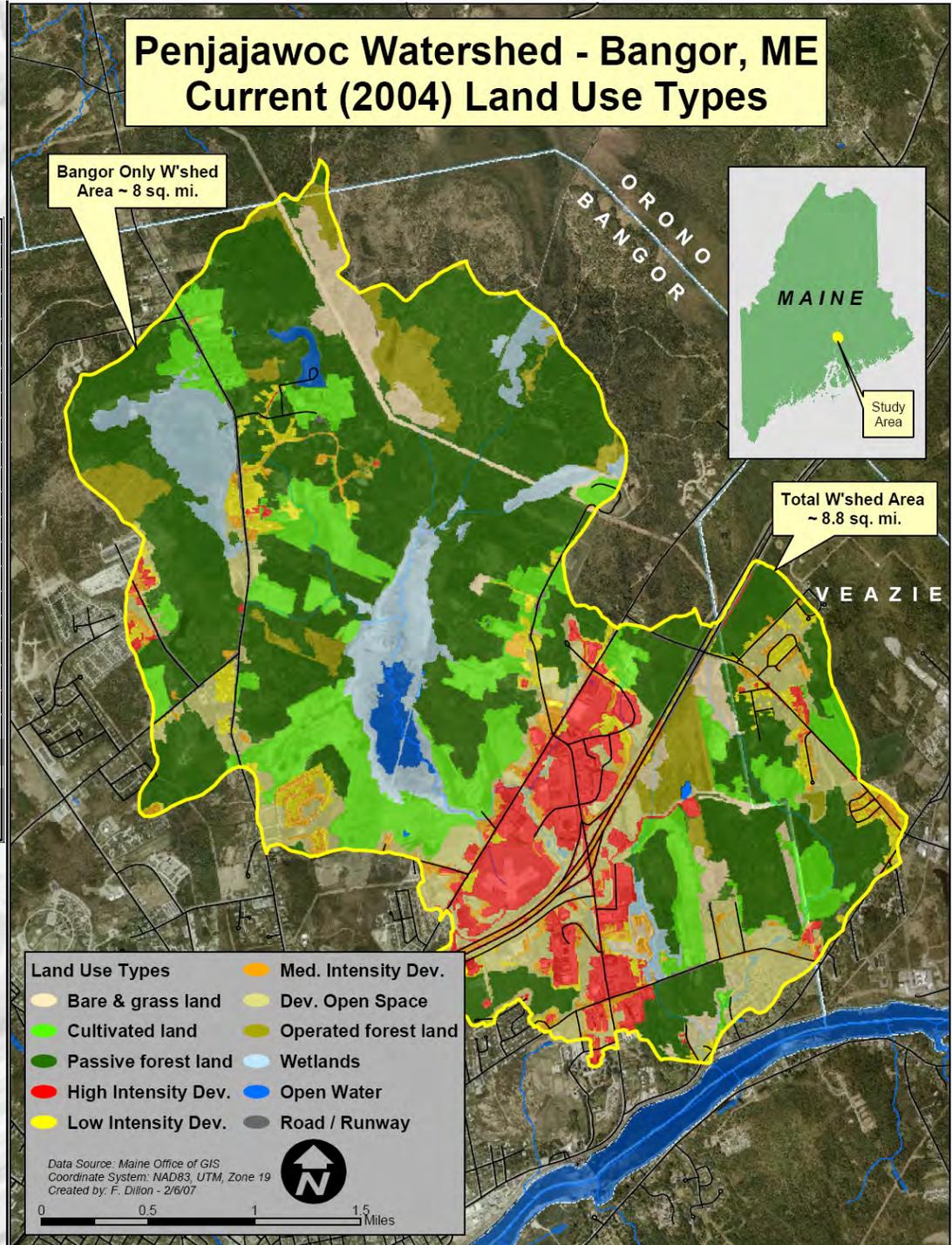
** Based on DEP's
most recent IC data*

*As of 2004, IC in
Bangor's portion
of watershed was ~13%*



Penjajawoc Land Uses

LU Code	Land Use Type	Total Acres	IC Range (%)	IC Coeff.	IC Acres
2	High Intensity Dev.	454.1	80-100	90	408.7
3	Med. Intensity Dev.	211.8	50-79	65	137.7
4	Low Intensity Dev.	189.1	21-49	35	66.2
5	Dev. Open Space	556.1	<20	10	55.6
6	Cultivated Land	357.9	0	0	0.0
7	Pasture / Hay	453.8	0	0	0.0
8	Grassland	8.1	0	0	0.0
9	Deciduous Forest	413.6	0	0	0.0
10	Evergreen Forest	744.7	0	0	0.0
11	Mixed Forest	1229.0	0	0	0.0
12	Scrub Shrub	205.6	0	0	0.0
13	Forested Wetland	192.8	0	0	0.0
15	Wetlands	218.5	0	0	0.0
16	Road / Runway	63.0	100	100	63.0
19	Unconsolidated Shore	2.9	0	0	0.0
20	Bare Land	1.0	0	0	0.0
21	Open Water	69.6	0	0	0.0
24	Light Partial Cut Forest	135.5	0	0	0.0
25	Hvy. Partial Cut Forest	95.3	0	0	0.0
26	Forest Regeneration	41.9	0	0	0.0
Totals:		5644.5			731.3
		Percent IC		13.0%	



Dominant LU Types

- Forest: ~47%
- Agriculture: ~14%
- High-Med Intensity Dev: ~12%
- Dev. Open Space: ~10%
- Wetlands: ~7%

Estimating Future Impervious Cover

NEMO Methodology

(Nonpoint Education for Municipal Officials)

Suggested Data

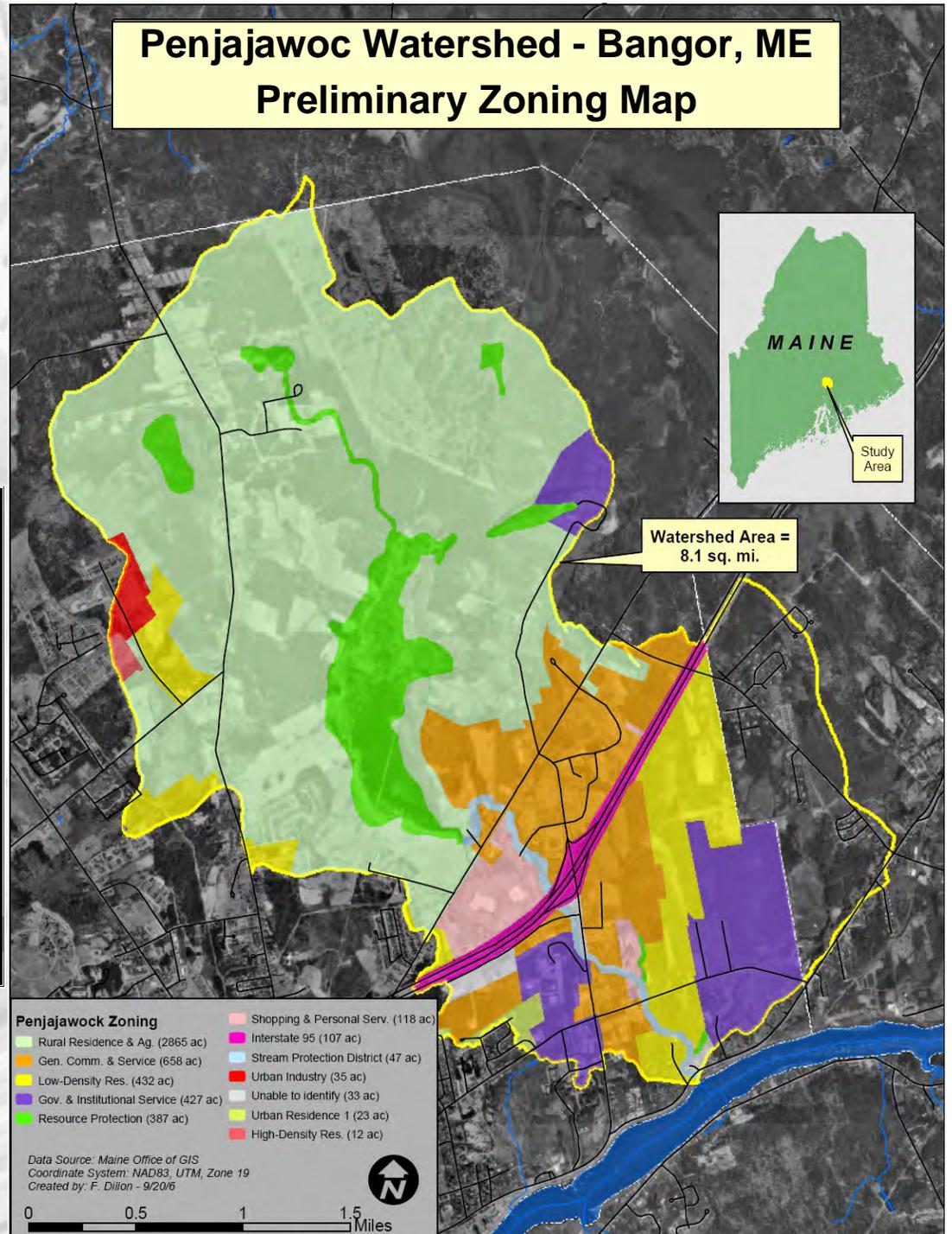
- Landcover
- Watershed boundaries
- Zoning data
- Unbuildable areas
- Soils
- Elevation or slope
- Parcels
- Water features
- Roads

Estimating Future IC per NEMO (cont)

- **Step 1:** identify areas that can be developed in future
- **Step 2:** assign IC values to anticipated future land uses
- **Step 3:** calculate future imperviousness

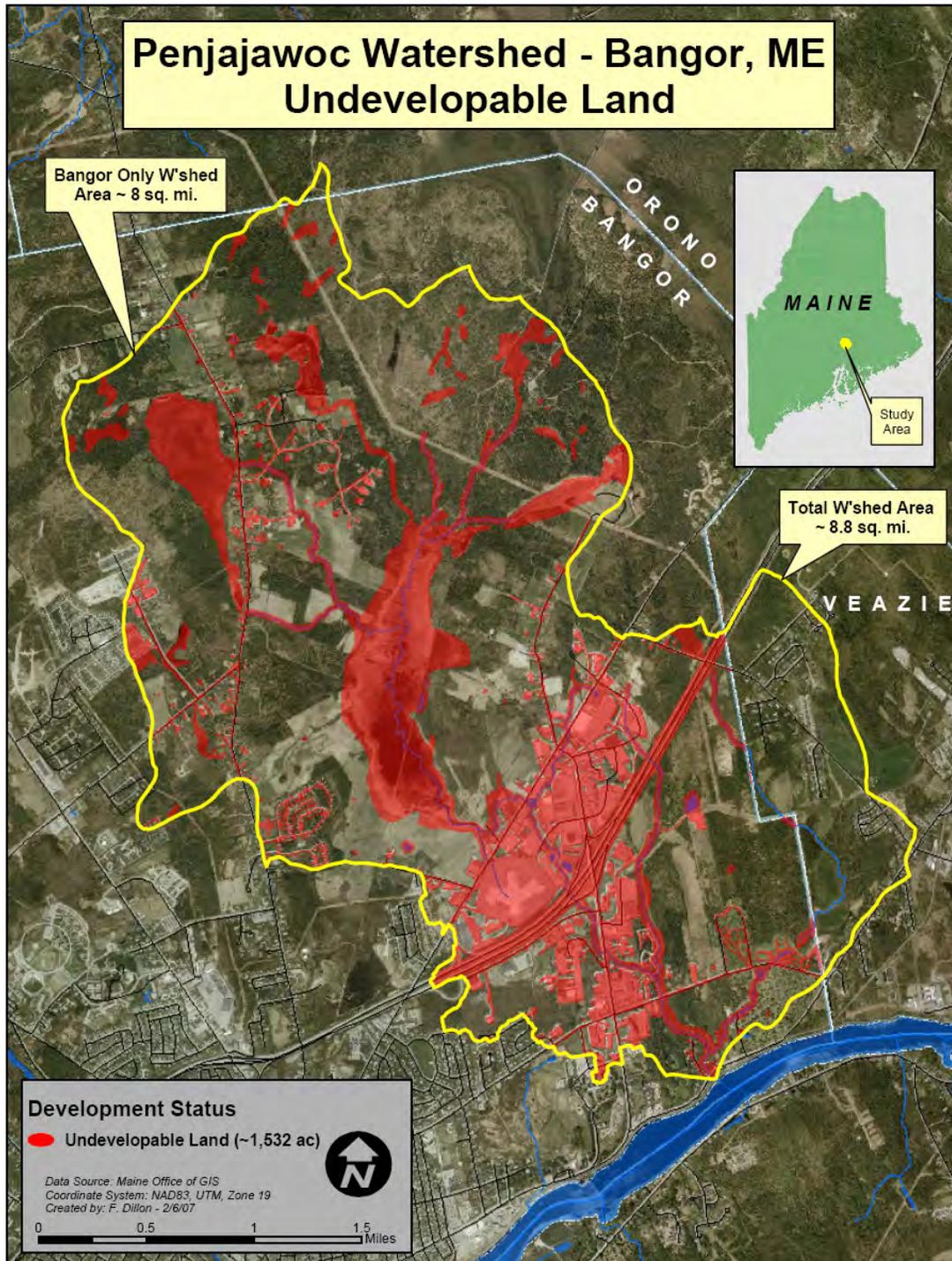
Start with current zoning...

Zone Descriptions	W'shed Acres
Rural Residence and Agricultural District	2865.2
General Commercial and Service District	658.2
Low-Density Residential District	432.3
Government and Institutional Service District	427.3
Resource Protection District	386.6
Shopping and Personal Service District	118.4
Interstate 95	107.3
Stream Protection District	47.2
Urban Industry District	35.3
Unable to identify	33.1
Urban Residence 1 District	22.8
High-Density Residential District	11.9
	5145.7



Penjajawoc Watershed - Bangor, ME Undevelopable Land

Bangor Only W'shed
Area ~ 8 sq. mi.



Subtract out undevelopable areas...

- *Resource protection*
- *Stream protection*
- *Wetlands*
- *Current IC*
- *Stream & pond buffers (75')*
- *High density residential*
- *I-95*

Undevelopable Land
~ 1,532 ac (30%)



Penjajawoc Watershed - Bangor, ME Developable Land

Bangor Only W'shed
Area ~ 8 sq. mi.



Total W'shed Area
~ 8.8 sq. mi.

...to determine
remaining
developable
areas.

*Developable Land
~ 3,614 ac (70%)*

Development Status

● Developable Land (~3,614 ac)



Data Source: Maine Office of GIS
Coordinate System: NAD83, UTM, Zone 19
Created by: F. Dillon - 2/6/07

0 0.5 1 1.5 Miles



Assign max allowable IS Ratios from Bangor ordinance and calculate IC at full buildout for remaining developable areas

Bangor Zoning Type in Penjajawoc W'shed	Acronym	Bangor IS Ratio	Acres	Full Buildout IC_Acres
Rural Residence and Agricultural District	RR & A	0.20*	2430	486
Government and Institutional Service District	G & ISD	0.70*	330	231
Shopping and Personal Service District	S & PS	0.70	240	168
General Commercial and Service District	GC & S	0.75	182	136
Low-Density Residential District	LDR	0.30	396	119
Urban Industry District	UID	0.70*	18	13
Urban Residence 1 District	URD-1	0.60*	19	12
Undevelopable Land	Undev	0	1532	0
Totals :			5146	1163
% IC at full buildout :			22.6%	
Current IC for W'shed** :		Acres	% IC	
		658	12.8%	
% increase in IC at full buildout :			76.9%	

* No ISR values listed in Bangor's Ordinance; estimated based on similar zone types.

** Based on DEP's most recent impervious cover data

Current (2004) IC = ~658 ac (13%)

Future IC at Full Buildout = ~1,163 ac (23%)

Increase from Current to Full Buildout: ~505 ac (77%)



Zoning for Stream Protection

(Center for Watershed Protection)

**TABLE 2: STRATEGIES TO MINIMIZE IMPERVIOUS AREA AT THE SITE LEVEL
(ADAPTED FROM WELLS 1994, SCHUELER 1994, PZC, INC. 1992)**

1. Reduce residential road widths	13. Vertical parking structures
2. Shorter road lengths	14. Require open space/green space
3. Cul-de-sac donuts	15. Require buffers
4. Disconnect roof leaders	16. Swales rather than curb/gutters
5. Cluster development	17. Encourage runoff to pervious surfaces
6. Angled parking	18. Commercial open space landscaping
7. Smaller parking stalls	19. Sidewalks on one side of street
8. Reduced parking ratios for some land uses	20. Reduce setbacks and frontage
9. Shared parking and driveways	21. Flexible minimum lot sizes
10. Shorter residential driveways	22. "Hourglass" streets
11. Reduced cul-de-sac radii	23. T or V shaped turnarounds
12. Taller buildings (with higher FAR ratios)	24. Permeable spillover parking areas

Zoning for Stream Protection (cont).

TABLE 8: RECOMMENDED PROCESS TO INSTITUTE WATERSHED-BASED ZONING

Step	Task
1.	Conduct comprehensive stream inventory
2.	Refine/verify impervious cover/stream quality relationships
3.	Map existing and future impervious cover at subwatershed level
4.	Designate subwatersheds into stream quality categories, based on growth patterns and attainable stream quality
5.	Modify existing master plan to meet subwatershed targets
6.	Incorporate any management priorities derived from larger watershed planning efforts (i.e., watershed, sub-basin or basin plans)
7.	Adopt specific stream protection strategies for each subwatershed
8.	Implement long-term monitoring and enforcement program to provide management feedback

Zoning for Stream Protection (cont).

TABLE 10: STREAM PROTECTION STRATEGIES UNDER THE WATERSHED-BASED ZONING FRAMEWORK

Urban Stream Classification	Sensitive 0-10% Imperv.	Degrading 11- 25% Imperv.	Non-Supporting 26 + % Imperv
Stream Quality Goal	Preserve biodiversity and channel stability at predevelopment level	Limit degradation to stream quality	Minimize pollutant loads delivered to downstream waters
Land Use Controls	Watershed-wide limits on imperv. cover, restrictions on site imperv. cover.	Upper limit on watershed impervious cover.	No watershed imperv. limits.
BMP Selection Criteria	Maintain pre-dev. hydrology (ED or I). Minimize stream warming and sedimentation. Only off-stream ponds Preference for filtering systems	Maintain pre-dev. hydrology (ED). Maximize pollutant removal. Ponds/wetlands OK with some restrictions	Maximize pollutant removal and quantity control. Remove N,P and metals, toxics No restrictions on ponds and wetlands
Streamside Management	Stream valley buffers, few uses allowed	Stream buffers	Greenways
Monitoring	Biological indicators, including single-species (e.g. trout)	Biological and physical indicators	Water quality trends, BMP performance
Enforcement	GIS tracking of impervious cover	GIS, biomonitoring trends, BMP surveys	Simulation model, WQS standards
Development Rights	Transferred out	No transfers	Transferred in
Other Tools	Land acquisition, extraordinary E&S control, special review	Regional BMPs	Pollution prevention, Stormwater retrofits, illicit connections, restoration inventory

The precise impervious cover ranges shown in this example are illustrative and may shift slightly due to regional and climatic conditions or historical management of the stream channel (e.g., ditching).

Conclusions

- Under current zoning, IC at full buildout will approach critical threshold that may result in irreversible damage to overall stream health
- Establishing zoning that uses impervious cover limits for subwatersheds (1-10 mi²) can mitigate against further water quality degradation

Limitations of Analysis

- Zoning area delineations somewhat inaccurate due to data conversion from CAD to GIS
- Didn't consider Comp Plan for potential future development scenarios (just used current IS ratios from ordinance)
- There may be additional undevelopable areas (e.g., dedicated open spaces, etc.)

Questions?

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