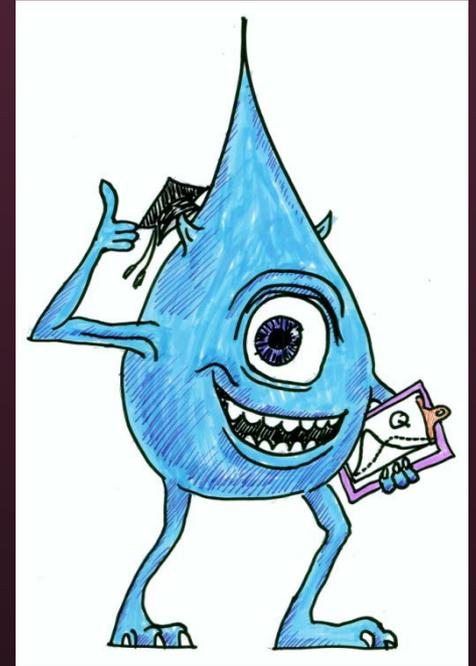


Evolution of Storm Water Concerns



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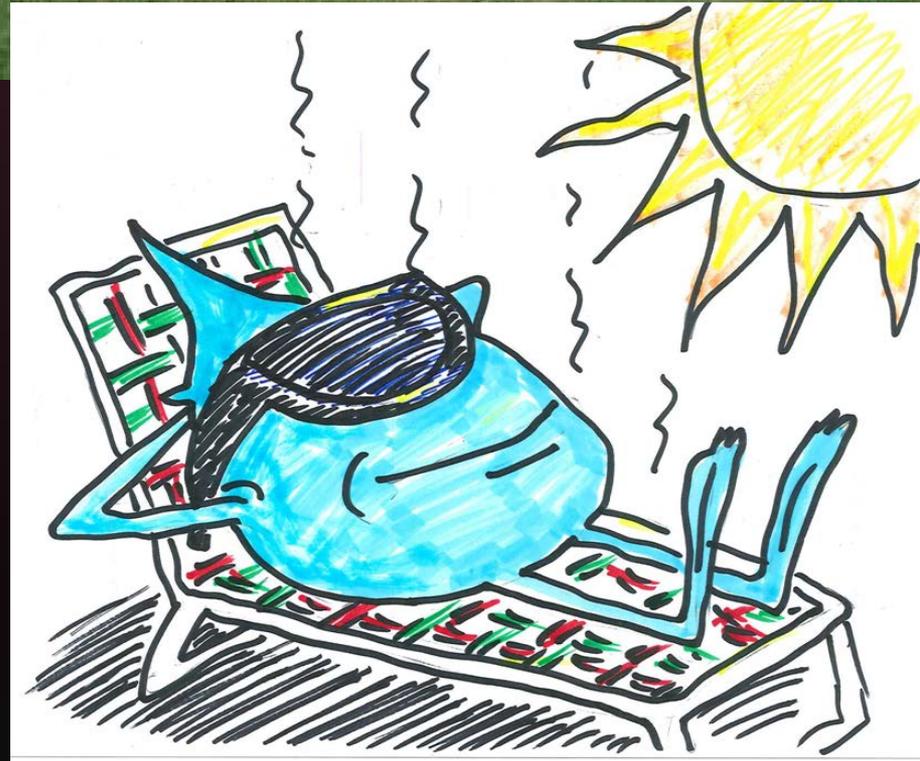
Storm Water Quantity

- 5,500 BC – Egyptians rely on floods to develop agriculture. Later, first dams, canals
- 350 BC – Aristotle links ground water and surface water
- 100 AD – Romans build aqueducts, relate cross-sectional stream flow area to flow capacity, measure channel slope
- 1,500 AD – Leonardo da Vinci: $Q = V \cdot A$, continuity equation, friction loss



Old European Guys

- 1674 – Perrault relates stream flow to rainfall measurements, conceives of hydrologic cycle
- 1670s - Mariotte measures flow of Seine River, cross-sectional velocity distribution
- 1686 – Halley measures pan evaporation



More Old Euro Guys

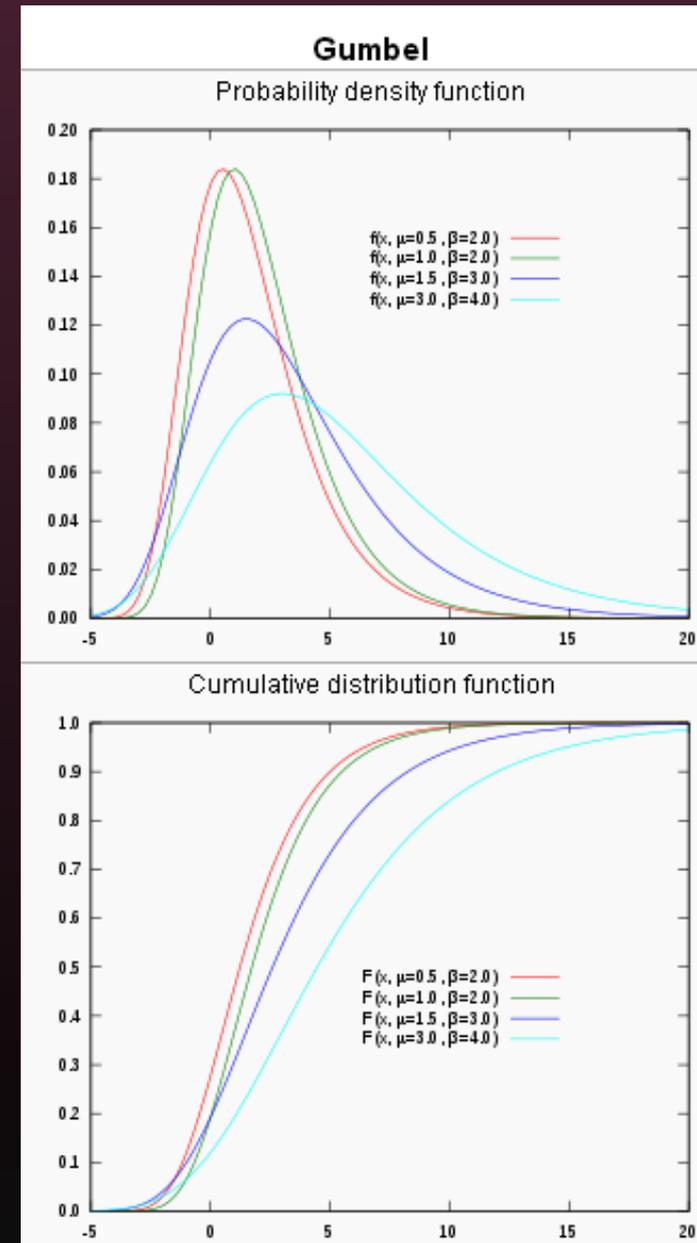
- 1732 – Pitot tube invented for flow measurement
- 1738 – Bernoulli publishes “Hydrodynamica”
– pipe flow– pressure head, velocity head
- 1775 – Chezy relates flow velocity to hydraulic radius
- 1851 – Peak discharge - Rational method developed by Mulvaney
- 1889 – Manning’s Formula for open-channel flow

The New World

- 1802 – Army Corps of Engineers founded
- 1860s – 1880s – First studies of Mississippi by USGS (founded 1879) and others
- 1891 – US Weather Bureau
- 1899 - First drainage district created in WI

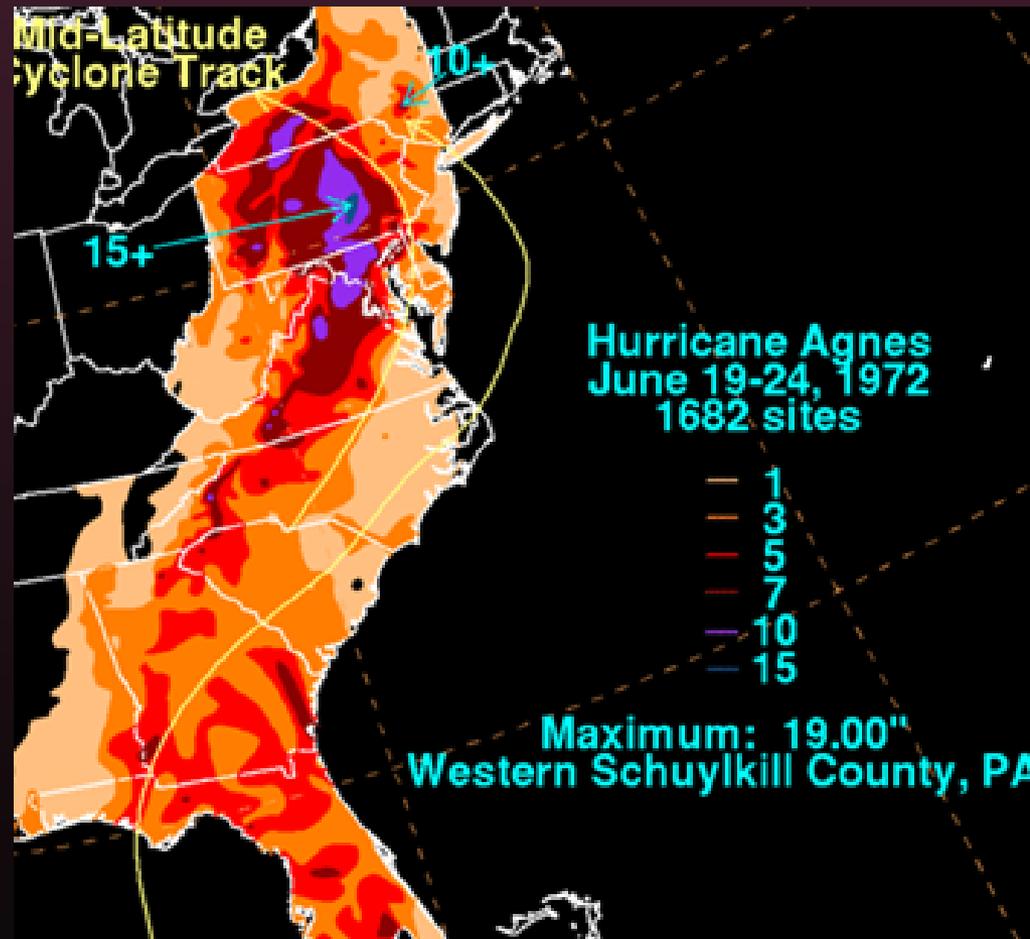
The Feds Take an Interest

- 1927 - Great Mississippi Flood – 30 ft! – accelerated rural / urban migration
- 1936 - Flood Control Act - Made flood control a Federal policy - ACOE = major Federal flood control agency – more levees - \$\$
- 1941 – Gumbel – frequency analysis of data, probability of extreme events, resisted Hitler



Flooding

- 1968 – National Flood Insurance Program (private companies dropped flood insurance starting in 1950s due to losses)
- 1972 – Hurricane Agnes hits NE US
- 1978 - FEMA created



Early Design Tools

- 1950s – Nomographs start to become available (for culvert flow – DOT Interstate projects?)
- 1950s – USDA develops
 - runoff curve numbers,
 - initial abstraction,
 - retention,
 - runoff.
- Published 1969

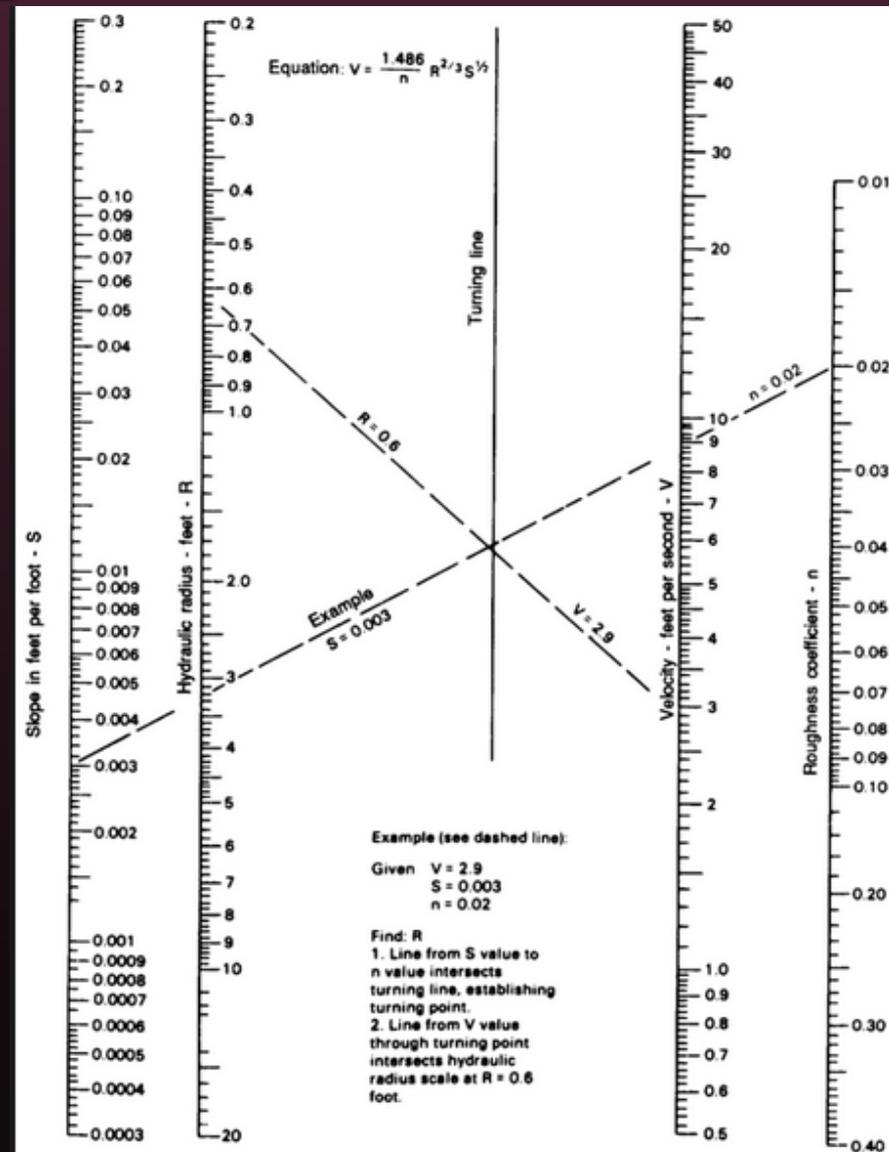


Figure 6-25. Nomograph for Manning's equation

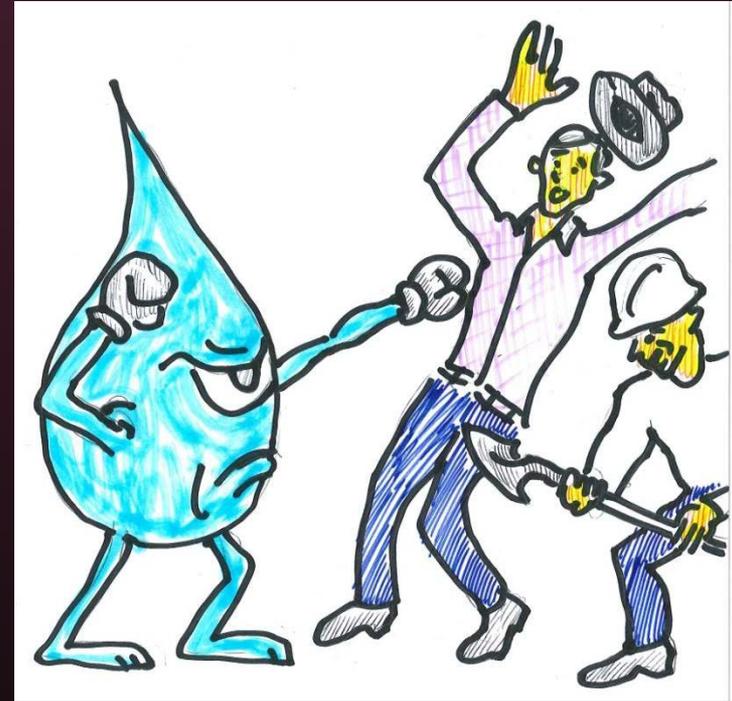
Digital Revolution

- 1966 – Stanford Watershed Model – First comprehensive model
- 1971 – SWMM – Most comprehensive model for urban runoff in storm sewers, updated '75, '81, '88 (Metcalf + Eddy for EPA)
- 1973 – HEC-1 - Floods from rainfall data (ACOE)
- 1975 - TR-55 published, tabular, revised in 1986, 1999 (USDA)
- 1976 – HEC-2 - Water surface profile
- 1983 - TR-20 computer model developed, used to re-compute TR-55 tables (USDA)



Quantity Regulations

- Common Enemy Doctrine
- Derived from English common Law
- Surface water is a "common enemy" to landowners
- Each landowner has the right to alter the drainage pattern of his land without regard for the effects on neighboring parcels, as long as that water flows to where it otherwise would have naturally flowed

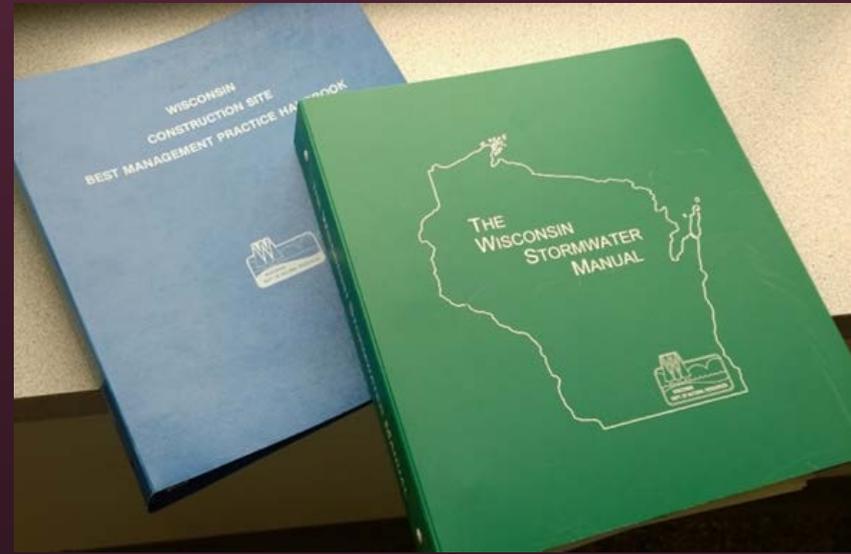


Reasonable Use Rule

- >1974: allows a landowner to make "reasonable" alteration to the drainage pattern of his parcel, with liability only occurring when the alteration causes "unreasonable" harm toward neighboring parcels. Judged in part on comparative benefits.
- Successful causes of action (>1980):
 - Nuisance (damage by unreasonable use)
 - Inverse condemnation/"takings" (property becomes useless/damages due)
 - Negligence (improper installation or maintenance)

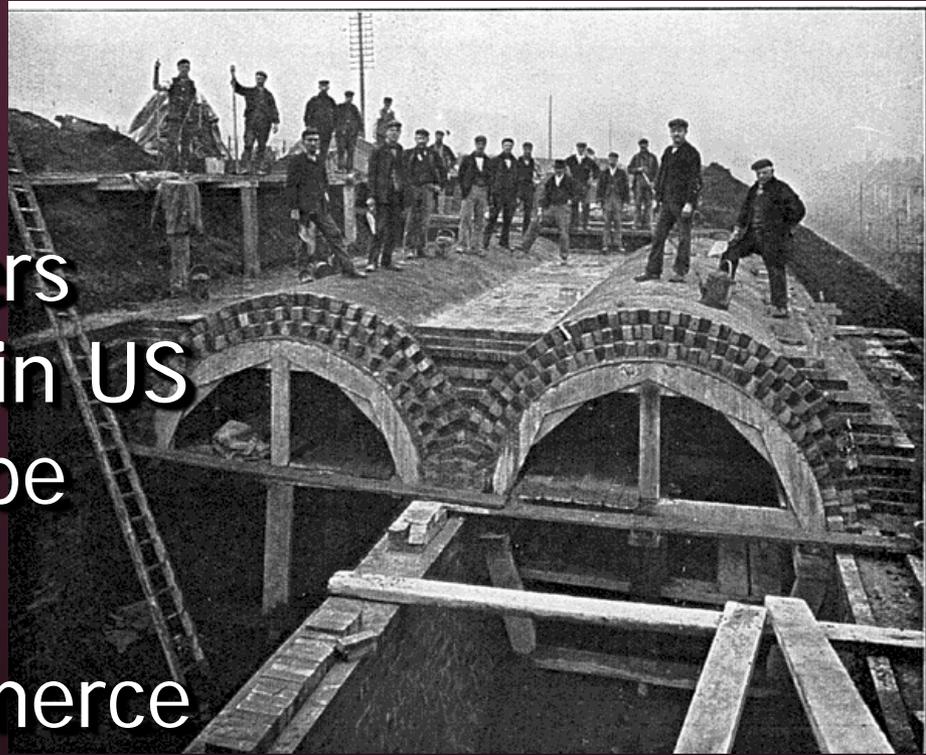
The Local Scene

- Late 1970s – Peak discharge starts to appear in local ordinances - availability of models, flooding concerns?
- 1994 – Wisconsin Green Book – early BMP design standards – UWEX, WDNR
- 1998 - Model storm water management ordinance finalized
- 2002 – NR 151 – Peak discharge in 2-year design storm only, infiltration / volume reduction



Water Quality

- 1850s – Municipal sewers start to be constructed in US – Streams assumed to be “self-cleansing.”
- 1887 – Interstate Commerce Act – Focus on railroads – ICC created
- 1890s – Scientists and engineers start to question capacity of streams – water supply – epidemiology



First Comprehensive Programs

- 1948 Federal Water Pollution Control Act
 - Authorized the Federal Works Administrator to assist states, municipalities, and *interstate* agencies in constructing sewage treatment plants
 - Funding ????

EPA



- 1962 – "Silent Spring" published on side effects of pesticides
- 1970 – EPA created, replacing USDA as pesticide overseer, eliminating conflict of interest



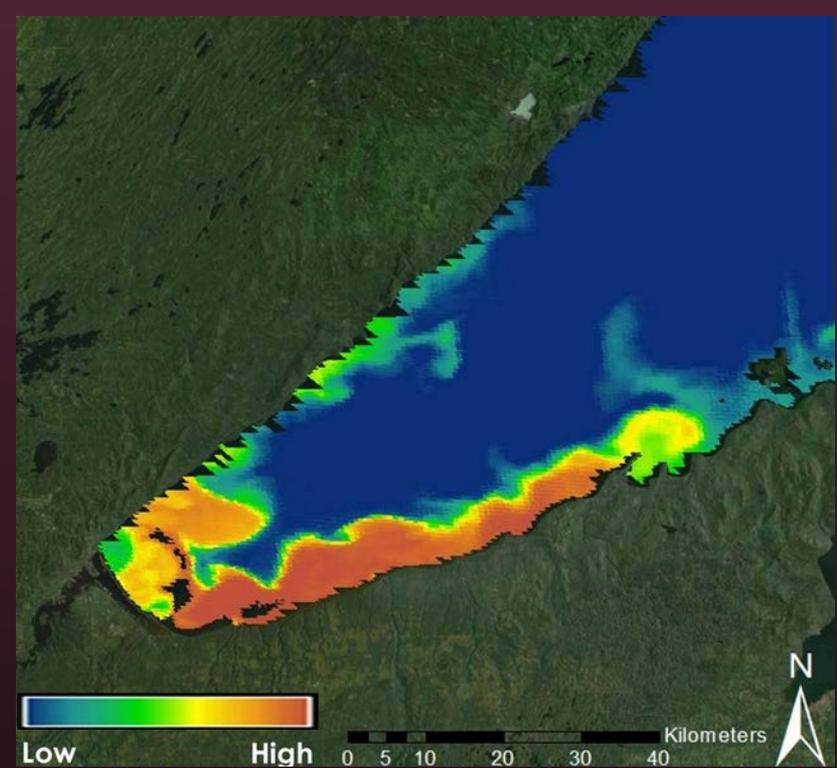
Point Sources

- 1972 – Clean Water Act established goals of:
 - eliminating releases of high amounts of toxic substances
 - eliminating additional water pollution by 1985
 - ensuring that surface waters would meet standards necessary for human sports and recreation by 1983
 - Implemented through NPDES
 - *\$85B in funding for WWTPs*



Nonpoint Sources

- 1970s – Growing awareness of water quality impact of nonpoint sources and storm water



Nationwide Urban Runoff Program (NURP)

- 1978 – NURP established by EPA as 5-year program to examine
 - Quality of urban runoff
 - Impact of urban runoff on surface water
 - Effectiveness of BMPs
- Analysis of water samples collected during 2300 storms in 28 major metropolitan areas.
- 1983 – NURP report published

Washington Co. Project

- 1978 – 1982
- \$2M EPA-funded research project
- Studied urban and ag nonpoint sources and institutional mechanisms to regulate nonpoint
- Led to creation of county Land Conservation committees in 1983
- Supported concept of State nonpoint program and local implementation

Wisconsin

- 1978 – DNR starts Priority Watershed and Lakes Program. Ended 2009
 - Identified sources of pollution (ag + urban)
 - Set load reductions - Precursor of TMDLs
 - Targeted BMPs, tech assistance, education in 86 watersheds
 - Voluntary, cost-sharing
 - Lessons: voluntary insufficient; more focus needed; monitoring inconclusive – variables
- Late 1980s – Water quality starts to appear in local Wisconsin ordinances

Ag Nonpoint

- 1984 - DNR put in place regulations for farms with >1000 animal units (CAFOs)
- 1992 - DNR expanded ag nonpoint regs to include "critical sites" through the Priority Watershed Program – Cost sharing



CWA Evolves -1987

- Section 319 Grant program established to reduce nonpoint sources (\$210M / yr in 2000s)
- Title V – any US Citizen may sue violator or EPA Administrator
- Required industrial and municipal separate storm sewer system ("MS4") storm water dischargers to obtain NPDES permits, by specific deadlines. Bigger cities, first
- Exemption for agricultural discharges continued
- Created a nonpoint source pollution demonstration grant program at EPA

Next Steps

- 1989 – Wisconsin Blue Book (erosion control)
- 1992 – Waukesha County Erosion Control ordinance
- 1994 – Wisconsin Green Book (post-construction storm water management)
- 1994 – NR 216 implements WPDES
- 1995 – Standards Oversight Council created by NRCS / DNR / DATCP

Post-construction Standards	Number	Effective Date
1. Bioretention for Infiltration [PDF 689KB] Tech Note	1004	Nov-10
2. Compost [PDF 90KB]	S100	Oct-04
3. Infiltration Basin Form 1003 [PDF 181KB] Tech Note Fig. 1 [PDF 315KB], Fig. 2 [PDF 259KB], Fig. 3 [PDF 83KB], Fig. 4 [PDF 118KB]	1003	Oct-04
4. Sizing Infiltration Basins and Bioretention Devices Tech Note	n/a	n/a
5. Infiltration Trench [PDF 167KB]	1007	May-12
6. Permeable Pavement [PDF] Tech Note [PDF]	1008	Feb-14
7. Proprietary Storm Water Sedimentation Devices [PDF 193KB]	1006	Apr-09
8. <i>Rain Gardens: A how-to manual for homeowners</i> " [PDF 3MB , Exit DNR]	n/a	Aug-05
9. Site Evaluation for Stormwater Infiltration [PDF] *	1002	03/2014
10. Vegetated Infiltration Swales <i>Updated 5/10/2007</i> [PDF 228KB]	1005	May-07

Making Sausage

- 1996 – Work starts on model storm water management ordinance (available in 1998, revised and put in NR 152 in 2002)
- 1997 – DNR gets mandate from legislature to develop nonpoint performance standards for ag and urban, leading to NR 151, etc. after five-year process – includes county land-and-water resource management (LWRM) plans

NR 151 and Standards

- 1998 – Waukesha County adds SWM to ordinance
- 1999 – First urban WI tech std. (wet det.)
- 1999 – Phase-out of priority watershed program starts – mainly impacts ag county LWRM plans, cost-share projects
- 2000 – Milwaukee, Madison Phase I MS4 permits
- 2002 – NR 151 – performance standards – NR 153, 155 – Ag TRM and urban grants

Now, Future?

- 2004 – NR 216 updated to reflect NR 151
- 2004 – Infiltration technical standards
- 2005 – County ordinance update
 - NR 216/151 standards
 - 25 intergov. Agreements - education
- 2008 – MS4 Phase II permits due
- 2010 – County becomes ALP
- 2010's – green and sustainable building becoming part of the culture
- TMDLs – Rock, Fox – GB, Milwaukee...
- Ag????