Appendix A: Soils in the watershed

Soils in the Allegan County portion of the watershed

Soil	Acres
Adrian muck	2432.7
Algansee loamy sand, protected, 0 to 3% slopes	1040.1
Aquents and Histosols, ponded	477.9
Aquents, sandy and loamy	61.2
Belleville loamy sand	228.7
Belleville-Brookston complex	54.7
Blount silt loam, 1 to 4% slopes	450.6
Brady sandy loam, 0 to 3% slopes	576.9
Brookston loam	140.0
Capac loam, 0 to 6% slopes	3462.7
Capac-Wixom complex, 1 to 4% slopes	339.3
Chelsea loamy fine sand, 0 to 6% slopes	5274.5
Chelsea loamy fine sand, 12 to 18% slopes	26.4
Chelsea loamy fine sand, 18 to 30% slopes	1.8
Chelsea loamy fine sand, 6 to 12% slopes	561.9
Cohoctah silt loam	191.0
Cohoctah silt loam, protected	289.8
Colwood silt loam	152.9
Corunna sandy loam	55.6
Covert sand, 0 to 4% slopes	3439.2
Glendora loamy sand	2628.8
Glendora loamy sand, protected	4126.1
Glynwood clay loam, 1 to 6% slopes	39.8
Glynwood clay loam, 6 to 12% slopes	2.7
Granby loamy sand	1987.2
Houghton muck	1999.3
Kibbie fine sandy loam, 0 to 3% slopes	191.0
Marlette loam, 12 to 18% slopes	53.5
Marlette loam, 18 to 35% slopes	14.4
Marlette loam, 6 to 12% slopes	395.7
Marlette-Capac loams, 1 to 6% slopes	1128.5
Martherton loam, 0 to 3% slopes	17.2
Martisco muck	110.2
Metamora sandy loam, 1 to 4% slopes	434.3
Metea loamy fine sand, 1 to 6% slopes	1589.5
Metea loamy fine sand, 6 to 12% slopes	174.3
Morocco fine sand, 0 to 3% slopes	4429.0
Morocco-Newton complex, 0 to 3% slopes	4605.6
Napoleon muck	54.4
Newton mucky fine sand	1796.6
Oakville fine sand, 0 to 6% slopes	16168.4
Oakville fine sand, 18 to 45% slopes	18.5
Oakville fine sand, 6 to 18% slopes	2663.0

Oakville fine sand, loamy substratum, 0 to 6% slopes	299.4
Ockley loam, 1 to 6% slopes	48.6
Ockley loam, 18 to 30% slopes	3.8
Ockley loam, 6 to 12% slopes	12.4
Oshtemo-Chelsea complex, 0 to 6% slopes	2081.4
Oshtemo-Chelsea complex, 12 to 18% slopes	94.2
Oshtemo-Chelsea complex, 18 to 35% slopes	70.2
Oshtemo-Chelsea complex, 6 to 12% slopes	527.1
Palms muck	216.7
Pewamo silt loam	48.2
Pipestone sand, 0 to 4 percent slopes	3154.6
Pits	67.8
Riddles loam, 1 to 6% slopes	119.4
Riddles loam, 6 to 12% slopes	1.4
Rimer loamy sand, 0 to 4% slopes	2877.6
Sebewa loam	109.9
Seward loamy fine sand, 1 to 6% slopes	1075.1
Sloan silt loam	64.1
Tedrow fine sand, 0 to 4% slopes	1053.7
Tekenink loamy fine sand, 12 to 18% slopes	6.5
Tekenink loamy fine sand, 2 to 6% slopes	351.9
Tekenink loamy fine sand, 6 to 12% slopes	76.9
Thetford loamy fine sand, 0 to 4% slopes	2982.2
Udipsamments, nearly level to gently sloping	53.6
Water	1129.5

Soils in the Van Buren portion of the watershed

Soil	**Acres**
Adrian muck	783.5
Algansee-Cohoctah complex	4376.2
Aquents and Histosols, ponded	628.1
Belleville loamy sand	1286.4
Blount silt loam, 0 to 4% slopes	2659.6
Brems sand, 0 to 2% slopes	4214.2
Bronson sandy loam, 0 to 3% slopes	763.3
Capac loam, 1 to 5% slopes	10208.2
Coloma loamy sand, 0 to 6% slopes	3843.3
Coloma loamy sand, 6 to 12% slopes	1743.4
Colwood silt loam	3340.2
Covert sand, 0 to 4% slopes	675.8
Edwards muck	346.5
Gilford sandy loam	2185.2
Glendora sandy loam	1787.0
Grattan sand, 0 to 6 percent slopes	218.7
Houghton muck	4757.0
Kalamazoo loam, 2 to 6% slopes	35.9
Kalamazoo loam, 6 to 12% slopes	98.8
Kingsville loamy sand	4839.5

Matherton loam, 0 to 2% slopes	634.1
Metea loamy fine sand, 1 to 6% slopes	2207.6
Metea loamy fine sand, 6 to 12% slopes	515.9
Morocco loamy sand, 0 to 2% slopes	2336.5
Napoleon mucky peat	277.1
Oakville fine sand, 2 to 12% slopes	33.7
Oakville fine sand, 25 to 60% slopes	1.4
Ormas loamy sand, 0 to 6% slopes	228.3
Ormas loamy sand, 6 to 12% slopes	27.2
Oshtemo sandy loam, 0 to 6% slopes	498.4
Oshtemo sandy loam, 6 to 12% slopes	183.2
Oshtemo-Coloma loamy sands, 12 to 18% slopes	438.4
Oshtemo-Coloma loamy sands, 18 to 25% slopes	248.8
Ottokee loamy fine sand, 0 to 3% slopes	1461.4
Palms muck	977.8
Pewamo silt clay loam	607.0
Pipestone-Kingsville complex, 0 to 3% slopes	8593.6
Pits	76.0
Plainfield sand, 0 to 6% slopes	3107.3
Plainfield sand, 6 to 12% slopes	633.0
Riddles sandy loam, 1 to 6% slopes	4083.0
Riddles sandy loam, 12 to 18% slopes	471.6
Riddles sandy loam, 18 to 25% slopes	141.9
Riddles sandy loam, 6 to 12% slopes	1887.5
Selfridge loamy sand, 0 to 3% slopes	12921.1
Sloan loam	2147.8
Spinks loamy sand, 0 to 6% slopes	1800.3
Spinks loamy sand, 6 to 12% slopes	372.6
Spinks-Oshtemo complex, 0 to 6% slopes	38.3
Spinks-Oshtemo complex, 6 to 12% slopes	229.1
Thetford loamy sand, 0 to 2% slopes	2692.1
Tuscola silt loam, 0 to 4% slopes	1674.5
Udipsamments and Udorthents, 0 to 4% slopes	383.7
Urban land - Brems complex, 0 to 4% slopes	301.0
Urban land - Coloma complex, 0 to 6% slopes	240.2
Water	1841.0

Appendix B: Lakes in the Black River Watershed

Name	Township	County	Acres	Connected to Black River?
Abernathy Lake	Waverly	Van Buren	4.1	Yes
Clear Lake	Lee	Allegan	19.7	No
Coffee Lake	Columbia	Van Buren	40.4	Yes
Crooked Lake	Clyde	Allegan	96.9	No
Deer Lake	Columbia	Van Buren	30.4	Yes
Ely Lake	Clyde	Allegan	27.0	Yes
Great Bear Lake	Bloomingdale/Columbia	Van Buren	166.2	Yes
Hutchins Lake	Ganges/Clyde	Allegan	378.8	Yes
Lake Eleven	Columbia	Van Buren	53.9	Yes
Lake Fourteen	Arlington	Van Buren	20.9	Yes
Lake Fourteen	Columbia	Van Buren	69.5	Yes
Lester Lake	Lee	Allegan	60.4	Yes
Little Bear Lake	Columbia	Van Buren	46.1	Maybe/Wetland
Little Tom Lake	Clyde	Allegan	18.1	Maybe/Wetland
Lower Jeptha Lake	Columbia	Van Buren	55.4	Yes
Lower Scott Lake	Lee	Allegan	119.5	Yes
Manitt Lake	Casco	Allegan	0.7	No
Max Lake	Bloomingdale	Van Buren	28.0	Yes
Max Lake	Waverly	Van Buren	4.4	Yes
Merriman Lake	Bangor	Van Buren	27.1	Yes
Mill Lake	Bloomingdale	Van Buren	107.0	Yes
Moon Lake	Geneva	Van Buren	14.6	Yes
Moriah Lake	Columbia	Van Buren	17.0	Yes
Mud Lake	Cheshire	Allegan	3.9	Yes
Mud Lake	Clyde	Allegan	4.4	No
Mud Lake	Columbia	Van Buren	23.4	Yes
Munn Lake	Bloomingdale	Van Buren	12.3	Yes
Munson Lake	Columbia	Van Buren	38.5	No
North Lake	Columbia	Van Buren	60.6	Yes
North Scott Lake	Arlington/Columbia	Van Buren	76.3	Yes
Osterhout Lake	Lee	Allegan	171.9	Yes
Picture Lake	Geneva	Van Buren	5.0	Yes
S. Branch Black River (Bangor Mill Pond)	Bangor/Arlington	Van Buren	22.7	Yes
S. Branch Black River (Breedsville Mill Pond)	Columbia	Van Buren	7.9	Yes
Saddle Lake	Columbia	Van Buren	282.5	Yes
School Section Lake	Bangor	Van Buren	36.1	Yes
Silver Lake	Columbia	Van Buren	50.1	Yes
Skunk Lake	Bloomingdale	Van Buren	6.6	Yes
South Scott Lake	Arlington	Van Buren	118.1	Yes
Spring Brook Lake	Lee	Allegan	15.3	Yes
Stillwell Lake	Columbia	Van Buren	18.3	Yes
Upper Jeptha Lake	Columbia	Van Buren	58.8	Yes
Upper Scott Lake	Lee	Allegan	94.4	Yes

Data source: Michigan Center for Geographic Information, 2003

Appendix C: Dams in the Black River Watershed

Dam Name	County	Owner	Year Built	Fish Passable?	River or stream name
Saddle Lk. Level Control Structure	Van Buren	Private	1932	No	Barber Creek
Great Bear Lk. Level Control Structure	Van Buren	Local Govt.	1964	Yes	Black River
Yacht Harbor Dam	Allegan	Private		No	Black River
Lower Scott Lk. Dam	Allegan	Private	1920	No	Lower Scott Lake Creek
Black River Dam (Hamlin Dam)	Allegan	Private	1967	No	N. Branch Black River
Bangor Dam	Van Buren	Local Govt.	1975	No	S. Branch Black River
Breedsville Dam	Van Buren	Local Govt.	1837	No	S. Branch Black River
Denofrio's Pond Dam	Allegan	Private		No	Spicebush Creek
Scott Lk. Level Control Structure	Van Buren	Local Govt.	1967	No	Tributary to Black River
Harry Dam	Allegan	Private	1968	No	Tributary to Black River
Osterhout Lk. Level Control Structure	Allegan	Private	1975	No	Tributary to Black River
Lafler Dam	Van Buren	Private	1958		Tributary to Black River
Effner Dam	Van Buren	Private	1967		Tributary to Great Bear Lake
Ely Lk. Flooding Dam	Allegan	State	1985		Tributary to Utter Drain
Barden Dam	Allegan	Private	1963	No	Tributary to N. Branch Black River
Crooked Lk. Dam (Structure #4)	Allegan	State	1962	No	Utter Drain
Surprenant Dam	Allegan	Private	1964	No	Wolf Drain

Appendix D: List of Species

Name	Type
American Crow	Bird
American Goldfinch	Bird
American Kestrel	Bird
American Redstart	Bird
American Robin	Bird
American Tree Sparrow	Bird
Bald Eagle	Bird
Baltimore Oriole	Bird
Bank Swallow	Bird
Barn Swallow	Bird
Belted Kingfisher	Bird
Black and White Warbler	Bird
Black Tern	Bird
Blackburnian Warbler	Bird
Black-capped chickadee	Bird
Blackpoll Warbler	Bird
Black-throated Green Warbler	Bird
Blue Jay	Bird
Blue-gray gnatcatcher	Bird
Blue-winged Teal	Bird
Blue-winged Warbler	Bird
Bobolink	Bird
Bonaparte's Gull	Bird
Brown Thrasher	Bird
Brown-headed Cowbird	Bird
Bufflehead	Bird
Canada Goose	Bird
Cape May Warbler	Bird
Cedar Waxwing	Bird
Cerulean Warbler	Bird
Chimney Swift	Bird
Chipping Sparrow	Bird
Cliff Swallow	Bird
Common Grackle	Bird
Common Loon	Bird
Common Snipe	Bird
Common Yellowthroat	Bird
Cooper's Hawk	Bird
Cuckoo spp.	Bird
Downy Woodpecker	Bird
Eastern Bluebird	Bird
Eastern Kingbird	Bird
Eastern Meadowlark	Bird
Eastern Phoebe	Bird
Eastern Screech Owl	Bird
Eastern Towhee	Bird
Eastern Wood Pewee	Bird
European Starling	Bird
Falcon spp.	Bird
Field Sparrow	Bird
Grackles	Bird
Gray Catbird	Bird
Great Blue Heron	Bird
Great Crested Flycatcher	Bird
Great Egret	Bird
Great Horned Owl	Bird
Green Heron	Bird
Herring gull	Bird
House Finch	Bird
House Sparrow	Bird
House Wren	Bird
Indigo Bunting	Bird
Killdeer	Bird
Lesser Scaup	Bird
Lincoln's Sparrow	Bird
Louisiana Waterthrush	Bird
Magnolia Warbler	Bird
Mallard	Bird
Mourning Dove	Bird
Mute Swan	Bird
Nashville Warbler	Bird
Northern Bobwhite	Bird
Northern Cardinal	Bird
Northern Flicker	Bird
Northern Harrier	Bird
Northern Rough-winged Swallow	Bird
Northern Shoveler	Bird
Northern Waterthrush	Bird
Osprey	Bird
Ovenbird	Bird
Palm Warbler	Bird
Pied-billed Grebe	Bird
Pileated Woodpecker	Bird
Purple Martin	Bird
Red-bellied Woodpecker	Bird
Red-breasted Merganser	Bird
Red-eyed Vireo	Bird
Red-shouldered Hawk	Bird
Red-tailed Hawk	Bird
Red-winged Blackbird	Bird
Ring-billed Gull	Bird

Ring-necked duck	Bird
Ring-necked Pheasant	Bird
Rock Dove	Bird
Rose-breasted Grosbeak	Bird
Ruby-crowned Kinglet	Bird
Ruby-throated Hummingbird	Bird
Ruffed Grouse	Bird
Sandhill Crane	Bird
Sandpiper sp	Bird
Savannah Sparrow	Bird
Scarlet Tanager	Bird
Sedge Wren	Bird
Short-eared Owl	Bird
Solitary Sandpiper	Bird
Song Sparrow	Bird
Sora	Bird
Spotted Sandpiper	Bird
Swainson's Thrush	Bird
Tennessee Warbler	Bird
Tern sp	Bird
Tree Swallow	Bird
Tufted Titmouse	Bird
Turkey Vulture	Bird
Upland Sandpiper	Bird
Veery	Bird
Vesper Sparrow	Bird
Warbling Vireo	Bird
White-breasted nuthatch	Bird
White-throated Sparrow	Bird
Wild Turkey	Bird
Willow Flycatcher	Bird
Wood Duck	Bird
Wood Thrush	Bird
Woodcock	Bird
Yellow Warbler	Bird
Yellow-bellied Sapsucker	Bird
Yellow-billed cuckoo	Bird
Yellow-rumped Warbler	Bird
Yellow-throated Vireo	Bird
Appalachian Brown	Butterfly
Azure, Spring	Butterfly
Cabbage White	Butterfly
Common Buckeye	Butterfly
Eastern-tailed Blue	Butterfly
Eyed Brown	Butterfly
Fritillary, Aphrodite	Butterfly
Fritillary, Great Spangled	Butterfly
Fritillary, Silver-bordered	Butterfly

Fritillary, Varigated	Butterfly
Little Wood Satyr	Butterfly
Monarch	Butterfly
Mourning Cloak	Butterfly
Northern Broken Dash	Butterfly
Pearl Crecent	Butterfly
Red Admiral	Butterfly
Red-spotted Purple	Butterfly
Sulphur, Clouded	Butterfly
Sulphur, Orange	Butterfly
Swallowtail, Black	Butterfly
Swallowtail, Eastern Tiger	Butterfly
Swallowtail, Spicebush	Butterfly
Swallowtail, Zebra	Butterfly
Viceroy	Butterfly
Wood Nymph, Common	Butterfly
Clam	Clam
Damselfly, Ebony	Damselfly
Variable Dancer	Damselfly
Black Saddlebags	Dragonfly
Meadowhawk, Ruby	Dragonfly
Pennant, Calico	Dragonfly
Pennant, Halloween	Dragonfly
Pondhawk, Eastern	Dragonfly
Skimmer, 12-spotted	Dragonfly
Skimmer, Widow	Dragonfly
Whitetail, Common	Dragonfly
Alewife	Fish
American brook lamprey	Fish
Black bullhead	Fish
Black crappie	Fish
Blackchin shiner	Fish
Blacknose dace	Fish
Blacknose shiner	Fish
Blackside darter	Fish
Bluegill	Fish
Bluntnose minnow	Fish
Bowfin	Fish
Brassy minnow	Fish
Brook silverside	Fish
Brook stickleback	Fish
Brook trout	Fish
Brown bullhead	Fish
Brown Trout	Fish
Carp	Fish
Central mudminnow	Fish
Channel catfish	Fish
Chestnut lamprey	Fish

Chinook salmon	Fish
Common Carp	Fish
Common shiner	Fish
Creek chub	Fish
Emerald shiner	Fish
Freshwater Drum	Fish
Gizzard Shad	Fish
Golden Redhorse	Fish
Golden shiner	Fish
Grass pickerel	Fish
Greater redhorse	Fish
Green sunfish	Fish
Hornyhead chub	Fish
Iowa darter	Fish
Johnny darter	Fish
Jonny darter	Fish
Lake chubsucker	Fish
Largemouth bass	Fish
Logperch	Fish
Longnose dace	Fish
Longnose sucker	Fish
Long-nosed Gar	Fish
Mottled sculpin	Fish
Muskellunge	Fish
Northern brook lamprey	Fish
Northern hogsucker	Fish
Northern longear sunfish	Fish
Northern pike	Fish
Pirate perch	Fish
Pugnose shiner	Fish
Pumpkinseed	Fish
Rainbow darter	Fish
Rainbow Trout/ Steelhead	Fish
Rockbass	Fish
round goby	Fish
Sand shiner	Fish
Sea lamprey	Fish
Shorthead redhorse	Fish
Smallmouth bass	Fish
Spotfin shiner	Fish
Spottail shiner	Fish
Spotted gar	Fish
Spotted sucker	Fish
Stonecat	Fish
Striped shiner	Fish
Tadpole madtom	Fish
Tiger Muskellunge	Fish
Walleye	Fish

Warmouth	Fish
White sucker	Fish
Yellow bullhead	Fish
Yellow perch	Fish
Bullfrog	Frog
Eastern Gray Treefrog	Frog
Green Frog	Frog
Northern Leopard Frog	Frog
Northern Spring Peeper	Frog
Western Chorus Frog	Frog
Wood Frog	Frog
Water Striders	Insect
Eastern Chipmunk	Mammal
Eastern Cottontail	Mammal
Fox Squirrel	Mammal
Meadow Jumping Mouse	Mammal
Muskrat	Mammal
Opossum	Mammal
Raccoon	Mammal
White-tailed Deer	Mammal
Woodchuck	Mammal
Mapleleaf (*Quadrula quadrula*)	Mussel
Agalinis, Slender	Plant
Agrimony, Tall Hairy	Plant
Alder, Speckled	Plant
Alumroot	Plant
American Bellflower	Plant
Amur River Privet	Plant
Anemone, Wood	Plant
Angelica	Plant
Arrow Arum	Plant
Arrowglass, Slender	Plant
Arrowhead, Common (Wapato)	Plant
Ash, Black	Plant
Ash, Prickly	Plant
Ash, Red	Plant
Ash, White	Plant
Asparagus, Garden	Plant
Aspen sp	Plant
Aspen, Large-toothed	Plant
Aster, Flat-topped	Plant
Aster, Lake Ontario	Plant
Aster, Large-leaved	Plant
Aster, Panicled	Plant
Aster, Purple-stemmed	Plant
Aster, Side-flowering	Plant
Autumn Olive	Plant
Avens, White	Plant

Baneberry, Red	Plant
Baneberry, White	Plant
Bartonia	Plant
Basswood	Plant
Beaked willow	Plant
Beak-Rush	Plant
Bebb's Sedge	Plant
Bedstraw	Plant
Bedstraw, Fragrant	Plant
Bedstraw, Stiff Marsh	Plant
Beech, American	Plant
Beechdrops	Plant
Beggar-ticks, Leafy-bracted	Plant
Bellflower, Marsh	Plant
Bellwort, Perfoliate	Plant
Bergamot	Plant
Bindweed, Hedge	Plant
Birch, Yellow	Plant
Bittercress, Hairy	Plant
Bittercress, Pennsylvanian	Plant
Bittersweet, Oriental	Plant
Black Willow	Plant
Blackberry, Common	Plant
Black-eyed Susan	Plant
Bladderwort, Flat-leaved	Plant
Blazing Star, Marsh (Dense)	Plant
Blue Flag Iris	Plant
Blue Flag, Southern	Plant
Blueberry sp	Plant
Blueberry, Highbush	Plant
Blueberry, Highbush	Plant
Blueberry, Hillside	Plant
Blue-joint	Plant
Blunt Broom Sedge	Plant
Boneset, Common	Plant
Bottle Brush Sedge	Plant
Bottlebrush Grass	Plant
Brambles	Plant
Bright-green Spike-rush	Plant
British Soldiers	Plant
Brome sp	Plant
Broom-sedge	Plant
Brown-eyed susan	Plant
Buckthorn, Alder-leaved	Plant
Bugleweed, Northern	Plant
Bulrush, Dark-green	Plant
Bur-Marigold, Nodding	Plant
Buttercup, Small-flowered	Plant

Butternut	Plant
Button Bush	Plant
Canada Bluegrass	Plant
Canadian St. John's-wort	Plant
Capillary Beak-rush	Plant
Cardinal Flower	Plant
Cat's-ear	Plant
Cattail, Common	Plant
Centaury, Forking	Plant
Cherry, Black	Plant
Chickweed, Mouse-eared	Plant
Chokeberry, Black	Plant
Cicely, Sweet	Plant
Ciliate-leaved Paspalum	Plant
Cinquefoil, Common	Plant
Cinquefoil, Rough-fruited	Plant
Cinquefoil, Shrubby	Plant
Clearweed	Plant
Clover, Little Hop	Plant
Clover, Red	Plant
Club Moss, spp	Plant
Clubmoss, Stiff	Plant
Common Flat Brocade Moss	Plant
Coontail	Plant
Coral-root, Autumn	Plant
Coral-root, Spotted	Plant
Cottonwood, Eastern	Plant
Cress, Common Winter	Plant
Cress, Spring	Plant
Cress, Water	Plant
Crowfoot, Hooked	Plant
Cucumber Root, Indian	Plant
Currant sp.	Plant
Cushion Moss	Plant
Daisy, Ox-eye	Plant
Dandelion, Common	Plant
Day-Lily, Canada	Plant
Delicate Fern Moss	Plant
Dewberry sp	Plant
Dissected Grape Fern	Plant
Dock, Curly	Plant
Dodder, Common	Plant
Dogbane, Spreading	Plant
Dogwood, Alternate-leaved	Plant
Dogwood, Flowering	Plant
Dogwood, Gray	Plant
Dogwood, Gray	Plant
Dogwood, Pale	Plant

Dogwood, Red Osier	Plant
Dryad Saddle	Plant
Duckweed, Lesser	Plant
Dutchman's Breeches	Plant
Dwarf Raspberry	Plant
Eastern Red Cedar	Plant
Elder, Common	Plant
Elder, Red-berried	Plant
Elm sp	Plant
Elm, American	Plant
Elm, Siberian	Plant
Enchanter's Nightshade	Plant
Fern Evergreen Wood	Plant
Fern, Bracken	Plant
Fern, Cinnamon	Plant
Fern, Clinton's Wood	Plant
Fern, Grape	Plant
Fern, Lady	Plant
Fern, Marsh Shield	Plant
Fern, New York	Plant
Fern, Rattlesnake	Plant
Fern, Royal	Plant
Fern, Sensitive	Plant
Fern, Shield	Plant
Fern, Spinulose Wood	Plant
Figwort, Eastern	Plant
Flat-tufted Feather Moss	Plant
Flax, Wild	Plant
Fleabane, Annual	Plant
Fleabane, Daisy	Plant
Fly Agaric	Plant
Four Tooth Moss	Plant
Fox Sedge	Plant
Foxglove Beard-tongue	Plant
Fungus	Plant
Fungus	Plant
Fungus	Plant
Garlic mustard	Plant
Gerardia, Purple	Plant
Giant Reed Grass	Plant
Ginseng, Large	Plant
Golden Ragwort	Plant
Goldenrod, Canada	Plant
Goldenrod, Common Flat-topped	Plant
Goldenrod, Ohio	Plant
Goldenrod, Rough-leaved	Plant
Goldenrod, Rough-stemmed	Plant
Goldenrod, Tall	Plant

Goldthread	Plant
Gooseberry sp.	Plant
Gooseberry, Prickly	Plant
Graceful Sedge	Plant
Grape Fern, Leather	Plant
Grape, Fox	Plant
Grape, River-bank	Plant
Grape, Wild	Plant
Grass, Blue-eyed	Plant
Grass, Cut	Plant
Grass, Deer-tongue	Plant
Grass, Fowl Manna	Plant
Grass, Orchard	Plant
Grass, Reed Canary	Plant
Grass-pink	Plant
Green Dragon	Plant
Green Sedge	Plant
Green Silk Moss	Plant
Greenbrier sp	Plant
Greenbrier, Bristly	Plant
Green-headed coneflower	Plant
Ground Cedar	Plant
Ground-cherry, Clammy	Plant
Groundsel, Common	Plant
Gum, Sour	Plant
Hardstem Bulrush	Plant
Hawkweed, Orange	Plant
Hawthorn sp	Plant
Hemlock, Eastern	Plant
Hepatica, Round-lobed	Plant
Hickory sp	Plant
Hickory, Pignut	Plant
Highbush Cranberry	Plant
Hog Peanut	Plant
Honewort	Plant
Honeysuckle, Glaucous	Plant
Hornbeam, American (Blue-beech)	Plant
Hornbeam, Hop	Plant
Horse-nettle	Plant
Horsetail	Plant
Horsetail, Field	Plant
Horsetail, Meadow	Plant
Indian-hemp	Plant
Inland Sedge	Plant
Iris, Yellow	Plant
Ironweed, Missouri	Plant
Ivy, Poison	Plant

Appendix E: List of Fish Species

Name	Status
Alewife	introduced
American brook lamprey	common
Black bullhead	present
Black crappie	common
Blackchin shiner	common
Blacknose shiner	common
Blacknose dace	present
Blackside darter	present
Bluegill	common
Bowfin	common
Bluntnose minnow	present
Brassy minnow	present
Brook stickleback	present
Brook silverside	present
Brook trout	rare
Brown Trout	introduced
Brown bullhead	common
Central mudminnow	common
Channel catfish	present
Chestnut lamprey	present
Chinook salmon	introduced
Common Carp	introduced
Common shiner	common
Creek chub	present
Emerald shiner	present
Freshwater Drum	present
Gizzard Shad	present
Golden Redhorse	common
Golden shiner	present
Grass pickerel	present
Greater redhorse	present
Green sunfish	common
Hornyhead chub	common
Iowa darter	present
Johnny darter	common
Lake chubsucker	present
Largemouth bass	common
Logperch	common
Longnose dace	present
Longnose sucker	present
Mottled sculpin	present
Muskellunge	introduced
Northern brook lamprey	common
Northern hogsucker	present
Northern longear sunfish	present
Northern pike	common
Pirate perch	rare
Pugnose shiner	rare
Pumpkinseed	common
Rainbow Trout/ Steelhead	introduced
Rainbow darter	present
Rockbass	common
round goby	introduced
Sand shiner	unknown
Sea lamprey	introduced
Shorthead redhorse	common
Smallmouth bass	common
Spotfin shiner	present
Spottail shiner	present
Spotted gar	present
Spotted sucker	rare
Stonecat	unknown
Striped shiner	rare
Tadpole madtom	rare
Tiger Muskellunge	introduced
Walleye	common
Warmouth	common
White sucker	common
Yellow bullhead	common
Yellow perch	common

Appendix F: Threatened, Endangered, and Special Concern Species and Communities in the Black River Watershed

Scientific Name	Common Name	Federal Status	State Status	Type
Acris crepitans blanchardi	Blanchard's Cricket Frog		SC	Animal
Clemmys guttata	Spotted Turtle		T	Animal
Elaphe obsoleta obsoleta	Black Rat Snake		SC	Animal
Emys blandingii	Blanding's Turtle		SC	Animal
Erynnis persius persius	Persius Duskywing		T	Animal
Ictiobus niger	Black Buffalo		SC	Animal
Incisalia irus	Frosted Elfin		T	Animal
Lanius ludovicianus migrans	Migrant Loggerhead Shrike		E	Animal
Lycaeides melissa samuelis	Karner Blue	LE	T	Animal
Microtus pinetorum	Woodland Vole		SC	Animal
Notropis anogenus	Pugnose Shiner		SC	Animal
Notropis texanus	Weed Shiner		X	Animal
Sistrurus catenatus catenatus	Eastern Massasauga	C	SC	Animal
Terrapene carolina carolina	Eastern Box Turtle		SC	Animal
Coastal plain marsh	Infertile Pond/marsh, Great Lakes Type			Community
Great blue heron rookery	Great Blue Heron Rookery			Other
Adlumia fungosa	Climbing Fumitory		SC	Plant
Agrimonia rostellata	Beaked Agrimony		SC	Plant
Carex albolutescens	Greenish-white Sedge		T	Plant
Carex festucacea	Fescue Sedge		SC	Plant
Cyperus flavescens	Yellow Nut-grass		SC	Plant
Eleocharis melanocarpa	Black-fruited Spike-rush		SC	Plant
Eleocharis microcarpa	Small-fruited Spike-rush		E	Plant
Eleocharis tricostata	Three-ribbed Spike-rush		T	Plant
Fuirena squarrosa	Umbrella-grass		T	Plant
Hemicarpha micrantha	Dwarf-bulrush		SC	Plant
Hibiscus moscheutos	Swamp Rose-mallow		SC	Plant
Hydrastis canadensis	Goldenseal		T	Plant
Linum virginianum	Virginia Flax		T	Plant
Ludwigia alternifolia	Seedbox		SC	Plant
Lycopodium appressum	Northern Prostrate Clubmoss		SC	Plant
Panax quinquefolius	Ginseng		T	Plant
Platanthera ciliaris	Orange or Yellow Fringed Orchid		T	Plant
Polygala cruciata	Cross-leaved Milkwort		SC	Plant
Polygonum careyi	Carey's Smartweed		T	Plant
Populus heterophylla	Swamp or Black Cottonwood		E	Plant
Potamogeton bicupulatus	Waterthread Pondweed		T	Plant
Psilocarya scirpoides	Bald-rush		T	Plant
Pygarctia spraguei	Sprague's Pygarctia		SC	Plant
Rhexia virginica	Meadow-beauty		SC	Plant
Rhynchospora macrostachya	Tall Beak-rush		SC	Plant
Rotala ramosior	Tooth-cup		SC	Plant
Scirpus torreyi	Torrey's Bulrush		SC	Plant
Scleria reticularis	Netted Nut-rush		T	Plant
Sisyrinchium atlanticum	Atlantic Blue-eyed-grass		T	Plant

Strophostyles helvula	Trailing Wild Bean		SC	Plant

LE: Listed Endangered
C: Candidate for federal status under the Endangered Species Act of 1998
SC: Special concern
T: Threatened
E: Endangered
X: Probably Extirpated
Source: Michigan Natural Features Inventory, 2003

Appendix G: Black River Watershed land protection priority model & agricultural land protection model

Southwest Michigan Land Conservancy

Black River Watershed Project

Emily Wilke, Geoffrey Cripe
Land Protection Staff
6851 S. Sprinkle Road
Portage, MI 49002

Table of Contents

Table of Contents	Page
Overview/ Scope of Work	3
Background	3
Land Protection Subcommittee	3
Natural Resources Based GIS Model	4
Priority Conservation Areas	5
Agricultural Model	7
Outreach	12
Landowner Contacts	12
Summary	13

Overview/Scope of Work

In 2006, the Southwest Michigan Land Conservancy (SWMLC) was contracted by the Van Buren County Conservation District (VBCD) under the authority of the Michigan Department of Environmental Quality (MDEQ) to initiate educational outreach for landowners within the Black River Watershed in pursuit of private land conservation objectives. SWMLC assembled a land protection subcommittee and started developing criteria for a geographic information systems (GIS) model that would identify priority areas for land protection in the Black River Watershed (BRW). Properties that exhibited high conservation values, based on the existence of natural resources that sustain the functionality of the BRW, were then targeted for the educational outreach program. SWMLC held two educational workshops in 2008 and drew approximately 30 interested landowners. Many interested landowners that received our mailing but could not attend one of the workshops contacted SWMLC for more information about land conservation. SWMLC also presented at many other workshops throughout the BRW about land conservation. Using the model as a guide, SWMLC will continue outreach efforts and will pursue leads with the goal of protecting valuable lands within the watershed in perpetuity.

Background

The BRW encompasses 287 square miles (183,490 acres) across two counties and 13 townships. The Watershed contains 530 miles of rivers, streams, and drains, 43 large named lakes (the largest is Hutchins Lake), and over 500 small lakes and ponds. The high quality waters support 70 species of fish, 130 species of birds, and 471 species of plants as of recorded in 2004. More then half of the land in the watershed is agriculture planted in unique crops such as blueberries. The MDEQ recognized that this watershed is an important area for conservation and environmental education and awareness to protect these significant resources. SWMLC focused its conservation efforts on the identification of land parcels containing ecologically significant property that should be conserved to maintain the high water quality of the Black River. These properties contain high ground water recharge, riparian habitat, forested wetlands, emergent wetlands and a variety of habitats that provide valuable habitat and ensure the continuation of a viable watershed ecosystem.

Land Protection Subcommittee

A group of citizen volunteers, government officials, and regional experts was asked to assist SWMLC in formulating a list of criteria, based on property attributes, to use in the development of a GIS model. Over the course of the last three years, eight meetings were held with the Land Protection Subcommittee to coordinate the model, ground truth the model, develop and distribute outreach materials, and engage citizens in the pursuit of BRW objectives during educational workshops. The subcommittee played a major role in the identification of sites within the watershed in need of priority consideration and the development of detailed criteria that would enable the model to be a success. Participants on the subcommittee included:

Name & Years Participated	Affiliation	E-mail
Baerren, Al 2006-2008	Silver Lake Association	albert.baerren@nmcco.com
Boutin, Carl 2006-2008	Van Buren County Resident	cbouton@btc-bci.com
Clemons, Tina 2006-2007	Allegan County Conservation District	tina.clemons@mi.nacdnet.net
Debruyn, Jay 2006-2007	Realtor, Developer in South Haven	jay@shoresofsouthhaven.com
Fuller, Erin 2006-2008	Black River Watershed Coordinator	erin.fuller@mi.nacdnet.net
Haas, Greg 2006-2007	Casco Township Parks Committee	haas310@hotmail.com
Kirkwood, Julia 2006-2008	Department of Environmental Quality	kirkwooj@michigan.gov

Lerg, John 2006-2008	Michigan Department of Natural Resources	lergj@michigan.gov
Lockhart, Amy 2006-2008	Van Buren County Conservation District	amy.lockhart@mi.nacdnet.net
Mead, Eileen 2006-2008	Casco Township Parks Committee	dennyeileen@aol.com
Micklin, Phil 2006-2008	Southwest Michigan Land Conservancy	micklin@wmich.edu
Nielson, Larry 2006-2007	Bangor City Manager	bangormi@btc-bci.com
Parman, Joe 2006-2008	Van Buren County Drain Commissioner	parmanj@vbco.org
Sass, George 2006-2008	South Haven Resident	sassgsass@lodisnet.com
Soltysiak, Dawn 2006-2007	Artist, Fennville Resident	gangesdawn@ispwest.com
Matthews, Peter 2007-2008	Van Buren County Resident	canoenut@bciwildblue.com
Thomas, Art 2006-2007	Farmer, Van Buren County	blueone234@hotmail.com
Venner, Rob 2006-2007	DeGraaf Nature Center	r.venner@cityofholland.com
Wilke, Emily 2006-2008	Southwest Michigan Land Conservancy	ewilke@SWMLC.org

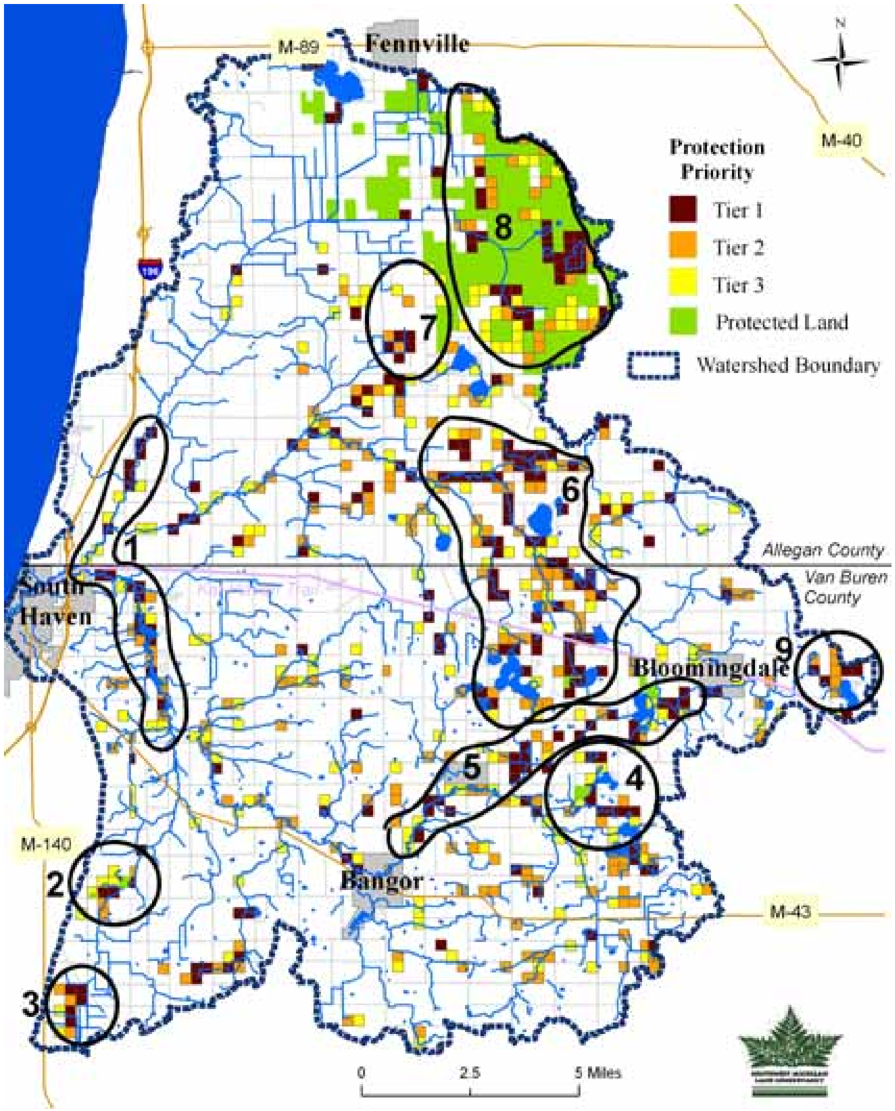
Natural Resources Based GIS Model

The model itself contains four "priority" tiers based on conservation value. In total, 233 quarter-quarter sections (Q-Q's) were identified as highest priority. The model was constructed by adding numerical ratings for a number of different conservation criteria to each Q-Q section in the BRW. Combining the values for each criterion allowed for the ranking of the Q-Q sections on the basis of conservation priority. The procedure for creating the model comprised the following steps:

- Creation of a quarter-quarter section base layer dataset.
- Creation and classification of a dataset for each conservation criterion decided by the Sub-Committee.
- Addition of data for each criterion as attributes to the base layer dataset.
- Classification (if necessary) of each criterion attribute in the model's database file (DBF) table.
- Weighting of each criterion class for each Q-Q section.
- Computation of the conservation value of each quarter-quarter section.
- Testing of outcomes against DOQ (aerial imagery), parcel data and other digital resources.
- Ground truthing the results by driving around the watershed.
- Classification and symbolization of the outcome for display in a map.

To date, the model has been accurate where highest-priority areas have been ground-truthed for verification. The attached map shows the final priority layer or "dataset" composed of priority Q-Q's and identifies the resulting nine SWMLC target areas which are circled. The following section summarizes the conservation attributes of each of the circled priority conservation areas as determined by the GIS model.

Priority Conservation Areas



1. **Forested River Corridor**. 1,480 acres of forested river corridor and adjacent forested wetlands. This relatively unfragmented forested river corridor is a buffer from the development along the lakeshore and sprawl from the city of South Haven. The forested river corridor is important breeding habitat for many bird species. Loss of this habitat type would have a major impact on the bird species that depend on river corridors for food and nesting. Riparian forests also play a critical role in water quality by preventing erosion and pollutants from entering the streams and providing shade for benthic macroinvertebrates, which are food for fish.

2. **Expanding Preserves**. 400 acres of high-priority natural land adjacent to 45 acres already conserved by SWMLC (Wintergreen Woods and Winterberry Woods preserves). This area is notable for its extensive wetlands of various types including forested, scrub-shrub, and emergent. Northern species, including eastern hemlock and magnolia warblers, are found in this area because the wetlands and back ridges stay very cool. Eastern hemlocks grow in the wetlands on the north facing side of the dunes and spotted salamanders cool off in the pools of water below the trees. This area has high groundwater recharge where currently high quality water is moving directly into the aquifer. Historically this area consisted of hemlock- white pine forest along the river and adjacent beech-sugar maple forest.

3. **Forested Wetlands**. 400 acres of forested wetlands near the Lake Michigan coast provides many benefits to wildlife. These forested wetlands contain the state-threatened swamp cottonwood and spotted turtle. This is a threatened ecosystem type along the highly developed coastline. The pre-European settlement land cover map shows that this area was historically a mixed conifer swamp with a section of black ash swamp.

4. **Upper and Lower Jeptha Lakes**. 720 acres of high-quality wetlands, marl flats, lakes with little development, and SWMLC's 50-acre Jeptha Lake Fen preserve. The Jeptha lakes are along a flight route for migratory birds and a haven for waterfowl. Other species of interest found in this area include the state-threatened Blanchard's cricket frog, Eastern Massasauga rattlesnake, state-threatened spotted turtle, and a beautiful display of marsh blazing star which thrives in the shallow grassy wet areas.

5. **River Corridor from Bangor to Gobles**. 1,800 acres along the lower river corridor. In the 1800s before European settlement more then 50% of the watershed was beech maple forest. This is a large area where some of the beech-maple forest still remains intact. A great blue heron rookery that at one time held over 200 nesting birds is located just south of Breedsville and is protected by the Michigan Nature Association. There is a large area of contiguous wetlands surrounding the rookery that is also home to species of concern such as the state-threatened spotted turtle and blandings turtle.

6. **Fisheries Protection**. 4,800 acres, encompassing many lakes with little development, including Lake 11, Lake 14, Little Bear Lake, Spring Brook Lake, and others that comprise the headwaters of the middle branch. There is also little development along the long stretches of shaded river corridor, which are a prime coldwater trout fishery. This area is also comprised of a large area of wetlands and an extensive amount of forested land including the forested area along the Kal-Haven Trail. This area also has high ground water recharge.

7. **Pullman Wetlands.** 360 acres of large contiguous wetlands near the town of Pullman. This is the largest area of intact privately owned wetlands in the watershed. Mostly emergent wetlands but also forested and scrub-shrub wetlands are very important duck breeding habitat. These wetlands are almost contiguous to the expansive protected land of the Allegan State Game Area providing even more wildlife habitat. These wetlands also serve as the headwaters of both the upper and middle branches of the Black River.

8. **Allegan State Game Area**. 2,920 acres, is a portion of the Allegan State Game Area (SGA) which is one of the two largest protected areas in Southwest Michigan. The in-holdings and unprotected land directly adjacent to the Allegan SGA are high priority for conservation for both the Michigan Department of Natural Resources and SWMLC. The Allegan SGA is comprised of forests, remnant oak-pine barrens, and wetlands including coastal plain marsh and bog. We would like to work to expand this already protected area. Headwaters of the upper branch of the Black River. Historically this area was majority white pine-white oak forest.

9. **Headwaters Area**. 440 acres, comprising the headwaters of the lower branch of the river, including Munn and Mill Lakes. Species of interest found in this area include the Blanchard's cricket frog, black rat snake, and Eastern Massasauga which are all indicative of the important wetlands, lakes, and surrounding undeveloped upland ridges. This area was historically the convergence of a white pine- mixed hardwood forest and a mixed conifer swamp.

Agricultural Model

OVERVIEW

University Outreach (UO) at the University of Michigan-Flint, on behalf of the Southwest Michigan Land Conservancy (SWMLC), developed an Agricultural Lands Inventory for the Black River Watershed in southwest Michigan. This inventory uses a multi-criteria scoring approach to identify agricultural lands throughout the Black River Watershed that are highest priority for perpetual conservation.

Currently, the nine counties of Southwest Michigan produce the highest cumulative agricultural receipts in the state (highest total market value of agricultural production). Farms within the Black River Watershed account for the vast majority of fruit/berry/nut production within Southwest Michigan, which ranks #1 in the state for fruit production. Van Buren County is ranked #1 in the nation for blueberry and cucumber production and second in the state for grape production. Allegan County also ranks among the top 5 counties in the state for fruit production and also provides significant agricultural acreage toward greenhouse and nursery operations. Southwest Michigan ranks highest in the state for acres of greenhouse and nursery operations.

Approximately 55% of land use in the Black River Watershed is agricultural in nature. Conversion pressures are an especially grave concern to the state of agriculture in the Black River Watershed, as Allegan and Van Buren Counties rank 2nd and 3rd respectively as the most agriculturally vulnerable counties between now and 2020 in the state (*MSU Land Transformation Analysis*.) Farmland loss and conversion threaten to erode the agricultural base in the watershed and ultimately devastate Michigan's #1 economic industry. Considering growth projections, lack of funding for purchase of development rights efforts, and inadequate zoning and subdivision regulations in the areas comprising the Black River Watershed, direct agricultural preservation through conservation easements and PA 116 enrollment is critical to this regions agricultural prosperity. The availability of significant federal and state income and property tax incentives will serve as a catalyst for voluntary land protection, and outreach and educational initiatives to promote these incentives will be prioritized and directed with this agricultural land inventory.

Southwest Michigan Land Conservancy staff has invested significant time over the past two years compiling information to assist with the creation of this analysis, and spent considerable time ground-truthing available crop data layers. The Conservancy found that existing crop data information from the National Agricultural Statistics Service's crop data layer was inaccurate with regard to the identification of certain specialty crops such as blueberries, though the accuracy of the layer in identifying common row crops was inconclusive. The Conservancy's initial efforts to mimic County level PDR program criteria and the scoring thereof through data layer creation, digitization and model criteria ranking proved difficult. Specifically, efforts to supplement spatial information with non-spatial criterion such as MAEAP and conservation reserve program enrollment were unsuccessful based on unavailable information or inaccurate data. Thus, the Conservancy and University Outreach have created new datasets based on a vast array of spatial and non-spatial information from state and local sources and developed an expanded analysis that both prioritizes existing farms for preservation and identifies land most suitable for agricultural use.

The objectives of this inventory are multiple and include 1) ensuring the long-term sustainability of the region's agricultural base and production stability by protecting established farms that meet these critical needs, 2) identifying potential areas for agricultural conservation practices that would increase water quality, 3) recognizing land that is best-suited to agricultural and classifying the most appropriate crop use accordingly based on various factors such as soil utility and texture, drainage, slope, irrigation needs, etc. and 4) determining where lands enrolled in temporary conservation programs exist, and how we can build off existing blocks of conserved farmland and balance farmland protection with growth needs.

This inventory utilizes a multi-criteria decision model for the Southwest Michigan Land Conservancy to support on-the-ground conservation activities such as the justification of acquisitions, proactive conservation, evaluation of opportunistic acquisitions, and the development of public relations.

The Agricultural Lands Inventory provides the Conservancy, as well as other conservation and agricultural organizations, with a mechanism to help direct and prioritize funds available for preservation efforts; to enhance collaboration on projects and planning across organizational boundaries; to allow for the prioritization of agricultural preservation activities; and to ensure the long-term sustainability of the Black River Watershed's agricultural resources.

METHODS

Data Development

Two data layers important to the analysis for prioritizing agricultural lands for protection that were not previously available are PA 116 lands and detailed agricultural land types. The Michigan Department of Agriculture administers the PA 116 program which restricts non-agricultural uses of a given parcel on a contract basis in return for income tax incentives and relief from certain local special assessments.

As part of this inventory, University Outreach has digitized all of the PA 116 lands within the Black River Watershed as currently identified by the Michigan Department of Agriculture as of Spring 2009. University Outreach has also developed a detailed agricultural inventory within the Black River Watershed. The detailed agricultural inventory was developed with existing crop data from SWMLC and aerial photos.

Criteria

The following criteria have been assessed and ranked at a parcel level for the Black River Watershed. These criteria can then be evaluated and prioritized for voluntary protection of farmland from development and conversion, and can also be used in the development of outreach and educational activities.

1. Size
2. Greater than 50% AG
    a. Emphasis on specialty crops
3. Soil Productivity
    a. Prime Farmland
    b. Farmland of Local Importance
    c. Prime Farmland if Drained
4. Fruit Site Rating
    a. Soil Factors
        i. Texture
        ii. Drainage
    b. Physiographic Factors
        i. Slope
5. Fruit Site Presence/Absence (is flagged)
6. Ag Zoning (note: not all townships are zoned and not all zoning data is available- this criteria subject to availability)
7. Presence/Absence of Riparian Features
8. Length of River or Stream
9. Proximity to Existing Protected Land
10. Landscape Compatibility – Percentage of Agricultural land within 1 mile
11. Enrollment in PA 116

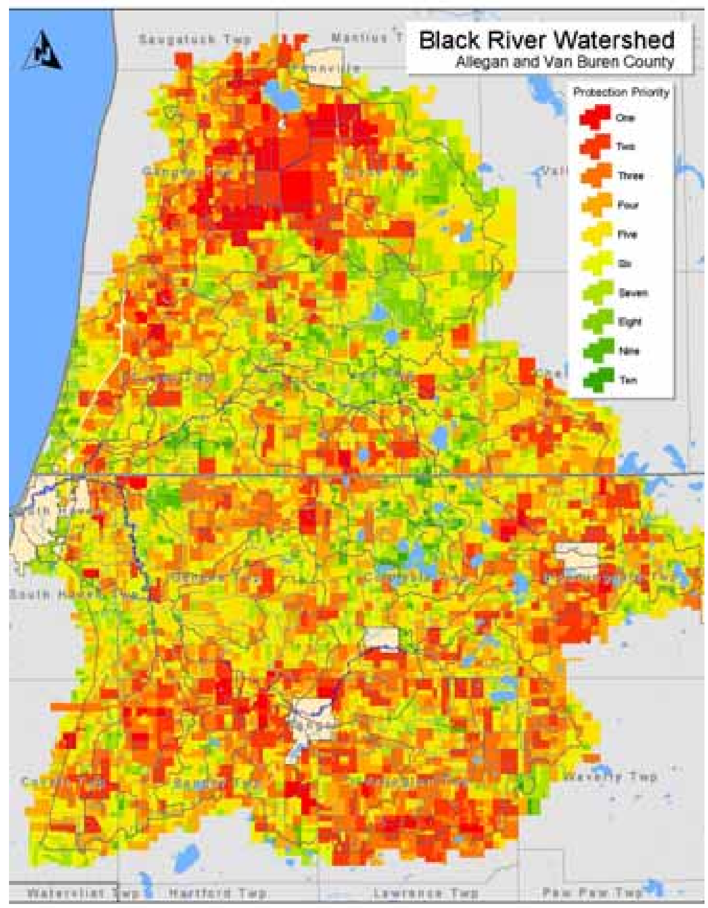
Results and Conclusions

Just over 1,200 parcels have been promoted to the initial parcel subset for land protection. The major criteria used to highlight this initial data subset include parcel size (over 20 acres) and the specification that each parcel's dominant land use is agricultural (over 51%). All parcels in the watershed have been scored based on the criteria listed above regardless of size and use. This will enable SWMLC to consider the role of smaller agricultural properties, especially with regard to fruit production. It will also enable SWMLC and other entities to re-visit and re-rank all parcels in the watershed as new information becomes available or as new factors become relevant. This data subset was further scored based on the spatial and non-spatial factors listed above.

The Black River Watershed is comprised of approximately 23,666 parcels of land, which are equal to approximately 183,490 acres. When scored using the criteria described above, the range of total score runs from 5 to 59 with a mean score of 25.

When ranked and broken into ten categories using natural breaks in the data, there are 1,233 parcels that fall into the top three categories with a sum total acreage of 59,146.99. The top three categories are as follows:

Priority One= 54 parcels with a score greater than 54
Priority Two= 450 parcels with a score greater than 43
Priority Three= 1233 parcels scoring greater than 39.

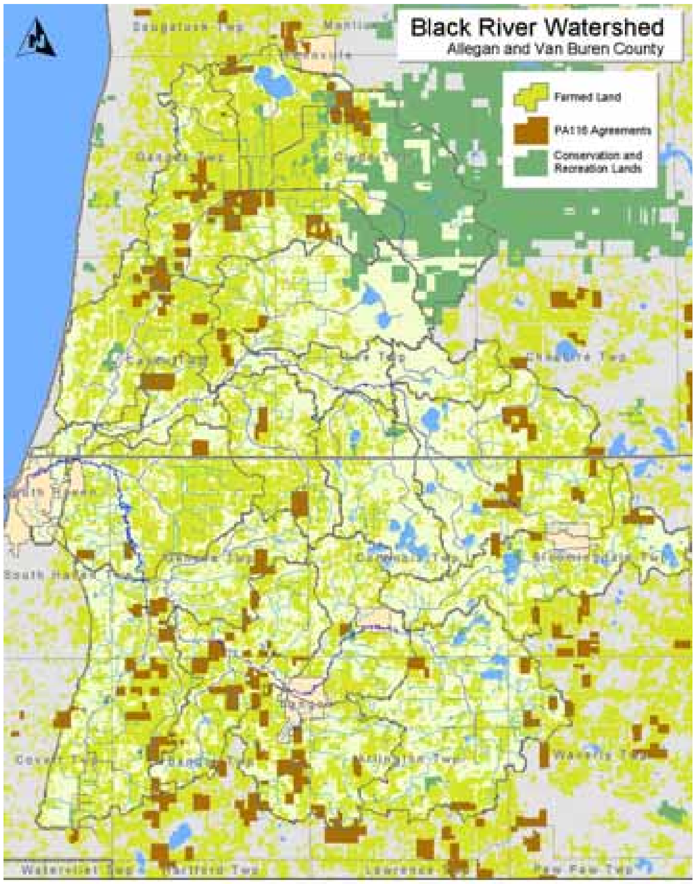


Parcels around the Allegan State Game Area scored very highly based on the large size of the parcels there, high PA 116 enrollment, and proximity to existing protected lands. Other common criteria that scored well here include the presence of factors that support very high potential for productive farmland (slopes, prime soils, soil texture, etc.), fruit site ratings, landscape compatibility and the presence and density of water resources. SWMLC will have the opportunity to protect compatible uses surrounding the Allegan State Game Area and negotiate best management practices through the conservation easement to protect water resources while expanding habitats conducive to wildlife and protecting the agricultural land base.

The lands comprising and surrounding the headwaters of the Black River Watershed also scored very highly based on soil types, drainage, and the presence and density of riparian features. These results underscore the utility of this model in recognizing the agricultural potential across the land base (Objective 3 above) and expand our conservation approach to avoid excluding non- agricultural property.

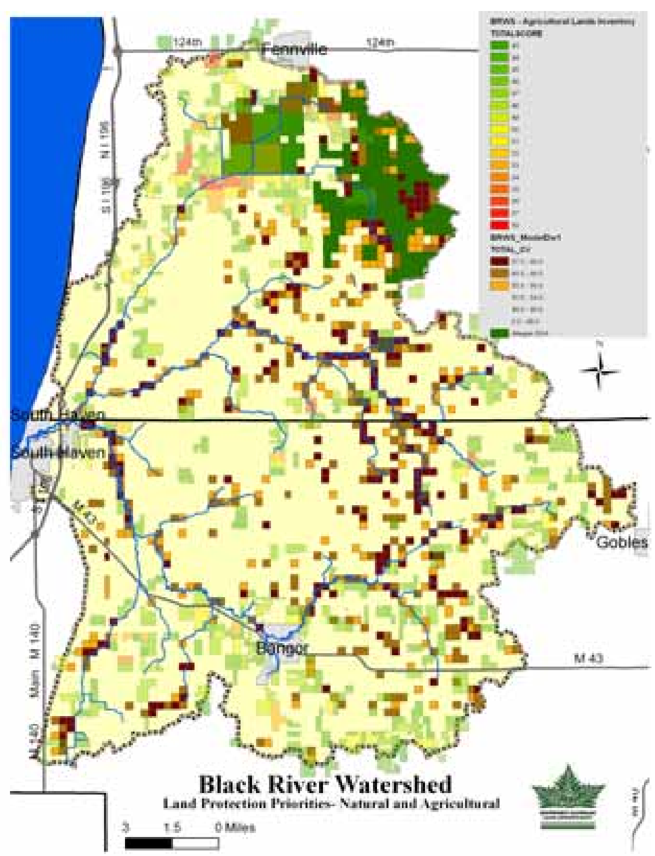
A third noticeable trend is that lands enrolled in PA 116 fared well overall across the watershed areas despite fairly even weights across the multiple criterion. This is a positive statistic in that some of the highest priority lands are at least temporarily protected.

PA 116 enrollment was derived from Michigan Department of Agricultural database queries and created from legal descriptions for the areas enrolled. Thus, these enrollment areas are not always parcel specific, as all or part of a particular parcel may be included or several parcels under the same ownership may be included under one enrollment. This results in a data layer that essentially ignores parcel boundaries. The advantages of this are many, but primarily, this will enable this layer to be updated annually as new parcel information becomes available without affecting the underlying PA 116 information. In addition, it is the intent of the County farmland protection programs to accept the perpetual maintenance of this layer for use into the future.



Several conclusions can be drawn from the PA 116 layer. First of all, the PA 116 program has good representation across the Black River Watershed. However, there is no evidence of a major core cluster or clusters of PA 116 land from which to center a permanent agricultural preservation effort. Thus, these farms may not be supporting each other. While micro-clusters of PA 116 enrolled lands are evident, they are not significant enough to create an urban growth boundary. Regardless, this layer has unique applicability to the model, as there is a direct correlation to these parcels and high developability factors based on their characteristics. PA 116 participation will be a major factor for directing education and outreach initiatives to protect existing farms, but enrollment alone has only a moderate positive correlation to how the parcel scored based on crop potential (scored by soils, drainage, and other physiographic criteria) across the board.

When we examine how the BRWS natural lands model interacts with the agricultural inventory it becomes apparent that though there is very minimal direct overlap (as would be expected), there are areas where ensuring compatible land uses adjacent to significant natural lands will achieve multiple goals including the protection of groundwater recharge through infiltration, habitat relationships that promote wildlife movement and low disruption of energy flow (wind, water, etc.) vital to the functionality of natural areas for wildlife.



SWMLC plans to further study the relationships between the highest priority areas for protection and mechanisms for balancing multiple conservation goals across the landscape while protecting critical agricultural resources in the Watershed. The role that agricultural lands have in ensuring water quality and quantity protection is very significant, and through conservation measures we can help ensure that agricultural productivity is balanced with resource protection measures.

Outreach

A landowner workshop is planned for the landowners of high priority agricultural properties in the watershed sometime in the next six months. During the grant cycle, two landowner workshops were held -- in January 2008 and August 2008. SMWLC presented and participated in many other workshops and events focused on protecting the water quality of the Black River Watershed. The most recent event that we participated in as part of this grant included a walk, paddle, and roll event in August 2009 where more then

30 people paddled down the Black River. Landowners with more then 20 acres in our high priority Q-Q sections were invited to the landowner workshops and the walk, paddle, and roll event. The Black River Watershed land conservation project is highlighted in our summer 2009 issue of *Landscapes*.

Landowner Contacts

Following is a list of landowners that we have had multiple communications with about land protection options for their property within the timeframe of this grant funded project.

	Landowner contact in the Black River Watershed 2006-2009		
	Name	**Phone #**	**Address**
1	Karl and Ruth Hewitt	269-253-4318	332 63rd St., S. Haven, MI 49090
2	Jack Spangler (daughter Jodie)	269-434-8619	35760 CR 687, Bangor, MI 49013
3	Don Sappanos Sr	269-906-0172	433 Blue Star, South Haven, MI 49090
4	Brent Sheridan	616-550-5231	
5	Dan Garvey	918-261-4355	
6	Carol Voytech	941-488-876	
7	Karen Hoad	843-406-0363	1101 Wayfarer Ln., Charleston, SC 29412
8	Nancy Kort		6 Brighton Ln., Oak Brook, IL 60523
9	Hilligan Family Farm		49th Street
10	Maynard Kaufman	269-656.1758	P.O. Box 361, Bangor, MI
11	Nelson Hodgman	269-434-6616	PO Box 215, Grand Junction, MI
12	HK Ellis		10940 CR 215, Grand Junction, MI
13	Dick Curtis	269-434-6662	
14	Jason Buero	269-838-2778	59119 16th Ave, Grand Junction, MI
15	Mike Wallace	296-227-3472	1113 68th Street, South Haven, MI 49090
16	Gloria Garner		211 Michigan Ave. #3, South Haven, MI 49090
17	Matt Sharl		212 W. Washington St Suite 1911, Chicago, IL 60606
18	Sam Ewbank	269-561-2505	On behalf of Bangor
19	Wendy Elsey	269-816-2837	54761 Lawerence Rd, Marcellus, MI 49067

In addition to these leads, SWMLC staff visited several additional sites of interest over the past few years. In total, 12 landowner contacts were made and discussions regarding conservation options were pursued and over four hundred of landowners were educated about BRW objectives, resource management, and conservation options.

Summary

In summary, SWMLC plans to continue to rely on the results of the natural resources based and agricultural models as we focus our conservation efforts within the Black River Watershed. The models have been a true success in targeting high priority properties as we and the many other project collaborators work to improve water quality within the BRW and ensure its sustainability in perpetuity. We will use the results of this planning/implementation process and the Paw Paw River Watershed planning/implementation process to work toward purchasing development rights of the high priority parcels with additional grant funding for these two watersheds through the MDEQ 319 program which spans over the next three years. We plan to keep the volunteers that have helped us with this planning process and the landowners that we have been in contact with abreast of the current conservation activities and opportunities available.

Appendix H: Officials in the Watershed

Name	Address	City	Zip	Phone	Position
Dean Kapenga	5634 136th Ave	Hamilton	49419	(269) 751-8586	Allegan County Commissioner - District 5
Tom Jessup	6717 108th Avenue	South Haven	49090	(269) 637-3374	Allegan County Commissioner - District 8
Fritz Spreitzer	1244 Turkey Ln Rd	Allegan	49010	(269) 673-4131	Allegan County Commissioner - District 9
Rebecca Rininger	113 Chestnut	Allegan	49010	(269) 673-0440	Allegan County Drain Commissioner
Bill Colgren	43129 CR 215	Lawrence	49064	(269) 674-8420	Arlington Twp (Van Buren) Supervisor
Regina Hoover	68129 34th Ave	Covert	49043	(269) 427-8965	Bangor Twp (Van Buren) Supervisor
Jim Lisowski	109 E Kalamazoo	Bloomingdale	49026	(269) 521-3800	Bloomingdale Twp (Van Buren) Supervisor
Allan Overhiser	7104 107th Ave	South Haven	49090	(269) 637-4441	Casco Twp (Allegan) Supervisor
Steve Revor	994 46th St	Allegan	49010	(269) 521-4522	Cheshire Twp (Allegan) Supervisor
Dorothy Appleyard	539 Phoenix St	South Haven	49090	(269) 637-0700	City of South Haven Mayor
Tommie Giles	2386 58th St	Fennville	49408	(269) 561-5214	Clyde Twp (Allegan) Supervisor
Dale Bradford	PO Box 323	Grand Junction	49056	(269) 434-6227	Columbia Twp (Van Buren) Supervisor
Wayne Rendell	45187 Blue Star Hwy	Coloma	49038	(269) 849-2074	Covert Twp (Van Buren) Supervisor
John Hebert	2107 68th St	Fennville	49408	(269) 543-4634	Ganges Twp (Allegan) Supervisor
Nancy Ann Whaley	63133 16th Ave	Bangor	49013	(269) 427-7607	Geneva Twp (Van Buren) Supervisor
Steve Miller	877 56th St	Pullman	49450	(269) 236-6485	Lee Twp (Allegan) Supervisor
Richard Sutherby	257 W. Monroe St.	Bangor	49013	(269) 427-5831	Mayor, City of Bangor
Dan Rastall	222 S Maple St	Fennville	49408	(269) 561-8321	Mayor, City of Fennville
Ross Stein	14149 73rd St	South Haven	49090	(269) 637-6746	South Haven Twp (Van Buren) Supervisor
The Honorable Tonya Schuitmaker	N1099 House Office Bldg., PO Box 30014	Lansing	48909	(517) 373-0839	State Representative - 80th District
The Honorable Bob Genetski	N1192 House Office Bldg., PO Box 30014	Lansing	48909	(517) 373-0836	State Representative - 88th Dist (Allegan)
The Honorable Ron Jelinek	PO Box 30036	Lansing	48909	(517) 373-6960	State Senator - 21st Dist (Van Buren)
The Honorable Patricia Birkholz	PO Box 30036	Lansing	48909	(517) 373-3447	State Senator - 24th Dist (Allegan, Barry, Eaton)
The Honorable Peter Hoekstra	31 E 8th St	Holland	49423	(616) 395-0030	US Congressman - 2nd District
The Honorable Fred Upton	157 S Kalamazoo Mall, Suite 180	Kalamazoo	49007	(269) 385-0039	US Congressman - 6th District
The Honorable Carl Levin	110 Michigan NW, #134	Grand Rapids	49503	(616) 456-2531	US Senator
The Honorable Debbie Stabenow	3230 Broadmoor St, Suite B	Grand Rapids	49512	(616) 975-0052	US Senator

Tom Erdmann	73280 8th Ave	South Haven	49090	(269) 637-8640	Van Buren County Commissioner - District 1
Susan Hammond	295 E. Main Street	Breedsville	49027	(269) 427-7281	Van Buren County Commissioner - District 2
Denise Massey	14961 32nd Street	Gobles	49055	(269) 628-5001	Van Buren County Commissioner - District 3
Richard Freestone	31002 60th Avenue	Bangor	49013	(269) 427-7674	Van Buren County Commissioner - District 4
James Toth	51640 35 ½ St	Paw Paw	49079	(269) 655-1814	Van Buren County Commissioner - District 5
Joe Parman	219 E Paw Paw St	Paw Paw	49079	(269) 657-8241	Van Buren County Drain Commissioner
Tom Rock	109 E Kalamazoo	Bloomingdale	49026	(269) 521-3222	Village of Bloomingdale President
T. Wayne Hammond	295 E Main St	Breedsville	49027	(269) 427-7281	Village of Breedsville President
Bernard Wilfong	42114 M-43	Paw Paw	49079	(269) 657-6847	Waverly Twp (Van Buren) Supervisor

Appendix I: Planning and Zoning Assistance in the Black River Watershed

The Van Buren Conservation District (VBCD) and the Southwest Michigan Planning Commission (SWMPC) with grant funds from the Michigan Department of Environmental Quality provided planning and zoning assistance to several municipalities in the watershed. The purpose of the assistance was to empower local officials to incorporate watershed protection measures into plans and policies. Further, the language developed during this project is provided as a model for other municipalities in the watershed. All master plan and zoning ordinance language can be viewed at www.swmpc.org/ordinances.asp.

The Van Buren Conservation District solicited proposals from municipalities within the Black River Watershed for planning and zoning assistance. The Black River Watershed Project Steering Committee ranked the proposals and awarded assistance to four communities (Arlington Township, Bangor City, Clyde Township and Columbia Township). The selection was based on amount of land in the watershed, the amount of land in a priority area, and the community's commitment to protecting water quality and natural resources. Each of the four communities signed a partnership agreement with the Van Buren Conservation District.

Process for Improving Master Plan and Zoning Documents in the Black River Watershed:

- Review master plan and zoning ordinance
- Meet with planning commission to identify issues of concern
- Develop priority list of issues
- Develop master plan language
- Adopt master plan language
- Develop zoning ordinance language

The assistance provided included a review of the master plan and zoning ordinance. A document review tool was developed by SWMPC to evaluate master plan and zoning ordinances. The tool can be found at http://www.swmpc.org/communityasmt.asp and can be utilized by other municipalities to review their master plans and zoning ordinances. The review was followed by meetings with the planning commission to identify issues of concern for the municipality. From the meetings, SWMPC developed a list of priority issues for the planning commission to consider addressing. Then SWMPC met with the planning commission to develop master plan and/or zoning ordinance language to address priority issues.

The following municipalities in the Black River Watershed received planning and zoning assistance from the Southwest Michigan Planning Commission:

Arlington Township
Bangor City
Bloomingdale Township
Bloomingdale Village
Clyde Township
Columbia Township
South Haven Township
South Haven City
Waverly Township
Van Buren County

In addition to the four selected municipalities, several other municipalities in the watershed received assistance in various ways. Waverly Township received assistance through the Paw Paw River Watershed Project. South Haven City asked SWMPC for assistance in developing parking requirements which would allow pervious pavement. Bloomingdale Township and Bloomingdale Village were updating their Recreation Plan and incorporated water quality language. South Haven Township was updating their master plan and zoning ordinance and incorporated many water quality issues and concerns. Lastly, Van Buren County is currently working with the SWMPC to develop their first recreation plan. This plan will highlight watersheds, water quality issues and green infrastructure.

SWMPC developed recommended master plan language for Arlington, Clyde and Columbia Townships. The City of Bangor does not have a master plan. The following table summarizes the issues and topics that language was developed by municipality.

Master Plan Language Recommendations by Municipality

Issue	Arlington Township	Clyde Township	Columbia Township
Watersheds	X		X
Black River Watershed Plan	X		X
Lakes	X	X	X
Streams	X		X
Riparian Buffers	X	X	X
Wetlands	X		X
Floodplains	X		X
Stormwater Management – Low Impact Development	X	X	X
Impervious Surfaces	X	X	X
Native Vegetation	X	X	X
Woodlands	X		X
Wildlife Habitat	X		X
Wildlife Corridors	X		X
Agricultural Lands	X		X
Green Infrastructure	X	X	X
Erosion and Sediment Control	X		
Land Protection and Management	X		
Invasive Species		X	

The following zoning ordinance language recommendations were developed for each municipality.

Zoning Ordinance Language Recommendations by Municipality

Zoning Ordinance Language	Bangor City	Clyde Township	Columbia Township
Building setbacks from water bodies (streams, rivers, lakes, wetlands) with a native vegetative buffer	X	X	X
Improve parking standards to reduce impervious surfaces (shared parking, parking space size, minimum parking requirements)	X	X	X
Require open space in Planned Unit Developments	X		
Site plan review (identification of natural features and review standards for protection)	X	X	X
Encourage low impact development techniques	X	X	
Encourage use of native species in landscaping	X	X	X
Improve private road standards to reduce impervious surfaces			X
Require a buffer between agriculture and residential uses to protect agricultural landowners		X	

Appendix J: Summaries of Previous Water Quality Studies

Below are excerpts and summaries of previous studies that have been done in the watershed by organizations such as the Michigan Department of Environmental Quality and the Michigan Department of Natural Resources. These studies can help locate current problem areas in the watershed, but some information in them may be outdated (for example, areas in Bangor have undergone remediation for PCBs and heavy metals since these reports were completed). Updated reports will be added to this plan as they become available. Issues of concern are indicated in bold text. Locations of these waterbodies are shown in the figure at the end of this document.

Overall Watershed

- Walterhouse 2003

"…water quality throughout the Black River Watershed was adequate to support acceptable biological communities at locations with suitable riparian and in-stream habitat. Unfortunately, **historic channelization and dredging** of many of the streams, wetland drainage, sandy soils, and the current land management activities of riparian owners provides the aquatic biota of streams in the Black River Watershed with limited stable habitat" (p. 2).

North Branch Black River

- MDNR 1976

Bottom substrate of the North Branch was noted as being very **silty** and representative of slow flow. Suspended solid concentrations indicated a problem with **erosion** in this area. Fecal coliforms were generally low during this study. Water quality was **slightly nutrient enriched**. Macroinvertebrate sampling indicated good water quality with a high diversity of species.

- Cooper 1999

Habitat at one location (at 68th St. near 108th Ave.) was ranked as fair due to a **lack of hard bottom substrate and sand sediment**. Macroinvertebrate populations were rated as acceptable, though diversity was considerably lower than comparable locations on the Middle or South Branch.

- Walterhouse 2003

The North Branch has historically been dredged upstream of 111th Ave., creating a relatively **homogenous channel**, lacking meanders and diversity of depths and velocities. The stream channel at some locations was noted as **incised**, and the riparian zone was not functioning as a floodplain. Upstream stream segments have been **channelized** and have a **narrow riparian zone**. They have a low flow and are exposed to sunlight. Nutrients were within acceptable ranges. Macroinvertebrate communities were rated as acceptable at two sites on the North Branch. Of the two sites, the downstream site (103rd Ave.) had a habitat rating of "good", while the upstream site (113th Ave.) had a "marginal" habitat rating. Substrate was primarily sand.

<u>Black River Drain</u>

- Lakeshore Environmental 1996

Lakeshore Environmental, Inc. completed a study of the Black River Drain in the area of the Allegan State Game Area for the Allegan County Drain Commission. They examined a variety of water quality parameters, including fecal coliform, BOD, nitrate nitrogen, total phosphorus, and conductivity. Fecal coliform, nitrate nitrogen and phosphorus concentrations decreased in a spring sampling event (compared to a fall sampling event, a time at which waterfowl activity in the Allegan State Game Area is high). **Fecal coliform** levels were highest in areas downstream from the central portion of the game area, and these levels were elevated only in fall sampling events. Conductivity and BOD were also in the suspect or problem ranges for all sampling locations and dates.

- Cooper 1999

Cooper reviewed the Lakeshore Environmental (1996) study and nutrient export from the Allegan State Game Area:

> "While it is entirely possible that sediment and nutrient transport may be encouraged by feeding waterfowl, these water quality parameters are also known to degrade from agricultural practices in the watershed and channel dredging itself which promotes sedimentation from bank erosion.

> In addition, **channelization** increases erosive power of the stream itself during high water evens by the removal/elimination of meanders, bends, and channel debris that reduce bank erosion. Increases in nutrient concentrations in stream channels that have undergone dredging are common and even expected. The very process that lowers the channel bed to promote drainage **also removes critical substrate and flow diversity** that promotes/enables natural biological processes to utilize and thereby remove nutrients from the water column" (p. 4).

Thus, the origin of sediment and nutrients downstream of the Allegan State Game Area is not yet clearly defined.

Middle Branch Black River

- MDNR 1976

This study (with one station on this Branch) noted good gravel substrate and generally clear water. Salmon were observed in November 1975. Nutrients and suspended solid levels were low. **Sodium and chloride concentrations were elevated**, indicating a possible upstream source of wastes.

- Heaton 1997

Macroinvertebrate communities were rated as acceptable, tending toward excellent. The designated use of coldwater fishery was not being met. Habitat was rated as "fair" (moderately impaired), due to a **lack of cobble, boulder, and woody debris instream substrate** and excessive **sand and silt deposition from streambank erosion.** Water quality was within the normal range for streams in this ecoregion.

- Cooper 1999

Habitat was rated good for fish and macroinvertebrates due to the presence of woody debris and stable, undercut banks. High amounts of **sand deposition** were also noted. The macroinvertebrate community was rated as good, tending toward excellent.

- Walterhouse 2003

Macroinvertebrate communities were rated as acceptable, tending toward excellent, and habitat was rated "good." Sand was the predominant substrate, but habitat features such as woody debris, root wads, undercut banks, and deep pools were noted. The stream channel had not been channelized, and was surrounded by a wide wooded floodplain. Water quality was within the normal range for streams in this ecoregion.

<u>Barber Creek (Middle Branch)</u>

- Heaton 1997

The aquatic macroinvertebrate community and the physical habitat were both rated "excellent" (non-impaired). No salmonid species were collected during this study period, and thus, the designated use of coldwater fishery was not being met.

- Macroinvertebrate populations were rated as acceptable, though diversity was low. Populations were dominated by midge or black fly larvae, possible indicators of **nutrient enrichment**. Habitat was slightly impaired due to sediment **deposition, embeddedness, and channel structure lacking in diversity.**

<u>Scott Creek (Middle Branch)</u>

- Heaton 1997

Biological integrity of this creek was rated as acceptable based on aquatic macroinvertebrate communities. However, this acceptable rating tended towards poor downstream of an industrial point source discharge. Physical habitat was rated as "fair" (moderately impaired), due to **lack of available bottom substrate, extensive embeddedness, absence of pool and riffle habitat, and lack of vegetative stability of the streambanks**. Concentrations of **ammonia** were elevated at one site on this stream. Concentrations of **arsenic, chromium, copper, mercury, nickel, lead and zinc** in the sediment were relatively elevated at one station. **Acetone** was detected in the sediment at two sites. **Methyl ethyl ketone, toluene, ethylbenzene and xylene** were detected at one site (downstream of the above mentioned point source discharge).

- Cooper 1999

Riparian conditions were noted as excellent, contributing to good habitat scores. Macroinvertebrate communities were rated as acceptable, though limited by poor bottom substrate due to **deposition and embeddedness**. **High nutrient conditions** may exist as suggested by the high density of midge fly and black fly larvae.

- Walterhouse 2003

This stream has historically been channelized, but dredging had not occurred recently. The riparian zone is well vegetated. Macroinvertebrate community was rated as acceptable. Habitat was rated as marginal due to **absence of riffle habitat and deposition and movement of sand substrate**. Water quality was within the normal range for streams in this ecoregion

Spicebush Creek (Middle Branch)

- Heaton 1997

Biological integrity was rated acceptable based on the aquatic macroinvertebrate community. Physical habitat was rated as "fair" (moderately impaired), due to the **lack of bottom substrate cover, excessive embeddedness due to sand and silt, absence of pool and riffle habitat, and lack of vegetative stability of the streambank**. No salmonid species were collected in Spicebush Creek during this study, and thus the designated use for coldwater fishery was not met. Water quality was within the normal range for streams in this ecoregion.

- Cooper 1999

This creek was noted as being a classic **dredged** channel with a wide, shallow streambed, steep banks, **sedimentation**, and **poor substrate**. The habitat was thus rated as fair. Macroinvertebrate populations were rated as acceptable, though there was a scarcity of species indicative of excellent water quality.

Spring Brook (Middle Branch)

- Walterhouse 2003

Some portions of Spring Brook appear to have been channelized in the past, but now appears to be a natural, wetland bordered, low-gradient stream with fine substrate. The macroinvertebrate community was rated acceptable and the habitat was rated as good. The stream substrate is predominantly sand, and riffle habitat was absent at the sample location.

South Branch Black River

- MDNR 1976

Nutrient levels in this study were low, as were total dissolved and suspended solid concentrations. The only parameters with elevated levels were **iron and fecal coliform** (indicating a possible sanitary or livestock waste source).

- Hull 1989

This study focused primarily on the South Branch of the Black River in the Bangor area, though one station was upstream, immediately below the Breedsville impoundment. Overall aquatic habitat quality was low as a result of **heavy deposition of sand and silt**. Despite the lack of quality habitat, aquatic macroinvertebrates were moderately to highly abundant. Lower species diversity and abundance was found below two **point-source discharges** in Bangor. Effluent from these discharges included heavy metals, PCBs, oil and grease, chlorides and dissolved salts. Substrate downstream of one discharge was described as "oily sludge beds overlain by several inches of silt" (p. 2).

- Gashman 1990

Sediment and fish samples were collected in this study of the South Branch in Bangor, in the area of a **point-source discharge**. PCBs were detected at high levels in fish samples. Elevated levels of PCBs and heavy metals were also found in sediment downstream of the discharge.

- Cooper 1999

Macroinvertebrate populations were rated acceptable at two sites (one upstream and one downstream of Bangor). Habitat was rated good at the upstream site and excellent at the downstream site. Signs of **nutrient enrichment** (such as dense growths of Cladaphora) were noted.

- Heaton 1997

The South Branch of the Black River in some locations was found to not meet its designated use as a coldwater fishery. Much previous sampling of this branch focused on the area of the Bangor Millpond, where elevated levels of PCBs and heavy metals were found. Biological integrity of the South Branch (based on fish collections) ranged from poor to excellent. Habitat was rated as “fair” (moderately impaired) for the majority of the south branch due to **a lack of cobbles, boulders, and large woody debris, as well as due to the excessive sand and silt deposition from stream bank erosion. Phosphorus and ammonia concentrations** were elevated at one location in this study.

- Walterhouse 2003

From the confluence of the Black River upstream to Bangor, the river is primarily a naturally meandering stream bordered by wooded floodplain with good sinuosity. The flow regime may be **flashy**. Sand is the predominant substrate and riffle habitat is infrequent. In this study, the most downstream site (at 70th St.) received a rank of excellent for the macroinvertebrate community (this was the only site rated as excellent in the study). Habitat was rated at good, with such elements as pools, woody debris, root wads, overhanging vegetation, and sand, muck, and detritus substrates. The flashiness of the flow regime was the only poor habitat element at this site.

The South Branch was also evaluated in Lion’s Park in Bangor. The macroinvertebrate community was rated as acceptable and the habitat was ranked marginal. Riffle habitat was present (though consisted primarily of unnatural objects like brick and concrete), but the habitat was negatively impacted by the flashiness of the flow regime and **lack of a natural riparian zone** in Lion’s Park.

This branch was also evaluated above the Breedsville impoundment (at 52nd St.). The macroinvertebrate community at this site rated as acceptable and the habitat was rated as marginal. Sand was the dominant substrate, and in-stream cover was sparse. **Movement and deposition of sand** at this site (just below the confluence of the Great Bear Lake Drain and the Black River Extension Drain) created a relatively uniform stream channel. Turbidity in the South Branch may be due to spawning and feeding behavior of carp in the Breedsville Impoundment (a large number of carp were documented here in June and July 2002).

- Wolf and Wuycheck 2004

Approximately 26,000 cubic yards of sediment were removed from the South Branch of the river in the area of the Bangor Mill Pond. The sediment was contaminated with PCBs and heavy metals. Restoration and remediation of the area concluded in June 2004 (L. Nielsen, personal communication, June 15, 2004).

<u>Black River Extension Drain (South Branch)</u>

- Cooper 1999

Macroinvertebrate sampling in this drain found very **poor diversity** and noted that the stream channel was **“void of all structure and channel diversity due to channelization”** (p. 2).

<u>Butternut Creek (South Branch)</u>

- Walterhouse 2003

This stream and all of its tributaries have been **channelized**, though dredging of some segments has not occurred for a number of years. The macroinvertebrate community was rated as acceptable, and the habitat was rated as good. Some meanders had reestablished, and the site had deep pools and woody debris. Sand was the predominant substrate. A wide riparian corridor was noted. Water quality results were within the normal range for streams in this ecoregion.

<u>Cedar Creek (South Branch)</u>

- Cooper 1999

Macroinvertebrate samples at two sites on this creek indicated fair to poor habitat and acceptable macroinvertebrate diversity (though relatively low density). **Hard substrate was lacking and excessive sedimentation and embeddedness were noted. Banks were also in poor condition.**

- Walterhouse 2003

This stream and all of its tributaries have been **channelized**, though dredging in some areas has not occurred recently. Streambanks were well vegetated. This stream is **incised** and sand is the dominant substrate. The **riparian zone if often very narrow**, and row crops were found to begin at the edge of the stream banks in many locations. Macroinvertebrates were scored as acceptable and habitat was rated marginal due to the **deposition and movement of sand substrates.**

Cedar Drain (South Branch)

- Cooper 1999

Two sites were sampled for macroinvertebrates (upstream and downstream of the Bangor wastewater sewage lagoons). The upstream site had a poor macroinvertebrate community rating and a **poor habitat** rating. The downstream site had acceptable populations with low density, and habitat was rated as fair.

Eastman Creek (South Branch)

- Cooper 1999

Macroinvertebrate populations were rated acceptable and habitat was rated good tending toward excellent. However, some of the species found were relatively pollution tolerant species.

- Walterhouse 2003

The macroinvertebrate population was rated as acceptable and the habitat was rated as good. Riffle habitat was absent, and sand was the predominant substrate. Portions of this stream have been **channelized** in the past. Streambanks were well-vegetated and were not eroding. The riparian zone was intact. Water quality results were within the normal range for streams in this ecoregion.

Great Bear Lake (South Branch)

- Fusilier 1998

Secchi disk trends show that both basins of Great Bear Lake are getting less clear. A significant **algal bloom** occurred in both the spring and summer of 1997. Surface **phosphorus concentrations** were high in both spring and summer. The north basin appeared to be more affected by nutrient inputs than the south basin.

- Walterhouse 2003b

Sampling results from this and previous studies indicate that phosphorus is the limiting nutrient in Great Bear Lake. Results of this study indicate that water quality may have improved.

- Fusilier 2003

There is no clear trend in phosphorus concentrations in the lake over the past 20 years. However, the phosphorus levels have at times been above 20 µg/L, a level at which excessive algae and aquatic plant growth may occur. The lake experienced a significant algal bloom in April 2000. Both the north and south basins of the lake have experienced a decline in clarity over the past 20 years. A Lake Quality Index (LQI) has been calculated for the lake over the past 20 years and shows no type of trend.

- Walterhouse 2004

The Michigan Department of Environmental Quality developed a Total Maximum Daily Load (TMDL) for phosphorus in Great Bear Lake. This report estimates that 90% of the total annual nonpoint source load comes from agricultural land uses in the Great Bear Lake watershed. The model used does not account for pollution from precipitation or several other sources. The TMDL establishes a spring overturn phosphorus goal of 0.030 mg/L, which will require a 29% reduction in annual phosphorus loading.

- Walterhouse 2007

Spring turnover phosphorus concentration in the north basin of the lake was 0.050 mg/L, and 0.025 in the south basin, for an acre weighted average concentration of 0.046 mg/L, above the TMDL goal. Sampling also indicated that a sediment trap installed upstream of Great Bear Lake does not reduce total suspended solids, nitrogen or phosphorus (though observations indicate that the trap is capturing storm event bed load). One sampling event occurred during a storm event, demonstrating that phosphorus loads increase dramatically during storm events.

Great Bear Lake Drain (South Branch)

- Cooper 1999

Macroinvertebrate diversity in this drain was low (though this may be due to the close proximity of the sampling site to Great Bear Lake). The habitat was considered fair (moderately impaired) due to **bottom deposition, embeddedness, and lack of streamside cover.**

Haven & Max Lake Drain (South Branch)

- Fusilier 1998

Sampling in the Haven & Max Drain indicated that **nutrients** were added to the drain between CR 388 (38th St.) and 41st St., upstream of Bloomingdale. Both nitrate **nitrogen and phosphorus** concentrations increased between these two road-stream crossings. Denitrification appeared to be occurring in the stream, and little or no nitrates were added below 41st St. The same appears to be the case for phosphorus.

- Cooper 1999

High concentrations of **phosphorus** (and ortho-phosphorus in particular) may indicate an impairment of the biological community and habitat (typically, ortho-phosphorus concentrations are low as a result of biological assimilation).

- DEQ 2000

Photographs and notes taken by DEQ personnel in the summer of 2000 noted **high, steep eroding banks** in a stretch of this drain between CR 388 (near 3850th St.) and the Remington & Powers Drain. **Turbid water, sediment, vegetation, and algae** were also noted in Fritz Drain, which enters Haven & Max Lake Drain in this segment. Downstream of this, (between 45th and 42nd Streets) **steep, eroding banks and heavy sediment deposition** were also noted, though at least one section with cobble substrate was also found. A rust colored matter (bacterial) was prevalent, especially in seep areas.

- Fusilier 2003

The highest phosphorus inputs to this drain come from the Munn Lake Drain.

- Walterhouse 2003b

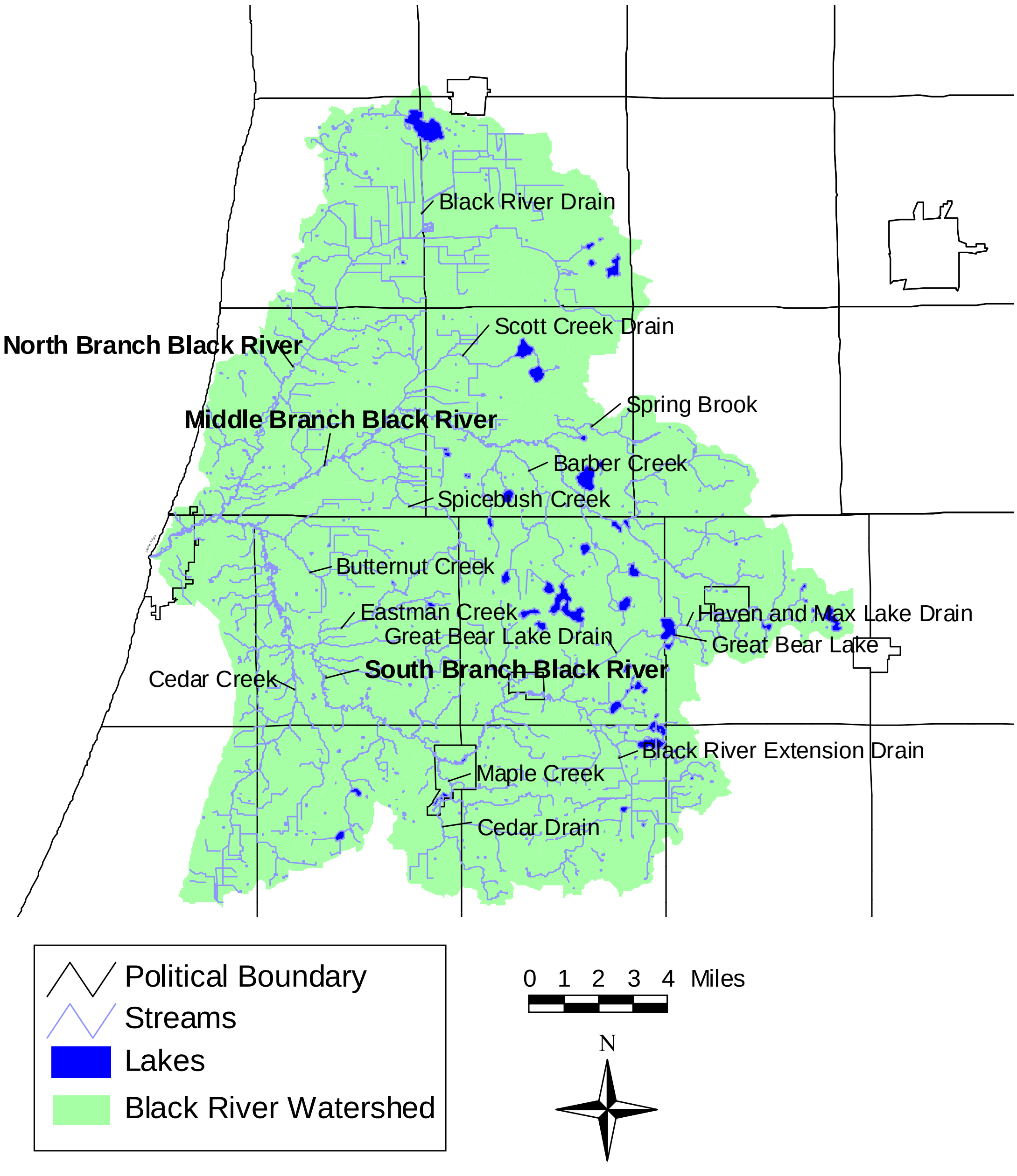
The highest concentrations of phosphorus upstream of Great Bear Lake were found in Munn Lake Drain (which flows into the Haven & Max Lake Drain near 3850th St.). This study concluded that phosphorus and nitrogen concentrations do not increase downstream of the Bloomingdale Wastewater Treatment Plant.

Maple Creek (South Branch)

- Heaton 1997

Biological integrity was rated as acceptable tending towards excellent. The habitat was rated as good (slightly impaired). Ammonia and phosphorus concentrations were elevated, both upstream and downstream of the Bangor wastewater sewage lagoons. Upstream sources of nutrients may be agricultural runoff. Most of the above-mentioned studies have been entered into a Geographic Information System (GIS) housed at the Van Buren Conservation District.

Waterbodies in the Black River Watershed



Map created by Erin Fuller, Van Buren Conservation District, March 2005
Data Source: Michigan Center for Geographic Information

Appendix K: Black River Watershed Bank Erosion Study

Monitoring Stream Bank Erosion with Bank Pins in the Black River Watershed (Allegan and Van Buren Counties)

Final Report
3/12/05

Black River Watershed Project

(Tracking code 2002-0067)

Project Partners:
Van Buren Conservation District
Michigan Department of Environmental Quality

Prepared by:
Erin Fuller
Black River Watershed Coordinator
Van Buren Conservation District
1035 E. Michigan Avenue

Paw Paw, MI 49079

Table of Contents

Acknowledgements 41
Introduction 42
Methods 42
Results 45
Site number: BRN-17 45
Site number: BRN-14 46
Site number: BRM-02 46
Site number: BR-13 47
Site number: BRS-57 47
Site number: BRS-63 47
Site number: Lion’s Park 48
Site number: BRS-39 49
Discussion 49
Appendix A 51
Appendix B 53

List of Figures

Figure 1: Bank Erosion Study Sites 44
Figure 2: BRN-17 45
Figure 3: BRN-14 46
Figure 4: BRM-02 46
Figure 5: BR-13 .... **Error! Bookmark not defined.**
Figure 6: BRS-57 47
Figure 7: BRS-63 .... **Error! Bookmark not defined.**
Figure 8: Lion's Park .... **Error! Bookmark not defined.**
Figure 9: BRS-39 .... **Error! Bookmark not defined.**

Acknowledgements

I would like to offer my profound thanks to the volunteers that gave their time and energy to this project: Sam Ewbank and sons, Sheri Lemon, and staff of the City of Bangor Department of Public Works (including Steve Lowder, John Halliburton, and Jack Weber). Much gratitude is also due the City of Bangor for contributing their employees' time to this project. Larry Nielsen, Bangor City Manager, was instrumental in facilitating and coordinating staff training and participation. Thank you also to the landowners that were kind enough to allow us to access their property for this study. Without their cooperation, this study could not have occurred. Julia Kirkwood of the Michigan Department of Environmental Quality provided much support, and was willing to risk becoming stuck forever in the muck of the Black River to assist with this project. Joe Rathbun, also of the Michigan Department of Environmental Quality, provided essential assistance throughout the entire course of the project. It would not have happened without his expertise and guidance.

-Erin Fuller

Introduction

Black River Watershed Project staff and volunteers monitored stream bank erosion at various locations in the Black River Watershed in Allegan and Van Buren Counties. Erosion and sedimentation have been determined to be critical issues in the watershed, but data on the rate of bank erosion in the watershed is lacking. In addition to helping locate sites where erosion is most critical and providing information with which to estimate of sediment loading in the watershed, this study helps provide a baseline against which to evaluate best management practice (BMP) effectiveness in the future.

Bank erosion pins were placed at eight sites throughout the watershed. The methods followed the standard operating procedure cited in Appendix A. Embeddedness was also analyzed using the procedure described in the Michigan Department of Environmental Quality's Great Lakes and Environmental Assessment Section Procedure #51 (May 2002). Volunteers were engaged to perform measurements of the bank pins and embeddedness at several of the sites. The Black River Watershed Coordinator monitored bank pins at the remaining sites and acted as project manager.

Methods

The methodology for this study was derived from the standard operating procedure "Monitoring Stream Bank Erosion with Erosion Pins," (Appendix A) devised by Joe Rathbun of the Michigan Department of Environmental Quality (MDEQ). This procedure has been used by MDEQ in similar studies in the Rouge River watershed in southeast Michigan (J. Rathbun, personal communication).

Sites for placement of bank erosion pins were chosen by selecting road-stream crossing sites with visible signs of erosion. Sites with obvious human-induced erosion were eliminated. Sites were distributed on both tributary streams and on the three main branches of the river. Some sites were on natural reaches and some were on previously channelized reaches. All sites had natural vegetation adjacent to the streambank. Fifteen sites were initially chosen that met these criteria. Landowners were contacted by phone or mail and permission was granted to access eight of the fifteen sites. These eight sites are shown in

Figure .

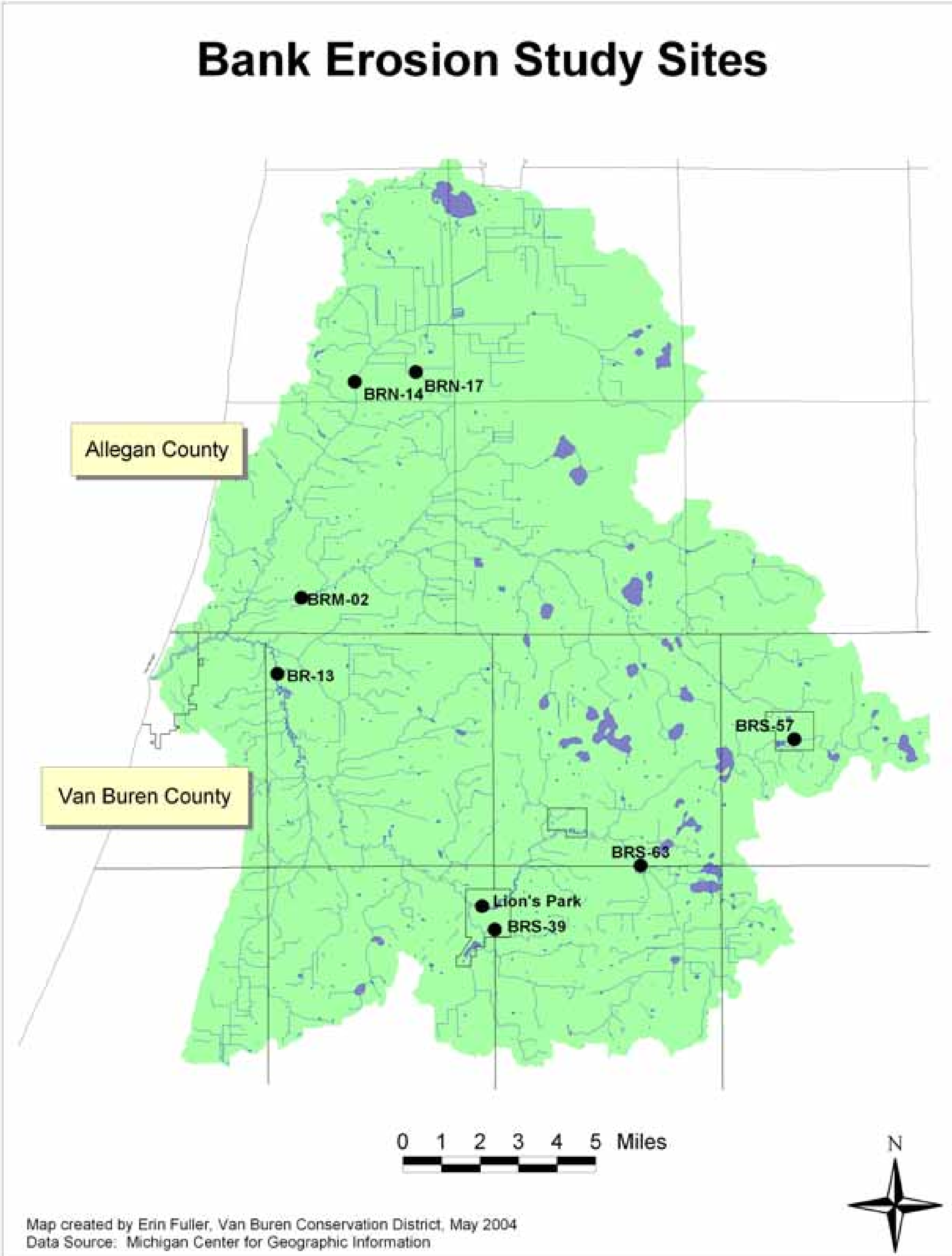
Pins were installed on June 9, 2004. The pins were 1/8 inch-diameter wooden dowels spray-painted fluorescent orange. Where conditions permitted, pins were installed in two locations at each site (denoted as the “upstream” location and the “downstream” location), and on both the left and right banks. This was not always feasible due to bank height, substrate, and vegetative cover. Several pins (the number depended on bank height) were installed at each of these locations, typically in a vertical arrangement on the bank. Photographs were taken of the sites, and each site was marked with orange flagging tape. At the time of installation of the erosion pins, bricks were placed in the channel for the purpose of estimating embeddedness at those sites lacking natural cobble substrate.

Volunteers were all trained individually on the proper methodology for measuring bank pins and embeddedness. Measurements of bank pins were taken from June 9, 2004 to November 18, 2004. Sites were visited shortly after major storms (a major storm was defined as any event in which rainfall of 0.25” or more occurred in any 24-hour period). The project manager contacted and alerted volunteers to take measurements. Precipitation information was obtained from the Michigan Automated Weather Network website at <http://www.agweather.geo.msu.edu/mawn/> from sites in the watershed (Grand Junction in Van Buren County and Fennville in Allegan County).

Measurements were taken in the following manner: a washer was placed over the dowel and pushed toward the bank until it touched the bank. The distance from the washer to the end of the bank pin was measured with a ruler, in millimeters. Measurements were recorded on the “Black River Watershed Bank Pin and Embeddedness Inspection Form” (Appendix B). The washer was used to improve accuracy of the measurement.

Embeddedness was estimated by grasping and removing a brick or existing cobbles and estimating the percentage that they were buried in the sediment. This estimate was scored on the “Black River Watershed Bank Pin and Embeddedness Inspection Form” (Appendix B).

Figure 1: Bank Erosion Study Sites

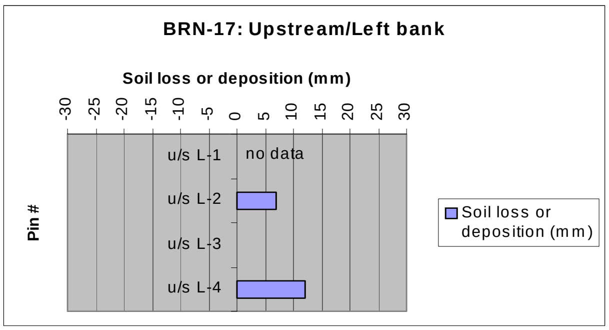


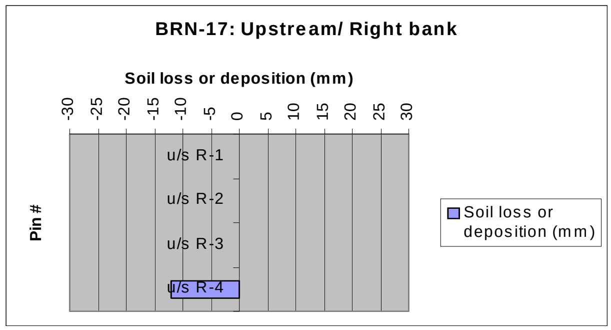
Results

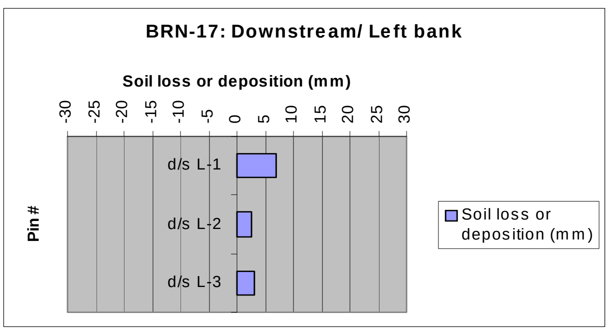
Measurement precision for this type of study has previously been established as approximately ± 1 or 2 mm (see Appendix A). Thus, any changes in measurements that were less than 2 mm were recorded as “no change.” The site with the most soil loss over the course of the study was BR-13, with a loss of 29 mm of soil recorded from the lowermost pin (L-6). The site with the most soil deposition over the course of the study was BRN-14, with 9.5 mm of soil deposited over the course of the study at the downstream/left bank location (pin # L-2). Other locations at the same site, however, also had soil loss. The full results of the study are below.

Site number: BRN-17

This site is located on the Black River Drain, a narrow, previously channelized tributary of the North Branch of the Black River. The surrounding land use is agriculture and forest. Pins were placed in three locations at this site.
Average embeddedness: 9.75 (Marginal)



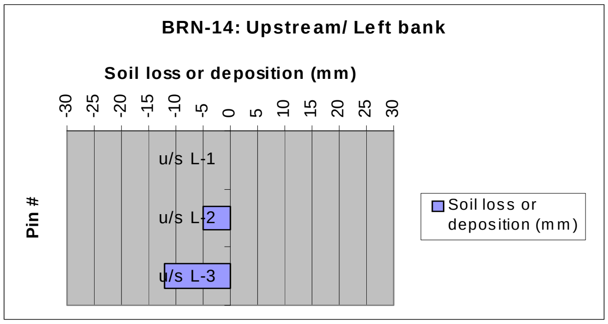


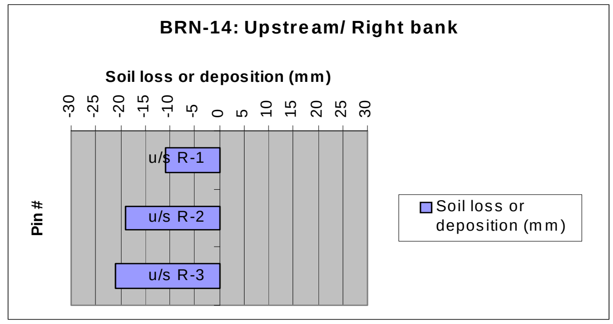


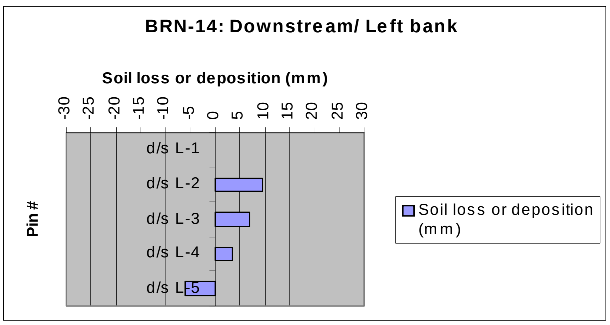
Site number: BRN-14

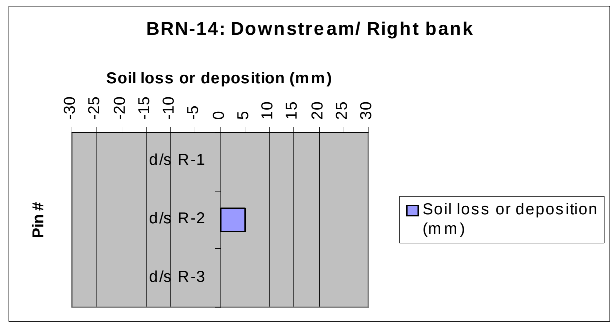
This site is located in a shallow section of the main stem of the North Branch of the Black River (this section is also technically considered part of the Black River Drain). The surrounding land use is forest. Pins were placed in four locations at this site.

Average embeddedness: 0.7 (Poor)





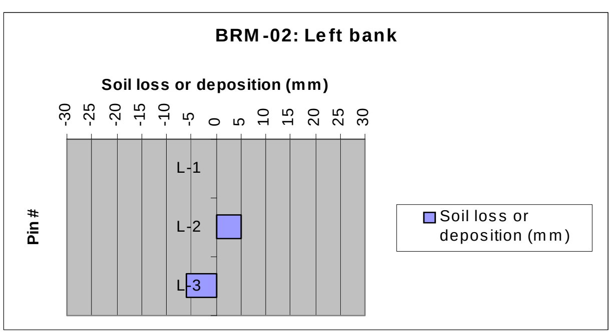


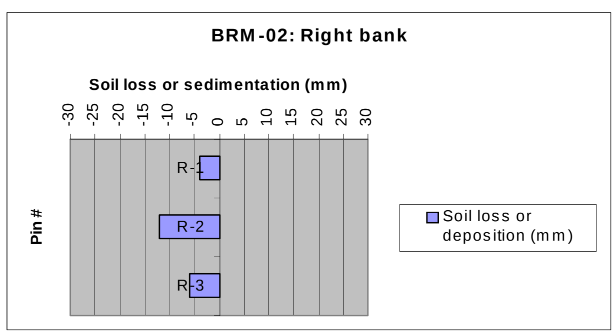


Site number: BRM-02

This site is located in a shallow section of the main stem of the Middle Branch of the Black River. The surrounding land use is forest. Pins were located on both the left bank and right bank. Due to the short height of the streambanks at this site, pins were placed on a horizontal axis approximately 5 feet apart. Pin #1 was the farthest pin upstream and pin #3 was the farthest downstream.

Average embeddedness: no data

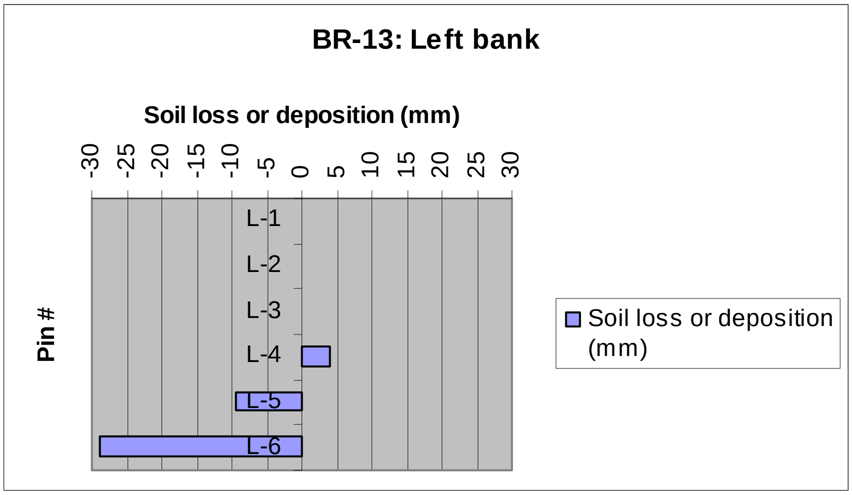




Site number: BR-13

This site is located in a section of the South Branch of the Black River. The surrounding land use is forest. Pins were placed in one location at this site.

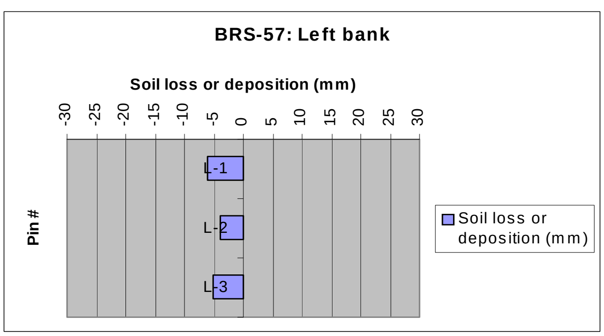
Average embeddedness: 1 (poor)

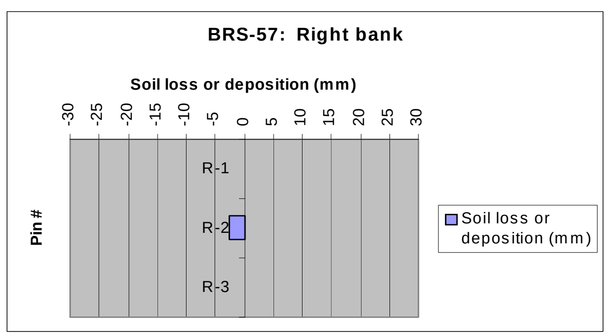


Site number: BRS-57

This site is located on the Haven & Max Lake Drain, a small tributary of the South Branch of the Black River. This drain has been channelized in the past, but is recovering. The site is just downstream of a park in the Village of Bloomingdale. The surrounding land use is forest and parkland. Pins were placed at two locations at this site.

Average embeddedness: 16.4 (excellent)

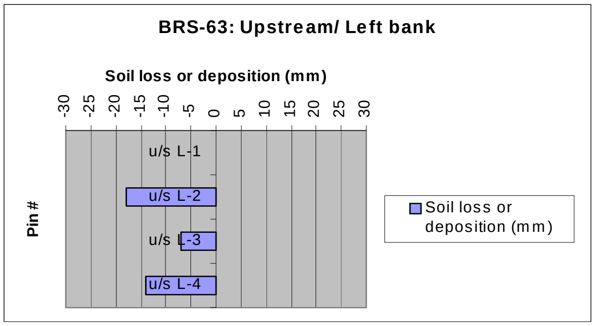


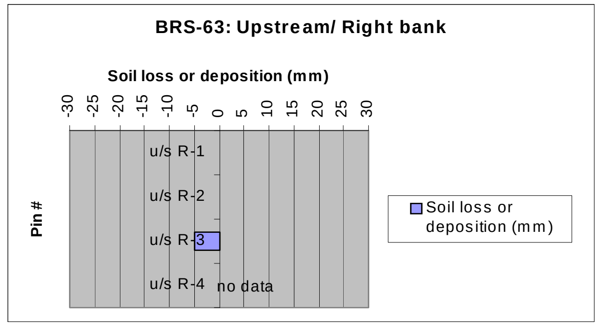


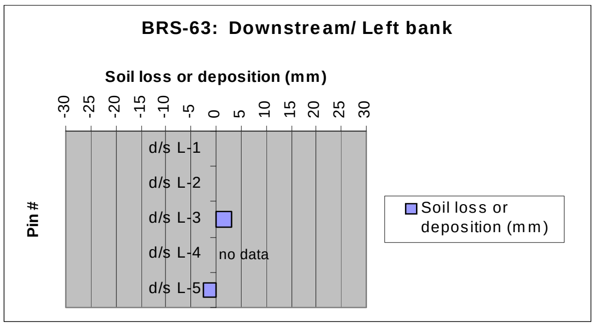
Site number: BRS-63

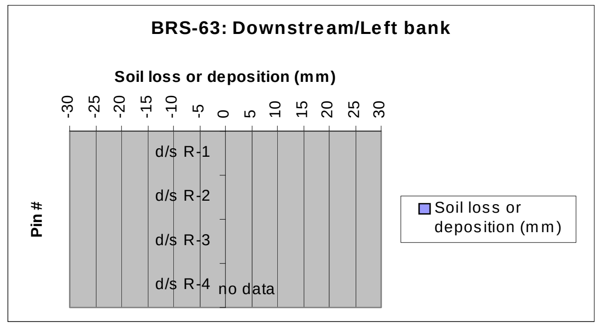
This site is located on the Black River Extension Drain, a tributary of the South Branch of the Black River. The surrounding land use is forest (a road also parallels this site). Pins were placed in four locations at this site.

Average embeddedness: 12 (good)





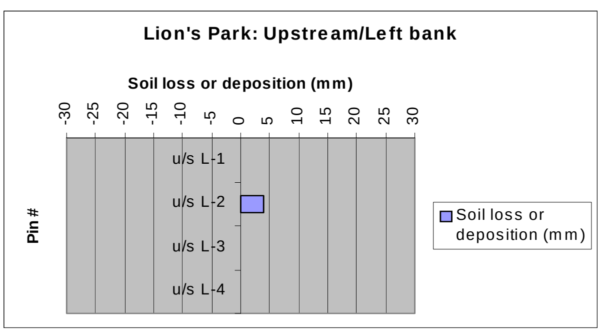


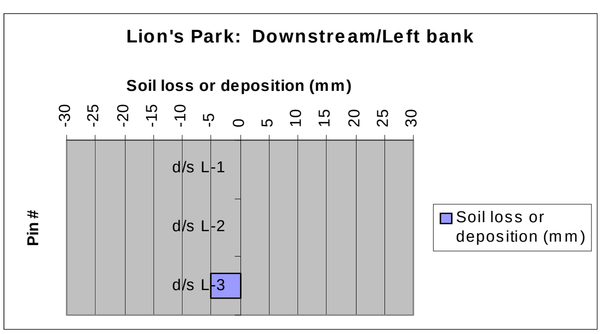


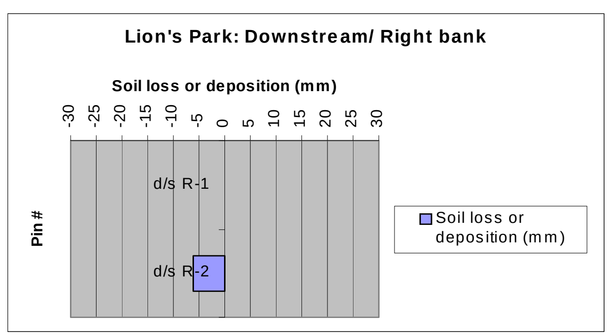
Site number: Lion's Park

This site is located on the South Branch of the Black River, in Lion's Park in the City of Bangor. The surrounding land use is forest and park land. Several foot paths run along the river. Significant disturbance occurred at this site (to both the vegetation and the erosion pins) during the fall fishing season. Pins were placed in three locations at this site.

Average embeddedness: 4 (poor)



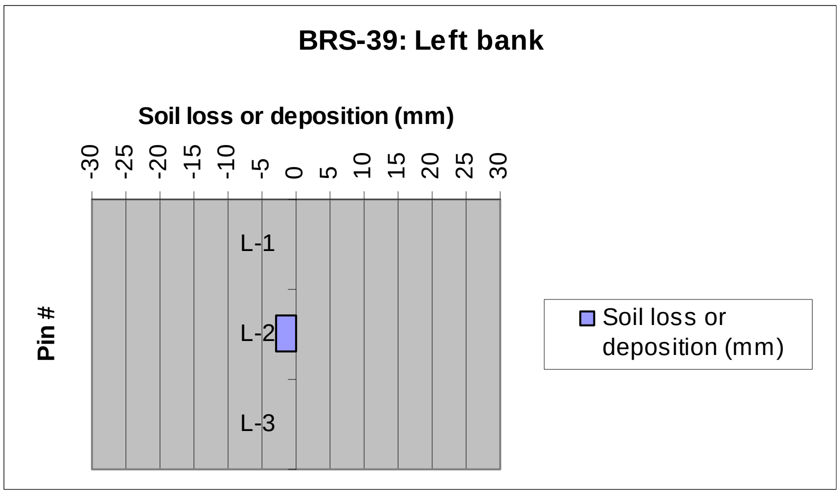




Site number: BRS-39

This site is located on the Boyer Drain, a small tributary of the South Branch that runs through the City of Bangor. The surrounding land use is forest and residential. Due to the short height of the streambanks at this site, pins were placed on a horizontal axis approximately 5 feet apart. Pin #1 was the farthest pin upstream and pin #3 was the farthest downstream.

Average embeddedness: 16.8 (excellent)



Discussion

At some sites, the river channel appears to be quite actively changing, while other sites appeared relatively stable. Sites in which high levels of bank erosion were expected (Lion's Park and BRS-57, for example) did not always exhibit this. Other sites that appeared relatively stable had higher rates of erosion than expected (such as BRM-02). The precise location of the pins at each site certainly influenced the measurements. For example, at BRN-14, a relatively straight-channeled reach, measurements of the upstream set of pins demonstrated soil loss on the left bank, while measurements on the downstream set of pins on the left bank demonstrated soil deposition (with the exception of the lowest pin, L-5, which lost 6 mm of soil over the course of the study). This is due to many factors, including the vegetation surrounding the pins, water currents, and streambank soil composition.

Embeddedness was also highly variable, ranging from a low score of 0.7 (poor: gravel, cobble and boulder particles [or bricks] are more than 75% surrounded by fine sediment) at BRN-14 to a high of 16.8 (excellent: gravel, cobble and boulder particles [or bricks] are 0-25% surrounded by fine sediment) at BRS-39.

Many pins broke over the course of this study, which certainly limited data collection. Several bank pins were sited in areas frequented by wildlife such as deer and raccoons (BRN-14 and BRN-17 especially). These locations suffered from high amounts of pin breakage, likely as a result of wildlife interference. Deer and raccoon tracks were found in close proximity to the pins and human interference at these sites was considered unlikely due to their remote locations. Some pins likely broke in high water events when debris was washed against them. Other pins likely broke due to human interference (especially the two sites that were in parks, BRS-57 and Lion's Park). Future studies should utilize pins of a larger diameter (3/8 inch or 1/4 inch).

Related to pin breakage, another issue that hampered this study was the difficulty of determining a pin's number if pins above or below it had been broken. For example, site BR-13 had 6 pins in a vertical arrangement. On 7/9/04, the volunteer in charge of the site reported a pin missing. Due to fluctuations in water level, it was impossible to determine if the pin was L-5 or L-6. In future studies, pins should be labeled with their number (or possibly color-coded). Additionally, the distance from the top of the bank to each pin could be measured.

In the future, more sites should be monitored if at all possible. The small sample size makes it impossible to draw conclusions for the watershed (or even a specific branch or tributary of the river). However, one of the most difficult aspects of this study was receiving landowner permission for accessing the river. Many landowners simply never responded to phone calls or letters. Access to sites can be physically difficult as well, given the steep banks in many areas, as well as the prevalence of poison ivy and stinging nettles. Safety is certainly concern for staff and volunteers monitoring these sites (most sites were monitored by one person rather than a team). Deeper sections of river may not be safely monitored by one person.

Overall, this was a useful pilot study. It brought out some aspects that should be improved upon in future studies. This is a simple, relatively inexpensive study that can be undertaken by volunteers. Before-and-after bank pin studies should be useful in monitoring effectiveness of streambank remediation efforts in the future.

Appendix A

STANDARD OPERATING PROCEDURE

MONITORING STREAM BANK EROSION WITH EROSION PINS

Joe Rathbun
Michigan Department of Environmental Quality – Water Division
Southeast Michigan District Office
(734) 432-1266
rathbunj@michigan.gov

1.0 Overview

Stream bank erosion is a natural process that occurs in every watershed. Bank erosion rates, however, are known to change when either the stream discharge pattern and/or volume changes, or when the sediment loading to the stream changes. Both stream discharge and sediment loading usually change in urbanizing watersheds (e.g., Whipple et al., 1981), sometimes drastically. Many stream channel assessment studies or restoration projects require estimates of stream channel stability, and this standard operating procedure (SOP) describes a technique for measuring stream bank erosion rates, using erosion pins.

Many erosion pin studies employ metal pins (e.g., Neller, 1988), but this SOP recommends wooden dowel rods. Excessively high rates of bank erosion can result in the loss of pins, and wooden pins will eventually decompose.

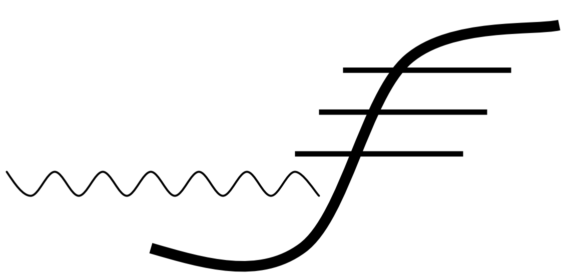
2.0 Procedure

1. Cut wooden dowel rods (1/8" or 3/16" diameter) into 12" to 18" lengths.

2. Paint one end a bright color (orange or red), for visibility.

3. Drive into the stream bank with a hammer, leaving ~ 2" protruding from the bank (see schematic, next page).

   - The number and pattern of erosion pins at any one location will vary depending on the purpose of the study. A typical installation involves 3 or 4 pins in a vertical arrangement up the bank, with the lowest pin being within a few inches of the waterline at base flow and the highest pin being within a few inches of the top of the bank.
   - The number of stations monitored will also depend on the purpose of the study. If monitoring the performance of a stream bank stabilization BMP, it is often desirable to install pins at nearby, similar banks that lack the BMP, in addition to monitoring the specific location of interest.



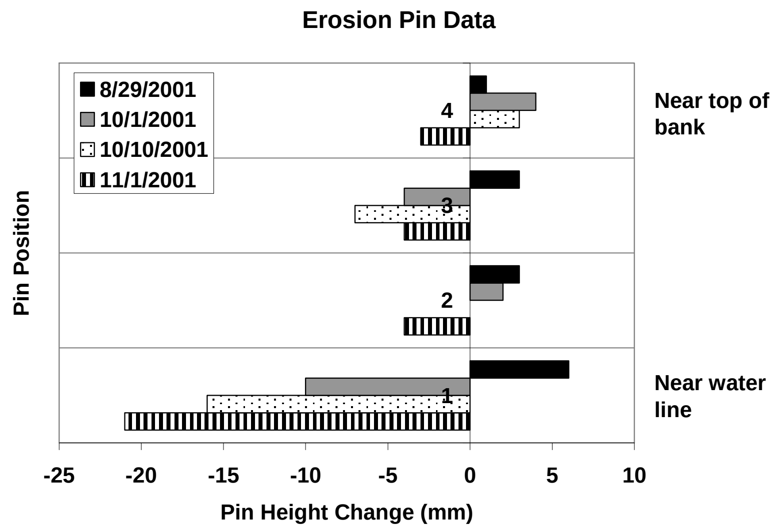
4. Measure the height of the erosion pins on the day they are installed ("Day 0" data) and again at periodic intervals, to the nearest millimeter.

   - Measurement frequency depends on the purpose of the study. Recommended intervals include monthly, or after every major rain event, or a combination of both.
   - Note that erosion pins will record soil or sediment deposition as well as erosion. If soil deposition is likely, greater than 2" should be left protruding from the bank on Day 0.

Note: if erosion pins are left in the bank over a winter, their heights should be measured early in the spring to check for frost-heave.

3.0 Data Calculation and Interpretation

(1) Pin heights recorded on the day the pins are installed are considered "Day 0" data, and all subsequent measurements are compared to these data. Measurements of bank erosion are typically expressed as negative numbers (subtracted from the Day 0 data), while bank deposition is expressed as positive numbers (added to the Day 0 data; see figure, below).



(2) Based on preliminary field studies by the author, the expected precision of careful erosion pin measurements is approximately ± 1 or 2 mm. Consequently, pin height changes of this amount or less should be interpreted as indicating 'no change.'

(3) The mass of eroded bank soil can be calculated from erosion pin data if the length and average height of the monitored bank is known, and if the bulk density of the bank soil is measured or estimated. Example bulk density figures are below.

Texture	Bulk Density (g/cc)
Sand	1.6
Loam	1.2
Clay	1.05

(Univ. of Saskatchewan)

4.0 References

Neller, R.J. 1988. A Comparison of Channel Erosion in Small Urban and Rural Catchments, Armidale, New South Wales. *Earth Surface Processes and Landforms.* 13:1-7.

Whipple, W., J.M. DiLouie, and T. Pytlar. 1981. Erosional Potential of Streams in Urbanizing Areas. *Water Resources Bulletin*. 17(1):36-45.

Appendix B

Black River Watershed Bank Pin and Embeddedness Inspection Form

1. Date & Time________________________________2. Site #________________________

3. Your name____

4. Are any pins shifted from their original position (perpendicular to the bank)? If so, please list which pins have shifted, using the naming convention shown on the back side of this sheet.

____

5. Are any of the pins missing or loose? If so, please list which pins are missing or loose, using the naming convention shown on the back side of this sheet.

____

6. Measurements

- Bank Pins: There are two sets of pins at each site. Record measurements of the upstream set in the box below to the left. Record measurements of the downstream set in the box below to the right. (Place a washer over the dowel and push it toward the bank until it touches the bank but is oriented at 90° (see diagram on the back side of this sheet). Measure from the washer to the end of the bank pin, in millimeters.

- Embeddedness: Grasp and remove a few existing cobbles or bricks and estimate the average depth that they are buried in the sediment. Estimate embeddedness and circle the appropriate score in the box below.

Upstream

Pin Length (mm)	
L-1_______	R-1_______
L-2_______	R-2_______
L-3_______	R-3_______
L-4_______	R-4_______

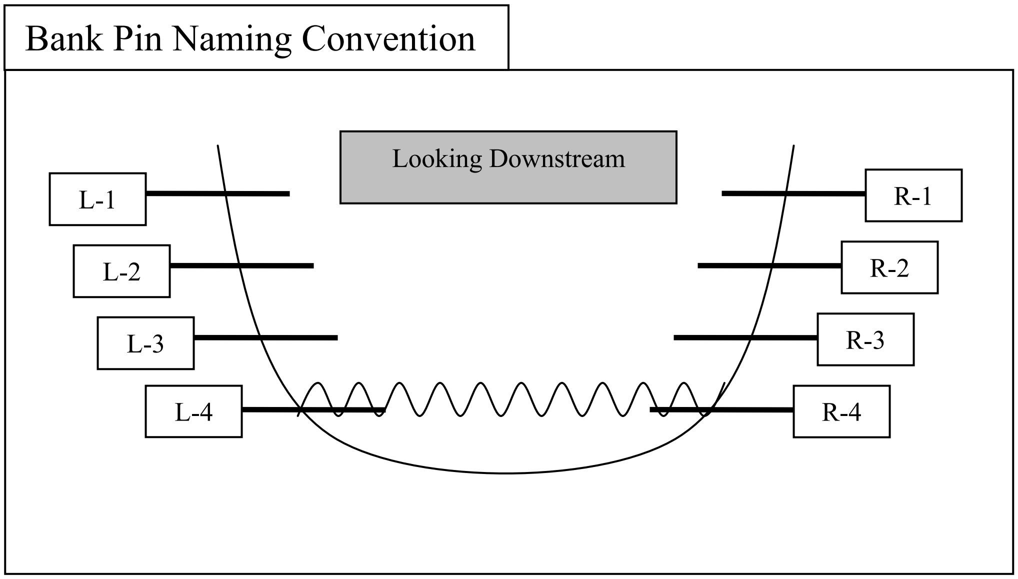
Downstream

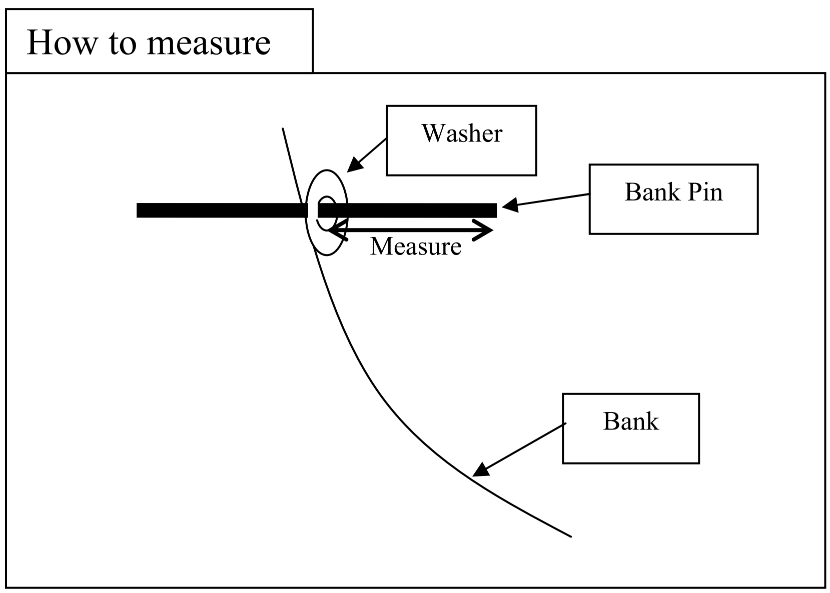
Pin Length (mm)	
L-1_______	R-1_______
L-2_______	R-2_______
L-3_______	R-3_______
L-4_______	R-4_______

Embeddedness

	Excellent	Good	Marginal	Poor
Embeddedness (Riffle/run stream)	Gravel, cobble and boulder particles (or bricks) are 0-25% surrounded by fine sediment.	Gravel, cobble and boulder particles (or bricks) are 25-50% surrounded by fine sediment	Gravel, cobble and boulder particles (or bricks) are 50-75% surrounded by fine sediment	Gravel, cobble and boulder particles (or bricks) are more than 75% surrounded by fine sediment
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Black River Watershed Bank Pin and Embeddedness Inspection Form





Return this form within 2 days of your measurement to:
Erin Fuller
Van Buren Conservation District
1035 E. Michigan Ave.
Paw Paw, MI 49079
Phone: (269) 675-4030 x5
Fax: (269) 675-4925
erin-fuller@mi.nacdnet.org

Appendix L: Build-Out Analysis and BMP analysis

Urban Build-Out Analysis for the Black River Watershed

Prepared for:
Southwest Michigan Planning Commission
185 East Main Street, Suite 701
Benton Harbor, MI 49022

Prepared by:
Kieser & Associates, LLC
536 E. Michigan Avenue, Suite 300
Kalamazoo, Michigan 49007

September 30, 2009

TABLE OF CONTENTS

1. Introduction 1

2. Build-out Modeling Methods 2
2.1 Base GIS Build-out Layer 2
2.2 Pollutant Load Calculations 5

3. Baseline Results 8
3.1 Urban Areas in the Black River Watershed 8
3.2 Baseline Pollutant Load and Runoff Results 10

4. Build-out Modeling Tool and Scenarios 15
4.1 Build-out Rules 15
4.2 Build-out Modeling Results 17

5. Conclusion 20

References 21

Appendix A: Pollutant loads and runoff volume per subwatershed 22
Appendix B: Pollutant loads and runoff volume per township 25

List of Tables

Table 1: Reclassification of IFMAP land use categories. 4
Table 2: Dates of Future Land Use maps used in the build-out analysis. 5
Table 3: Curve numbers selected for L-THIA modeling.......... 6
Table 4: Event mean concentrations for land use categories used in the build-out analysis. 7
Table 5: 2001 Land use breakdown (%) per 12-digit HUC subwatershed. 9
Table 6: Percentage of pollutant load and runoff volume per land use for the Black River Watershed. 10
Table 7: Future Land Use build-out rules defined by SWMPC. 16

List of Figures

Figure 1: L-THIA/Build-Out Non-Point Source Modeling Flow Chart. 3
Figure 2: Percentage of urban land use per 12-digit HUC subwatershed (based on 2001 IFMAP land use). ... 8
Figure 3: Sediment loading (lbs/ac/yr) per subwatershed. 11
Figure 4: Total phosphorus loading (lbs/ac/yr) per subwatershed. 11
Figure 5: Total nitrogen loading (lbs/ac/yr) per subwatershed. 12
Figure 6: Average annual runoff (in in/yr) per subwatershed. 12
Figure 7: Loads and runoff breakdown per land use per selected subwatershed. 14
Figure 8: Percentage change in TSS load per subwatershed under the 25% build-out scenario. 18
Figure 9: Percentage change in TP load per subwatershed under the 25% build-out scenario. 18
Figure 10: Percentage change in TN load per subwatershed under the 25% build-out scenario. 19
Figure 11: Percentage change in runoff volume per subwatershed under the 25% build-out scenario. 19

1. Introduction

Under contract to the Southwest Michigan Planning Commission, Kieser & Associates, LLC (K&A) has completed a "build-out" analysis for the Black River watershed. The Black River is a 10-digit HUC subwatershed in southwest Michigan. The build-out analysis provides an estimate of the impact of urban development on pollutant loads that is used to address the U.S. Environmental Protection Agency's nine-element requirements for watershed management plans. The build-out analysis for the Black River Watershed quantifies current and future pollutant loads and runoff volumes at different levels of build-out, highlighting areas that may become important for maintaining or improving water quality.

The Black River Watershed is predominantly agricultural with some large tracts of wetlands and protected forests. The main urban center is the City of South Haven, on Lake Michigan's shoreline in Van Buren County. Allegan County experienced a 7% population growth between 2000 and 2008 (US Census Bureau[1]), ten times the growth experienced by the entire State of Michigan. While most of the estimated non-point source pollution in the watershed is attributed to agricultural areas, it has been shown that urban areas in this area of the state contribute significantly to pollutant loadings (e.g., K&A, 2001; DeGraves, 2005). Where new development pressures exist, pollutant loads will increase unless policies are in place to mitigate the impacts of new development. In fact, two of the goals of the Black River Watershed Management Plan are: a) to reduce stormwater discharges as a means of reducing nutrient inputs to waterways, b) to improve land use policies and promote "smarth growth" to protect water quality (Fuller, 2005). Therefore, understanding and quantifying the impact of future urban development on water quality is key to developing adequate land use management plans that meet watershed management goals.

This analysis assesses the impact of zoning and future land use management on runoff volume and pollutant loads in the Black River Watershed. A simple empirical approach, similar to the one used by K&A in the St Joseph Watershed Management Plan (DeGraves, 2005) and in the Paw Paw River Watershed Management Plan (SWMPC, 2008), was used to calculate current and future runoff volumes and non-point source pollutant loads. Pollutant loads and runoff volumes were calculated using average annual runoff depth values calculated by the Long-term Hydrologic Impact Assessment model (L-THIA), and appropriate pollutant event mean concentration values from recognized citation sources. Four hypothetical scenarios, simulating urban build-out at a rate of 25, 50, 75 and 100% were defined to estimate the impact of urban development on water quality and quantity. Results are reported in this document.

[1] http://quickfacts.census.gov/qfd/states/26/26159.html

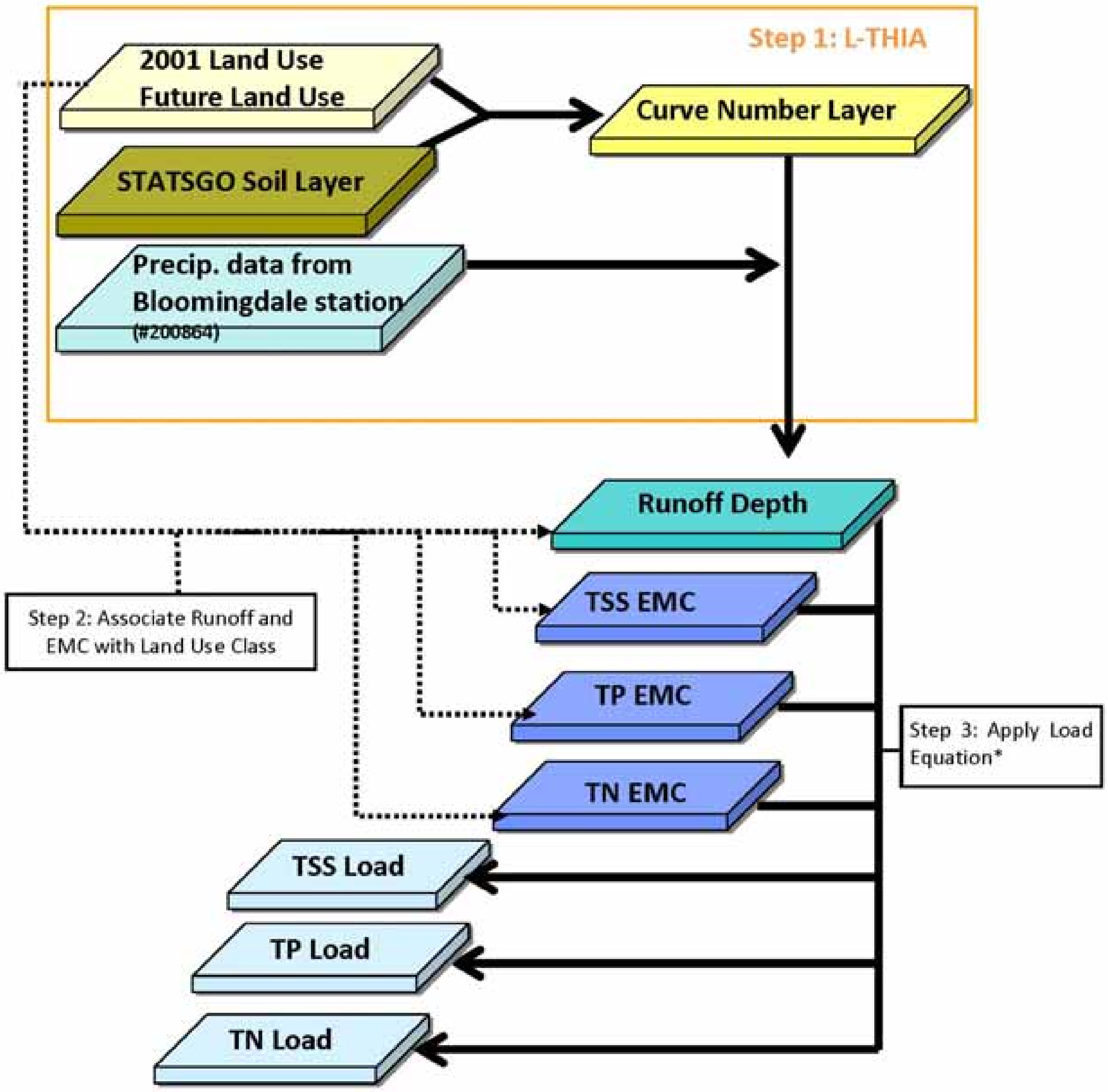
2. Build-out Modeling Methods

The build-out analysis and methodology is similar to the one conducted by K&A for the Paw Paw River Watershed Management Plan[2]. The build-out model developed for the Black River Watershed uses the same data sources used in the Paw Paw River WMP in order to provide consistency in results for the southwest Michigan region.

2.1 Base GIS Build-out Layer

The build-out analysis is based on the development of a complex GIS layer where multiple data layers (land use, soils, political boundaries, etc.) are overlaid and each unique record (i.e., polygon) is assigned individual runoff and event mean concentration values as well as specific management characteristics. The conceptual design is presented in Figure 1.

[2] http://www.swmpc.org/downloads/pprw_buildout_report.pdf



*Runoff Depth (in/yr) x EMC (mg/L) x 0.2266 x polygon area = total annual load (lbs)

Figure 1: L-THIA/Build-Out Non-Point Source Modeling Flow Chart.

3 | Kieser & Associates, LLC
Black River Watershed Build-Out Analysis Report

The following layers were used to create the base GIS build-out layer:

- 2001 IPFMAP land use: the 2001 IFMAP land use/land cover layer[3] was reclassified into nine broad categories to match, as much as feasible, land use categories with known event mean concentration values and land use categories available in L-THIA (Table 1).
- STATSGO soil layer: The STATSGO soil data layer[4] provided information on the hydrologic soil group for each soil type.
- 12-digit hydrologic unit code (HUC) subwatershed.
- Municipalities.

Table 1: Reclassification of IFMAP land use categories.

2001 IFMAP Classification		*Reclassified Values*	
Land Use Value	Land Use Category	*Reclassified Value*	*Reclassified Description*
1	Low intensity urban	1	Low density urban
2	High intensity urban	2	High density urban
4	Road/parking lot	3	Transportation
5	Non-vegetated farmland	4	Agriculture
6	Row crops	4	Agriculture
7	Forage crops/non-tilled herbaceous agriculture	4	Agriculture
9	Orchard/vineyard/nursery	4	Agriculture
10	Herbaceous openland	5	Rural open
12	Upland shrub/low density trees	5	Rural open
13	Parks/golf courses	6	Urban open
14	Northern hardwood association	7	Forest
15	Oak association	7	Forest
16	Aspen association	7	Forest
17	Other upland deciduous	7	Forest
18	Mixed upland deciduous	7	Forest
19	Pines	7	Forest
20	Other upland conifers	7	Forest
22	Upland mixed forest	7	Forest
23	Water	8	Water
24	Lowland deciduous forest	9	Wetlands
25	Lowland coniferous forest	9	Wetlands
26	Lowland mixed forest	9	Wetlands
27	Floating aquatic	9	Wetlands
28	Lowland shrub	9	Wetlands
29	Emergent wetland	9	Wetlands
30	Mixed non-forest wetland	9	Wetlands
31	Sand/soil	5	Rural open
35	Other bare/sparsely vegetated	5	Rural open

[3] Available from the Michigan Geographic Data Library at http://www.mcgi.state.mi.us/mgdl/
[4] Downloaded from the USDA NRCS Soil Data Mart at: http://soildatamart.nrcs.usda.gov/USDGSM.aspx

The Southwest Michigan Planning Commission (SWMPC) provided the following layers:

- 'No Change Layer' with protected/permanent features: Quarter-quarter sections within the proposed Allegan State Game Area that are more than 75% owned by the State of Michigan; conservation and recreation lands; and Southwest Michigan Land Conservancy protected areas.
- 'Intermediate Layer' with MDEQ regulated wetlands,
- 'Future Land Use' layer with generalized future land use categories for several municipalities within the watershed (see Table 2) based on future land use maps and plans.

Table 2: Dates of Future Land Use maps used in the build-out analysis.

Municipality	Master Plan Future Land Use Map Date
Arlington Twp	Land Use Plan, March 2009
City of Bangor	City of Bangor Community Park, Recreation, Open Space, and Greenway Plan - 2008-2013*
Bangor Twp	Master Plan 2001
Bloomingdale Twp (see note)	No Plan Available
Casco Twp	Casco Township Master Plan 2004
Cheshire Twp (see note)	No Plan Available
Clyde Twp	Land Use Plan Update/Amendment, March 2005
Columbia Twp	Columbia Township Master Plan 2002
Covert Twp	Future Land Use Plan, 2007
Ganges Twp	Ganges Township Land Use Plan 2006
Geneva Twp (see note)	No Plan Available
Lee Twp (see note)	No Plan Available
City of South Haven	Comprehensive Plan 2003
South Haven Twp	Master Plan for Land Use 2008
Waverly Twp	Future Land Use Plan, 2001-2006

* No future land use map was available. A generalized zoning map was used instead.
Note: As a zoning master plan was not available for those townships, a general "rural residential" future land use category was used in the analysis.

All layers (in shapefile format) were overlaid and processed through ESRI ArcGIS 9.3® to create one complex GIS layer with an extensive attribute table, including fields for current and future land use category, soil type and hydrologic soil group, subwatershed and township name, regulated wetlands or "no change" classification.

2.2 Pollutant Load Calculations

Both land use and soil layers were processed using the L-THIA GIS ArcView® extension to calculate runoff depth. L-THIA is a simple rainfall-runoff model developed by Purdue University[5]. It uses the SCS (Soil Conservation Service, now NRCS) Curve Number method and long-term precipitation data to calculate

[5] For more information, visit L-THIA website at:
http://www.ecn.purdue.edu/runoff/lthianew/Index.html

average annual runoff depths for each unique combination of soil and land use. Standard curve numbers from the TR-55 Manual were selected for each land use based on land use definition and imperviousness (Table 3).

Table 3: Curve numbers selected for L-THIA modeling.

	Curve Number for Hydrologic Soil Group			
Land Use Category	**A**	**B**	**C**	**D**
Agricultural	64	75	82	85
Forest	30	55	70	77
Rural Open	39	61	74	80
Urban Open	49	69	79	84
Transportation/Highways	89	92	94	95
Commercial	89	92	94	95
Industrial	81	88	91	93
Low Density Residential	54	70	80	85
Medium Density Residential	61	75	83	87
High Density Residential	77	85	90	92

The Rouge River National Wet Weather Demonstration Project conducted an extensive assessment of stormwater pollutant loading factors per land use class (Cave et al., 1994) and recommended event mean concentration (EMC) values for 10 broad land use classes (Table 4). These EMC values have since been incorporated into the Michigan Trading Rules (Part 30) to calculate pollutant loads from urban stormwater nonpoint sources. Runoff depth calculated through L-THIA, and event mean concentration values presented in Table 4, were added as attributes to the build-out layer and used to calculate current and future pollutant loads.

Pollutant loads were calculated using the simple equation:

$$EMC_L \times R_L \times A_L \times 0.2266 = L_L$$

Runoff volume was calculated as follows:

$$R_L \times A_L \times 0.0833 = R_v$$

Where:

EMC_L =	Event mean concentration for land use L in mg/L (Table 4).
R_L =	Runoff per land use L from L-THIA in inches/year.
A_L =	Area of land use L in acres.
0.2266 =	Unit conversion factor.
L_L =	Annual load per land use L in lbs/yr.
R_v =	Runoff volume in acre-feet/yr.

Table 4: Event mean concentrations for land use categories used in the build-out analysis.

Original Land Use Category (Rouge River)	2001 Reclassified Land Use Category	Future Land Use Category	Percent Impervious	TSS (mg/L)	TP (mg/L)	TN (mg/L)
Forest/rural open	Forest/rural open	N/a	0.5% (1)	51	0.11	1.74
Urban open	Urban open	Urban open	0.5%	51	0.11	1.74
Agricultural	Agricultural	Agricultural	3% (2)	145	0.37	5.98
Low density residential	Low density urban	Low density residential	10%	70 (3)	0.52 (3)	5.15 (3)
N/a	N/a	Rural residential (4)	varies	varies	varies	varies
Medium density residential	N/a	Medium density residential	30%	70	0.52	5.15
N/a	High density urban (5)	N/a	85%	120 (5)	0.31 (5)	3.54 (5)
High density residential	N/a	High density residential	85% (6)	97	0.24	3.29
Commercial	N/a	Commercial	90%	77	0.33	2.97
Industrial	N/a	Industrial	80%	149	0.32	3.97
Highways	Transportation	Highways	90%	141	0.43	2.65
Water/ wetlands	Water and Wetlands	Water/ Wetlands	0%	6	0.08	1.38

N/a: not applicable

Notes:

(1) Imperviousness for forest/rural open is considered similar to the Urban Open category value as it includes forested/open space areas where roads have been assigned to the Highways category.

(2) This value is based on density of farm roads, field access roads and farmsteads in the agricultural land use category.

(3) Low density residential category values will be applied to smaller parcel single family dwellings of less than two acres in size.

(4) This category includes parcels greater than 2 acres. The EMC value for Low Density Residential will be used to calculate the loading and runoff for 33% of the area of these polygons (corresponding to the homestead and associated acreage developed). The loading and runoff for the remaining 67% should be calculated using the EMC value of the current land cover (IFMAP) category in the polygon. If more than one IFMAP land cover type exists in the polygon, a proportion of the land cover categories equal to the original should be used to calculate the remaining 67% of the polygon.

(5) This land use was defined as 60% industrial, 25% commercial and 15% high density residential in the Paw Paw River Watershed. This ratio was determined by comparing areas identified in IFMAP as High Intensity Urban to 2003 and 2005 digital ortho-photographs and the 1978 MIRIS Land Use dataset. Event mean concentration values were re-calculated by weighting High Density Urban land use area using the above ratio.

(6) The High Density Residential land use range nationwide is from 50–100 percent imperviousness: the land use category determined from the Rouge River study defined it as high-rise apartment and condominium buildings that are four or more stories in height. These structures when combined with adequate parking reflect commercial or industrial land use category values.

3. Baseline Results

The 2001 IFMAP land use map was used as the baseline to calculate current runoff volume and pollutant load conditions in the Black River Watershed for 'current' conditions.

3.1 Urban Areas in the Black River Watershed

Figure 2 shows that only one out of 18 subwatersheds may be considered urban, with urban land use being greater than 10% of the area. This subwatershed, located at the mouth of the Black River, is 43% urban and mainly includes the City of South Haven and neighboring areas. The subwatershed (-0203) located to the north of the South Haven, along the Highway US-31, could be classified as urbanizing with about 9% of the land area in urban land use (including a large urban open area). The remaining land area in the watershed is mainly agricultural, with large tracts of forests and wetlands (including part of the Allegan State Forest in the north-west). The 2001 land use breakdown by subwatershed is shown in Table 5.

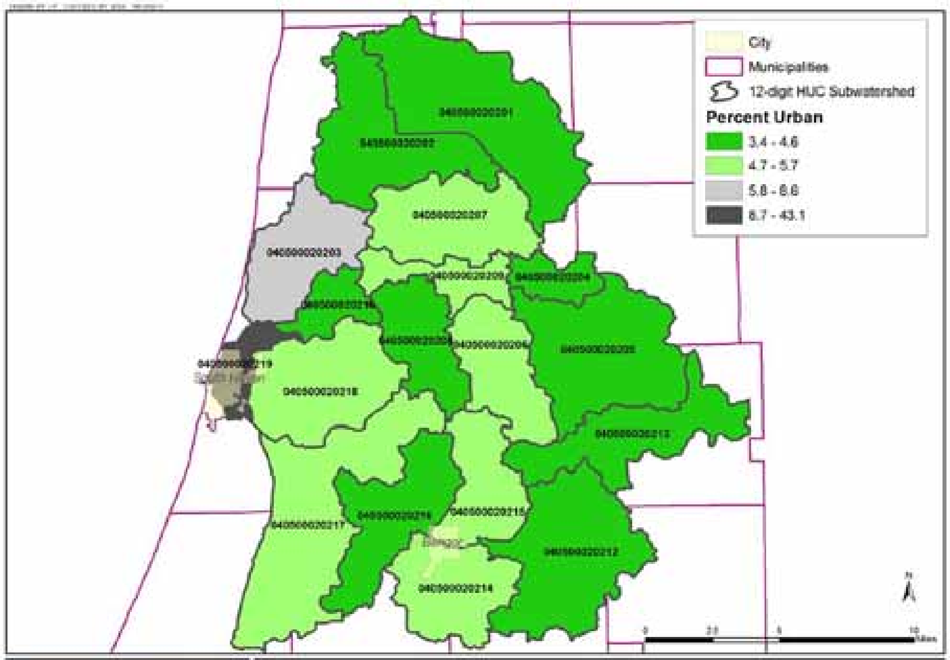


Figure 2: Percentage of urban land use per 12-digit HUC subwatershed (based on 2001 IFMAP land use).

Table 5: 2001 Land use breakdown (%) per 12-digit HUC subwatershed.

Subwatershed Name	12-Digit HUC	Low Density Urban	High Density Urban	Transport.	Agriculture	Rural Open	Urban Open	Forest	Water	Wetlands	*Total urban*
Black River Drain above Beaver Dam Drain	40500020201	0.9	0.5	2.0	34.3	11.8	0.0	26.5	2.3	21.7	3.4
Black River Drain at 111th Avenue	40500020202	1.1	0.4	2.5	63.5	9.7	0.0	14.9	0.1	7.6	4.0
North Branch Black River above Middle Branch Black River	40500020203	1.7	0.5	4.7	61.8	7.6	1.7	13.7	0.0	8.3	8.6
Spring Brook at mouth	40500020204	0.6	0.1	2.8	25.3	17.2	0.0	32.3	0.3	21.4	3.5
North Branch Black River at Spring Brook	40500020205	1.0	0.1	2.9	36.6	12.5	0.0	24.1	2.2	20.6	3.9
Barber Creek at mouth	40500020206	1.5	0.3	3.4	27.0	15.2	0.0	27.0	4.4	21.3	5.2
Scott Creek Drain at mouth	40500020207	1.4	0.3	3.2	27.4	16.9	0.0	31.8	1.8	17.3	4.8
Spicebrush Creek at mouth	40500020208	0.9	0.1	3.4	51.5	13.6	0.0	17.5	0.0	13.0	4.4
Middle Branch Black River at Spicebush Creek	40500020209	1.0	0.2	3.5	35.7	16.3	0.0	22.6	0.0	20.6	4.7
Middle Branch Black River at mouth	40500020210	1.1	0.2	2.8	46.9	13.3	0.0	20.5	0.0	15.2	4.1
Black River Extension Drain at mouth	40500020212	1.0	0.1	3.0	37.9	13.5	0.0	24.2	1.7	18.7	4.1
Great Bear Lake Drain at mouth	40500020213	1.2	0.3	3.1	36.1	12.2	0.0	23.6	2.8	20.8	4.6
Maple Creek at mouth	40500020214	1.3	0.4	3.9	50.9	11.1	0.0	20.9	0.0	11.4	5.6
South Branch Black River at Maple Creek	40500020215	1.5	0.4	3.5	39.8	15.3	0.0	22.8	0.6	16.1	5.4
South Branch Black River at gauge #04102700	40500020216	1.0	0.3	3.0	49.2	11.8	0.0	18.9	0.3	15.6	4.3
South Branch Black River at Cedar Creek	40500020217	1.4	0.2	3.7	47.0	14.0	0.0	19.7	0.0	14.0	5.3
South Branch Black River at mouth	40500020218	1.8	0.4	3.4	54.2	11.2	0.0	17.3	0.0	11.6	5.7
Black River at mouth	40500020219	15.1	10.0	17.9	15.4	13.3	0.0	20.5	0.8	7.0	43.1
	Total	*1.5*	*0.5*	*3.4*	*42.8*	*12.8*	*0.1*	*22.0*	*1.1*	*16.0*	*100.0*

3.2 Baseline Pollutant Load and Runoff Results

Pollutant loads for Total Phosphorus (TP), Total Nitrogen (TN), Total Suspended Sediment (TSS) and runoff volume per land use were calculated for the Black River Watershed under current conditions (i.e., 2001 land use). Modeling results (Table 6) show that, while agriculture remains the largest non-point source of pollutants within the Black River Watershed, urban land uses contribute over 25% of the total pollutant load although they occupy only 5% of the land area (Table 5).

Table 6: Percentage of pollutant load and runoff volume per land use for the Black River Watershed.

	% of total load/volume			
Land Use Category	**TSS**	**TP**	**TN**	**Runoff**
Agriculture	65.6	62.0	77.2	58.4
Forest	3.1	2.5	3.0	7.9
High density urban	1.8	1.7	1.5	1.9
Low density urban	0.9	2.4	1.8	1.6
Transportation	26.0	29.4	14.0	23.8
Urban Open	0.0	0.0	0.0	0.0
Rural open	2.5	2.0	2.5	6.4
Water	0.0	0.0	0.0	0.0
Wetlands	0.0	0.0	0.0	0.0

Total runoff volumes and pollutant loads were also calculated for each subwatershed within the Black River for these parameters. All values are presented in Appendix A. Figures 3 to 6 present TSS, TP and TN baseline loadings, and average annual runoff per subwatershed. The highest loading subwatershed (-0219) for all pollutants is consistently the urban subwatershed at the mouth of the Black River. The subwatersheds (-0214, -0216) to the south and west of the City of Bangor have the second highest loading values. This area is mainly agricultural, and located on clay soils with moderately high runoff potential (see Figure 7 for further analysis).

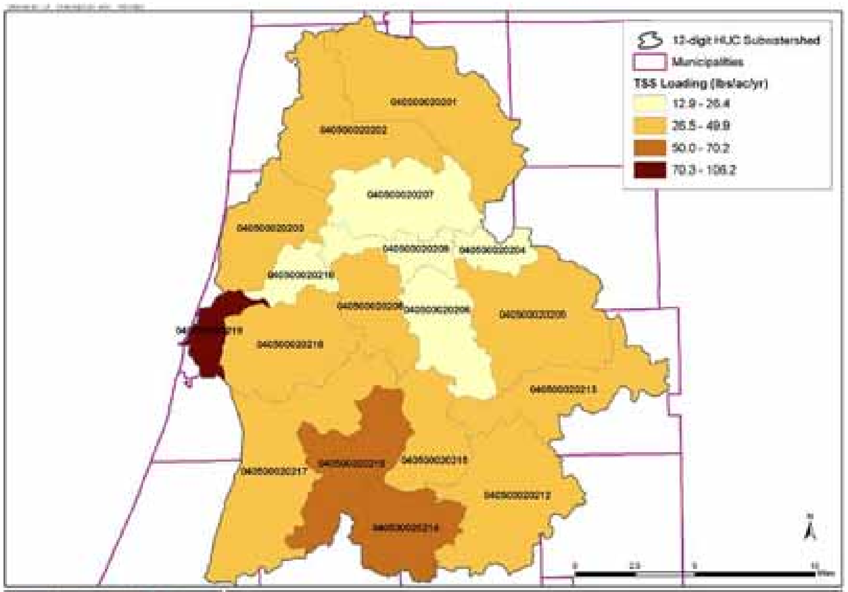


Figure 3: Sediment loading (lbs/ac/yr) per subwatershed.

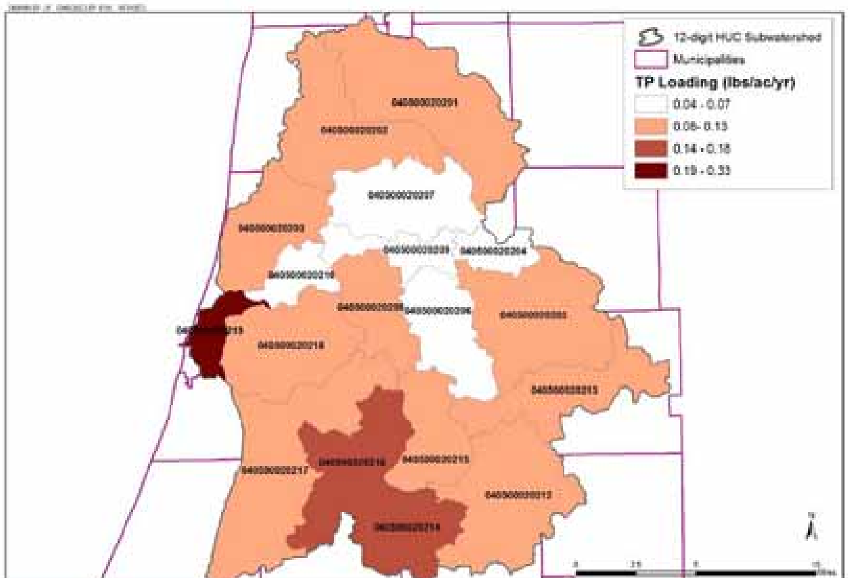
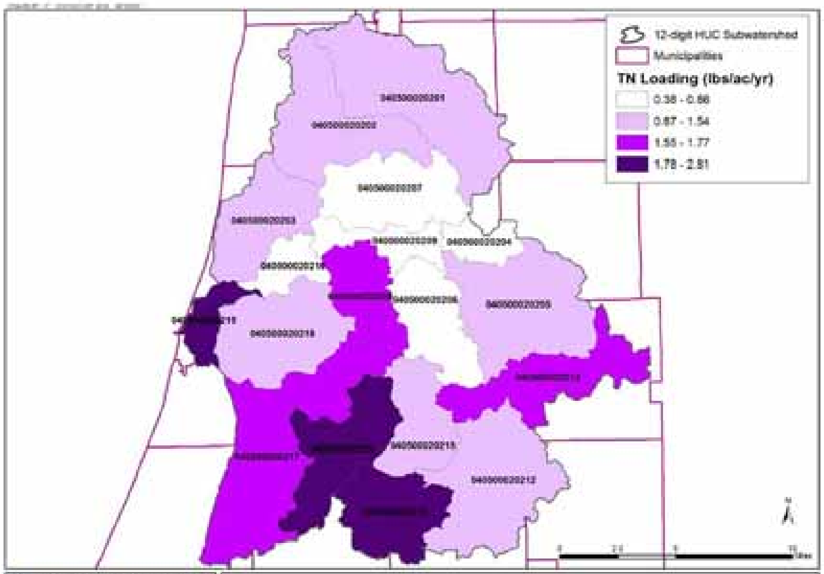
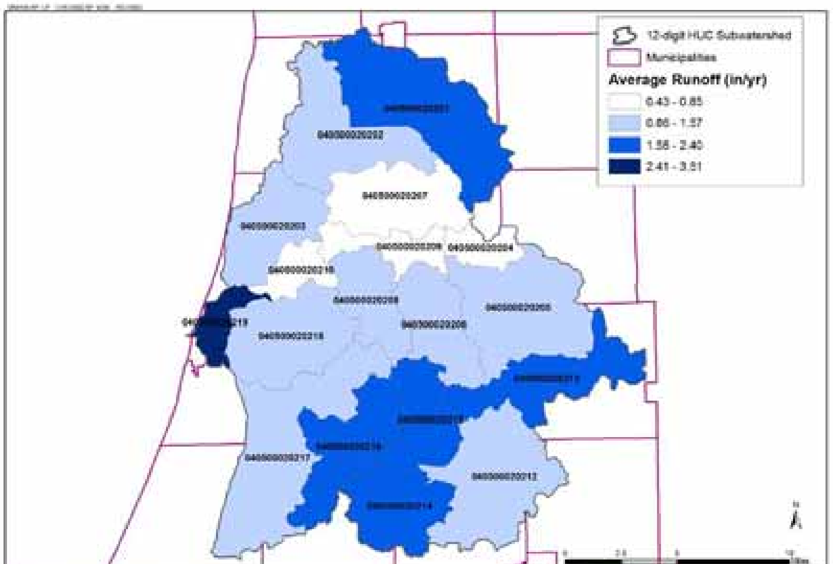


Figure 4: Total phosphorus loading (lbs/ac/yr) per subwatershed.



KIESER & ASSOCIATES

Figure 5: Total nitrogen loading (lbs/ac/yr) per subwatershed.



KIESER & ASSOCIATES

Figure 6: Average annual runoff (in in/yr) per subwatershed.

Figure 7 shows the distribution of pollutant loading and runoff volumes per land use category for the three highest loading subwatersheds in the Black River Watershed. In the South Haven subwatershed, over 80% of the pollutant load and runoff come from urban land uses (in particular, transportation). In the Bangor area subwatersheds, agriculture is the main contributor of pollutants and runoff. However, urban land uses contribute disproportionately high loads of TSS, TP and runoff when compared to the fraction of the area they occupy (similar to the Black River Watershed analysis presented in Table 6 above). For instance, in the Bangor subwatershed, urban areas contribute about 25% of the TP load while they only represent about 6% of the total acreage.

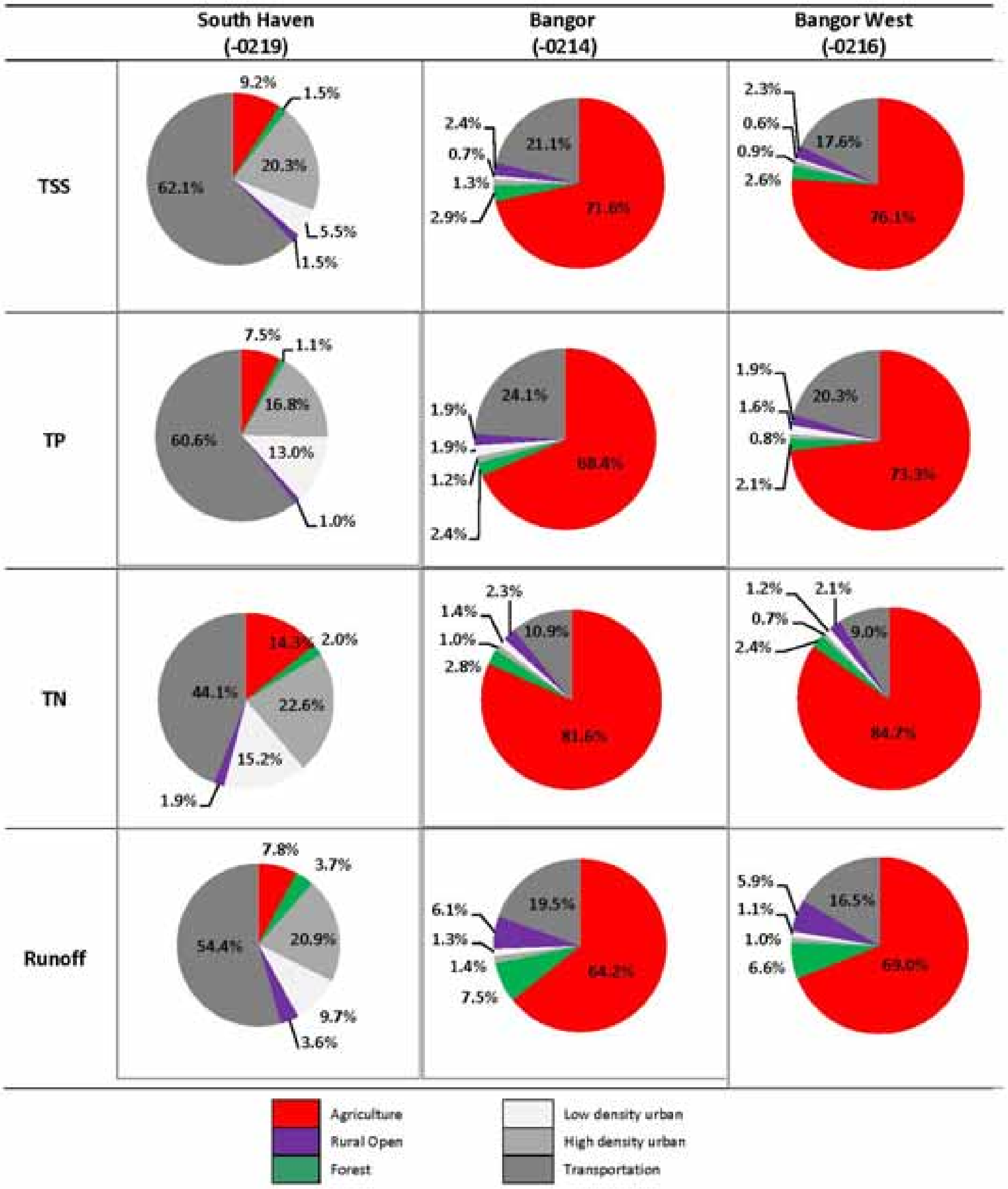


Figure 7: Loads and runoff breakdown per land use per selected subwatershed.

Total loads and runoff volumes for baseline conditions were also calculated for each township in the Black River Watershed. They are presented in Appendix B.

4. Build-out Modeling Tool and Scenarios

This section discusses the approach used for creating build-out scenarios that are compared to the 'current' loads associated with the 2001 land cover data.

4.1 Build-out Rules

The build-out analysis for the Black River was based on detailed Future Land Use maps compiled by SWMPC from township masterplans where available. Four build-out scenarios were defined to simulate increasing rates of urban development (25%, 50%, 75% and 100%) and were based on the zoned land use category (called Future Land Use). Within each scenario, SWMPC specified rules based on current and future land uses that either: allowed, prohibited or limited development, as described below and in Table 7.

Build-out rules narrative

For each build-out scenario, and within a defined polygon (subwatershed, township, village, etc.):

- The following land uses cannot be altered in the built-out: water, protected lands, utility easements, cemeteries.
- Regulated wetlands will be built out at a lower rate than the scenario's rate (as defined by SWMPC – see Table 7).
- When two rules apply to a defined polygon (e.g., Rural Residential or Agricultural Future Land Use within a regulated wetland), the build-out rates will be compounded. For instance, under the 25% build-out scenario, the final build-out rate for Agricultural Future Land Use within a regulated wetland will be calculated as follows: 6.25% (wetland rate) x 6.25% (agricultural rate) = 0.0039% (final build-out rate).
- Build-out change (for instance, increase in low density residential) will be applied to each individual polygon in the build-out GIS layer (note: each polygon contains one land use and one future land use category). The total area changed will correspond to 25%, 50%, 75%, and 100% of the area of Future Land Use polygons.
- Build-out can only occur from a non-urban or lower urban category to a higher urban category (see classes and rules in Table 7). For instance, highways or high density residential cannot be changed to low density residential, but low density residential can be changed to high density residential.

Table 7: Future Land Use build-out rules defined by SWMPC.

Class		Scenario 1	Scenario 2	Scenario 3	Complete Build Out
	NO CHANGE LAYER: Hydro, SWMPC Protected Lands, Cemeteries, Utility Easements	**25.00%**	**50.00%**	**75.00%**	
	Water	100% IFMAP	100% IFMAP	100% IFMAP	100% IFMAP
	Protected Lands	100% IFMAP	100% IFMAP	100% IFMAP	100% IFMAP
	Utility Easements	100% IFMAP	100% IFMAP	100% IFMAP	100% IFMAP
	Cemeteries	100% IFMAP	100% IFMAP	100% IFMAP	100% IFMAP
	INTERMEDIATE LAYER:				
	Regulated Wetlands	6.25% FLU; 93.75% IFMAP	12.5% FLU; 87.5% IFMAP	18.75% FLU; 81.25% IFMAP	25% FLU; 75% IFMAP
Class	**FUTURE LAND USE (FLU)**				
1	Urban Open	25% Urban Open; 75% IFMAP	50% Urban Open; 50% IFMAP	75% Urban Open; 25% IFMAP	100% Urban Open
1	Agricultural	6.25% LD Res; 93.75% IFMAP	12.5% LD Res; 87.5% IFMAP	18.75% LD Res; 81.25% IFMAP	25% LD Res; 75% IFMAP
1	Rural Res	8.25% LD Res; 91.75% IFMAP	16.5% LD Res; 83.5% IFMAP	24.75% LD Res; 75.25% IFMAP	33% LD Res; 67% IFMAP
2	Low Density Residential	25% LD Res; 75% IFMAP	50% LD Res; 50% IFMAP	75% LD Res; 25% IFMAP	100% LD Residential
2	Medium Density Residential	25% MD Res; 75% IFMAP	50% MD Res; 50% IFMAP	75% MD Res; 25% IFMAP	100% MD Residential
2	High Density Residential	25% HD Res; 75% IFMAP	50% HD Res; 50% IFMAP	75% HD Res; 25% IFMAP	100% HD Residential
2	Commercial	25% Commercial; 75% IFMAP	50% Commercial; 50% IFMAP	75% Commercial;25% IFMAP	100% Commercial
2	Industrial	25% Industrial; 75% IFMAP	50% Industrial; 50% IFMAP	75% Industrial; 25% IFMAP	100% Industrial
2	Highways	25% Highways; 75% IFMAP	50% Highways; 50% IFMAP	75% Highways; 25% IFMAP	100% Highways
2	Transportation Corridor	100% IFMAP	100% IFMAP	100% IFMAP	100% IFMAP

Class	**IFMAP LAND COVER**
1	Water/Wetlands
1	Forest/Rural Open
1	Urban Open/Parks
1	Agricultural
2	Low Intensity Urban
3	High Intensity Urban
3	Transportation/Highways

RULES (apply in ALL scenarios):

When NO CHANGE LAYER features are present, loading values are based on IFMAP land cover.
When INTERMEDIATE LAYER features are present, build-out occurs at rates specified above.
When FLU is Class 1 and IFMAP land cover Class is >= 2, loading values are based on IFMAP land cover.
When IFMAP land cover is Class 3 loading values are based on IFMAP land cover.

4.2 *Build-out Modeling Results*

The build-out load and runoff calculations for the 25, 50, 75, and 100% scenarios were conducted using a Visual Basic (VBA) code within the GIS environment. The VBA code was used to calculate the acreage of future and current land use for each record[6] in the build-out layer, under a defined scenario and according to the rules defined in Table 7. Once the acreage was known, total runoff volume and loads were calculated for each record using the equations presented in section 2.2 above and the GIS field calculator function.

For each scenario, six fields were created in the attribute table of the GIS build-out layer:

- New land use acreage under scenario xx% (e.g. 25%) (N_ACRES_xx)
- Remaining land use acreage (R_ACRES_xx)
- New TP, TN and TSS loads (Fxx_TPLD, Fxx_TNLD, Fxx_TSSLD)
- New runoff volume (ROV_xx)

Total pollutant load and runoff results per 12-digit HUC subwatershed are presented in Appendix A. The 25% build-out scenario was chosen to illustrate the impact of urban development on runoff and pollutant loads. Figures 8 to 11 present the percentage change in runoff volume and pollutant loads for the 25% build-out scenario compared to the baseline.

The figures below clearly highlight two areas in the watershed that will experience a significant increase in nutrient and sediment loads as well as runoff volume if urban areas increased by 25%:

- The South Haven subwatershed, with neighboring subwatersheds to the east and north; and
- The area to the north of Bangor, including the village of Breedsville and Saddle Lake.

Under the 25% scenario, TP load for the entire watershed would increase by 7%, TN load by 3% and runoff volume by 4%. The total increase in sediment load is not significant as increases in some watersheds are cancelled by decreases in others.

Overall, most subwatersheds would experience some varying amount of increase in loading and runoff volume. Only one watershed (-0210) does not experience increases in loads or runoff. This subwatershed is entirely zoned as "agricultural". Therefore, it will not only experience a lower rate of development but lower runoff and loads as the "agricultural" category is defined using a proportion of low density residential land use (this land use has a lower curve number than agriculture).

Total pollutant load and runoff results for the build-out analysis were also calculated per township. These results are provided in Appendix B.

---

[6] As explained in section 2 above, each record only contains one current and one future land use category as well as specific information as to whether it falls within a regulated wetland or a "no change" area.

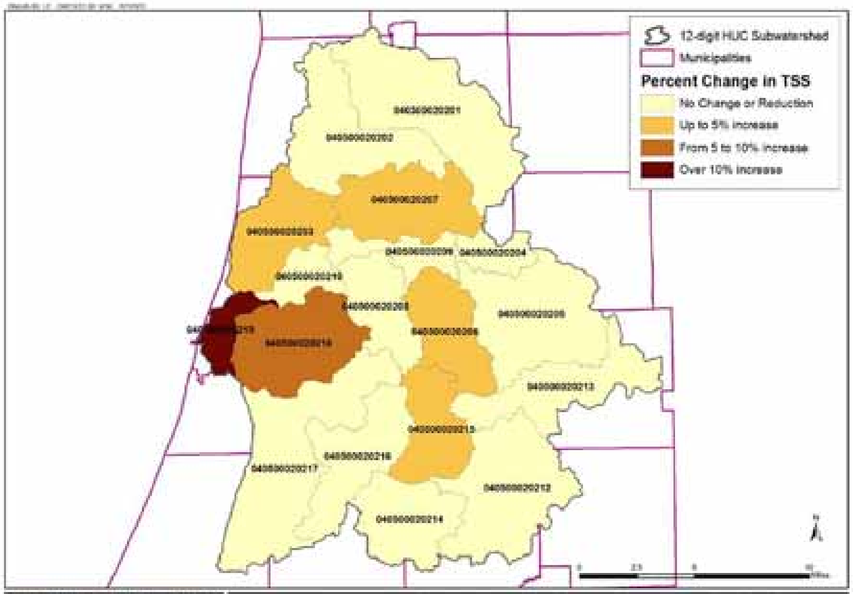


Figure 8: Percentage change in TSS load per subwatershed under the 25% build-out scenario.

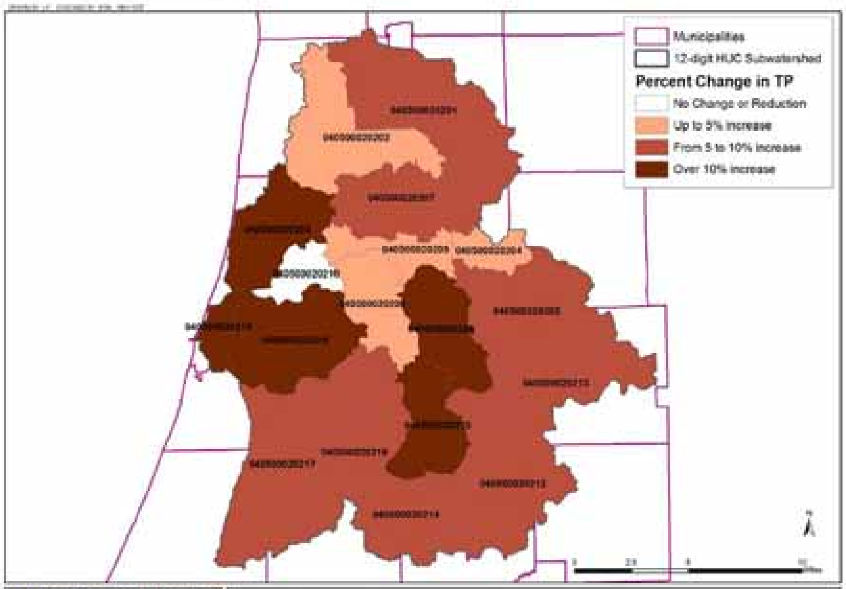


Figure 9: Percentage change in TP load per subwatershed under the 25% build-out scenario.

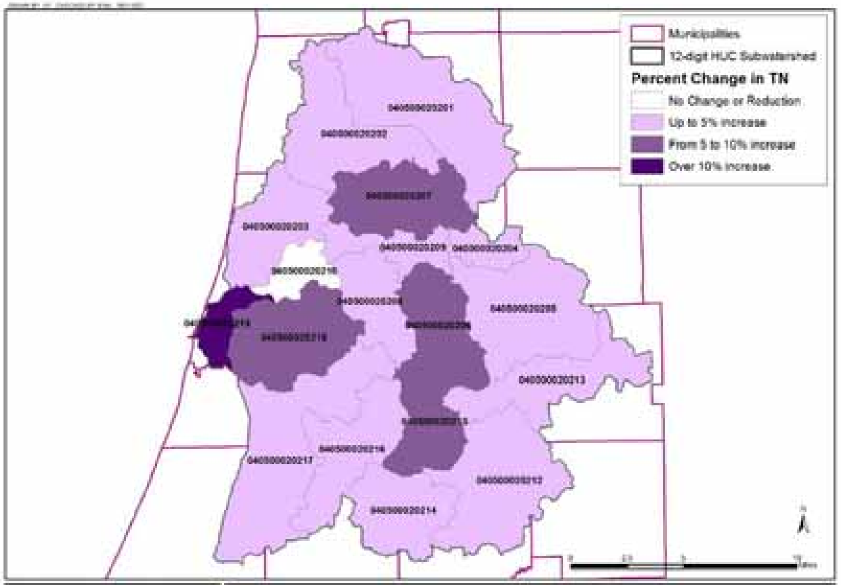


Figure 10: Percentage change in TN load per subwatershed under the 25% build-out scenario.

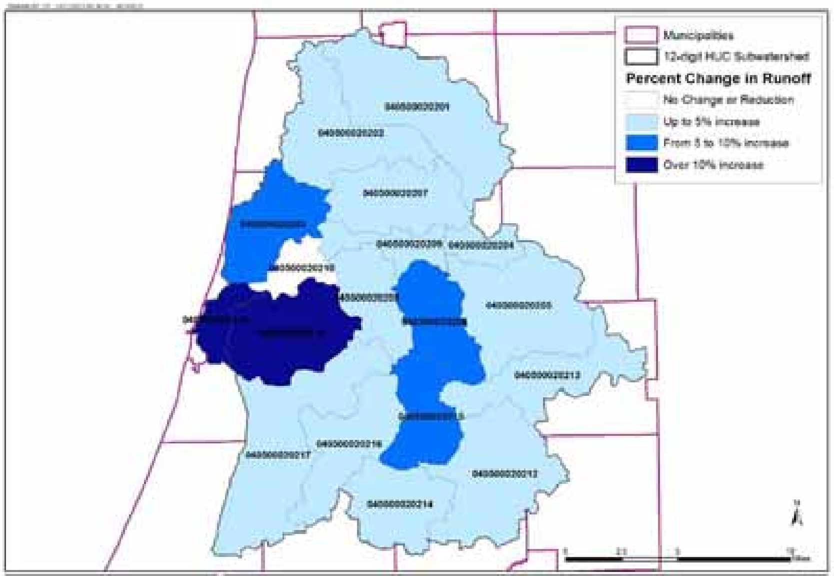


Figure 11: Percentage change in runoff volume per subwatershed under the 25% build-out scenario.

5. Conclusions

Using a runoff model (L-THIA) and pollutant event mean concentrations, a GIS build-out layer was developed to allow analysis of land use development and its impact on water quality within the Black River Watershed. The urban analysis results indicate that the City of South Haven currently has the highest pollutant loading per acre and the highest average annual runoff. However, two agricultural subwatersheds near the City of Bangor also rank high for pollutant loading and runoff. These subwatersheds have higher loading results almost certainly due to the low rates of infiltration in the subwatersheds' clay soils. Urban stormwater runoff is the largest non-point source of nutrient and sediment loads in the South Haven subwatershed, and contributes about 20% of the pollutant load and runoff in the two agricultural subwatersheds. Although agriculture currently is the largest non-point source of pollutants and runoff in the Black River Watershed, urban land use contributes over 25% of the total pollutant load and runoff.

The analysis of a hypothetical 25% build-out scenario showed that, in addition to the South Haven subwatershed, several subwatersheds currently not urbanized would experience a significant increase in pollutant loads and runoff volume. One subwatershed, located directly east of South Haven, will likely develop because of its proximity to the City. The two other subwatersheds, located north of the City of Bangor, may experience urban development because of the presence of recreational opportunities (Saddle Lake, Kal-Haven Trail) and expansion of the Village of Breedsville. Results from this scenario clearly emphasize the increasing importance of urban stormwater as a non-point source of pollution.

In conclusion, preserving water quality in the Black River Watershed will require the implementation of practices and regulations addressing both agricultural and urban land uses such as: agricultural best management practices, stormwater best management practices and ordinances promoting infiltration, retention, reduction in impervious surfaces; zoning regulations promoting mixed land uses and smart growth.

Results presented in this report are not intended to present an absolute or inerrant representation of the current and future situation in the Black River Watershed. They are instead meant to be used as estimates to guide the development and implementation of the watershed management plan. These results can be reliably used to inform discussions and decisions by local units of government and watershed managers regarding zoning and land use management needs.

Note: A separate, easy-to-use, load calculator and BMP tool and documentation have also been provided to the Southwest Michigan Planning Commission as a part of this project to help estimate changes in loads from land use management policies and the cost-efficiency of several commonly used stormwater BMPs.

References

Cave, K., Quasebarth, T., and Harold, E. 1994. *Technical Memorandum: Selection of Stormwater Pollutant Loading Factors. Rouge River National Wet Weather Demonstration Project RPO-MOD-TM 34.00.* Available at: http://rougeriver.com/proddata/modeling.html#MOD-TM34.00

DeGraves, A. 2005. St. Joseph River Watershed Management Plan. Friends of the St Joe River Association. Available at: http://www.stjoeriver.net/wmp/wmp.htm

Engel, Bernard. 2005. *L-THIA NPS Manual, version 2.3.* Purdue University and US Environmental Protection Agency. Available at:
http://www.ecn.purdue.edu/runoff/lthia/gis/lthia_gis_users_manual_ver23.pdf

Fuller, Erin. 2005. Black River Watershed Management Plan. Available at:
http://vbco.org/downloads/mgmtplan_draft3_1.pdf

Huff, F. A. and J. R. Angel. 1992. *Rainfall Frequency Atlas of the Midwest.* Illinois State Water Survey, Champaign, Bulletin 71.

Kieser & Associates. 2001. *Non-point Source Modeling of Phosphorus Loads in the Kalamazoo River/Lake Allegan Watershed for a Total Maximum Daily Load.* Prepared for the Kalamazoo Conservation District. Available at: http://kalamazooriver.net/tmdl/docs/Final%20Report.pdf

Kieser & Associates. 2003. *Empirical Sediment and Phosphorus Nonpoint Source Model for the St. Joseph River Watershed.* A report for the Section 319 Watershed Management Planning Grant. Available at: http://www.stjoeriver.net/wmp/docs/nps_model_report.PDF.

Kieser & Associates. 2008. *Modeling of agricultural BMP scenarios in the Paw Paw River Watershed using SWAT.* Prepared for the Southwest Michigan Planning Commission.

Southwest Michigan Planning Commission. 2008. Paw Paw River Watershed Management Plan. Available at: http://www.swmpc.org/downloads/PawPawRW/PPRW_WMP.pdf

State of Michigan Office of Regulatory Reform (MI-ORR). 2002. Part 30 - Water Quality Trading Rules. Available at:
http://www.state.mi.us/orr/emi/arcrules.asp?type=Numeric&id=1999&subID=
1999-036+EQ&subCat=Admincode.

Rouge River National Wet Weather Demonstration Project. 2001. *Appendix A of the Common Appendix for Rouge Subwatershed Management Plans Submitted in Fulfillment of the MDEQ Stormwater General Permit.* Available at:
http://www.rougeriver.com/pdfs/stormwater/TR37/Appendix_A.pdf.

Appendix A

Pollutant Loads and Runoff Volume per Subwatershed

Table A-1: Pollutant loads (in lbs/year) per subwatershed under baseline conditions and build-out scenarios.

	Baseline			25%			50%			75%			100%		
HUC12	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
040500020201	669,983	1,765	24,150	662,909	1,893	24,809	656,226	2,024	25,498	649,931	2,159	26,217	644,028	2,297	26,966
040500020202	549,714	1,455	20,445	538,099	1,516	20,472	526,519	1,578	20,504	514,972	1,641	20,541	503,461	1,704	20,584
040500020203	415,546	1,143	13,991	420,106	1,257	14,641	424,679	1,372	15,292	429,263	1,487	15,945	433,860	1,602	16,599
040500020204	51,289	141	1,624	50,461	147	1,640	49,656	152	1,659	48,876	158	1,680	48,119	164	1,702
040500020205	635,615	1,698	22,782	624,001	1,790	23,107	612,757	1,886	23,465	601,878	1,985	23,858	591,368	2,089	24,285
040500020206	224,579	619	7,374	231,216	693	7,931	237,936	769	8,496	244,739	845	9,068	251,626	922	9,648
040500020207	148,677	415	4,212	150,209	450	4,489	151,727	486	4,767	153,231	521	5,045	154,721	557	5,324
040500020208	353,916	943	12,750	345,587	980	12,792	337,380	1,018	12,845	329,293	1,058	12,909	321,329	1,099	12,983
040500020209	78,723	221	2,361	77,739	228	2,381	76,818	235	2,407	75,959	243	2,438	75,161	251	2,474
040500020210	45,343	127	1,396	44,248	125	1,362	43,153	124	1,328	42,059	123	1,295	40,966	122	1,262
040500020212	665,356	1,772	23,730	658,521	1,879	24,257	651,963	1,990	24,810	645,682	2,102	25,386	639,678	2,218	25,988
040500020213	491,073	1,319	17,458	483,757	1,408	17,882	476,763	1,500	18,333	470,088	1,594	18,809	463,735	1,691	19,312
040500020214	637,538	1,702	23,078	637,053	1,841	23,782	636,692	1,981	24,499	636,453	2,122	25,227	636,339	2,265	25,968
040500020215	313,615	855	10,760	320,729	941	11,368	327,946	1,029	11,984	335,267	1,117	12,610	342,693	1,207	13,243
040500020216	647,887	1,716	23,987	629,437	1,822	24,243	611,229	1,930	24,524	593,257	2,041	24,829	575,527	2,155	25,159
040500020217	985,302	2,651	35,068	967,146	2,798	35,559	949,292	2,948	36,081	931,733	3,101	36,631	914,476	3,258	37,212
040500020218	461,952	1,246	16,396	489,685	1,374	17,503	517,463	1,503	18,615	545,282	1,633	19,732	573,144	1,762	20,853
040500020219	342,552	1,070	9,070	389,253	1,217	10,612	435,955	1,364	12,153	482,658	1,511	13,694	529,364	1,659	15,236
Total	*7,718,662*	*20,857*	*270,633*	*7,720,155*	*22,360*	*278,832*	*7,724,155*	*23,889*	*287,261*	*7,730,620*	*25,443*	*295,915*	*7,739,594*	*27,022*	*304,800*

Table A-2: Runoff volume (in acre-feet/year) per subwatershed under baseline conditions and build-out scenarios.

HUC12	Baseline	25%	50%	75%	100%
040500020201	2,112	2,163	2,216	2,271	2,327
040500020202	1,488	1,512	1,537	1,562	1,588
040500020203	1,125	1,206	1,288	1,369	1,451
040500020204	141	142	144	145	147
040500020205	1,800	1,828	1,858	1,890	1,925
040500020206	641	690	739	789	840
040500020207	475	489	503	517	531
040500020208	981	988	995	1,003	1,012
040500020209	218	220	222	224	226
040500020210	117	115	113	111	110
040500020212	1,915	1,955	1,997	2,041	2,086
040500020213	1,429	1,458	1,488	1,520	1,554
040500020214	1,802	1,879	1,958	2,037	2,116
040500020215	916	980	1,045	1,110	1,176
040500020216	1,811	1,836	1,863	1,892	1,922
040500020217	2,766	2,807	2,851	2,897	2,945
040500020218	1,256	1,415	1,573	1,732	1,892
040500020219	1,020	1,215	1,409	1,604	1,799
Total	*22,015*	*22,899*	*23,799*	*24,714*	*25,646*

Appendix B

Pollutant Loads and Runoff Volume per Township

Table B-3: Pollutant loads (in lbs/year) per township under baseline conditions and build-out scenarios.

	Baseline			25% buildout			50% buildout			75% buildout			100% buildout		
Municipality	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS	TP	TN
Arlington Twp	878,276	2,324	31,857	869,535	2,485	32,643	861,100	2,648	33,456	852,973	2,815	34,297	845,154	2,984	35,166
Bangor Twp	1,051,359	2,784	39,238	1,011,882	2,920	39,191	972,595	3,059	39,168	933,488	3,201	39,167	894,571	3,346	39,190
Bangor, City of	102,049	308	2,762	126,107	362	3,432	150,165	415	4,102	174,222	468	4,771	198,279	522	5,441
Bloomingdale Twp	676,282	1,797	24,824	662,484	1,907	25,229	649,030	2,019	25,664	635,910	2,135	26,128	623,133	2,254	26,622
Casco Twp	685,740	1,895	22,600	688,514	2,034	23,310	691,321	2,173	24,024	694,162	2,314	24,743	697,035	2,454	25,465
Cheshire Twp	240,227	644	8,579	233,908	666	8,574	227,753	690	8,585	221,762	715	8,611	215,936	743	8,653
Clyde Twp	701,434	1,848	25,463	688,250	1,985	26,067	675,373	2,125	26,694	662,800	2,268	27,346	650,535	2,413	28,022
Columbia Twp	629,811	1,719	21,069	637,987	1,887	22,229	646,528	2,058	23,419	655,433	2,232	24,640	664,704	2,409	25,890
Covert	164,079	446	5,584	163,837	477	5,733	163,691	510	5,890	163,643	543	6,056	163,692	577	6,230
Ganges	487,603	1,291	18,206	481,885	1,341	18,273	476,195	1,392	18,345	470,530	1,444	18,420	464,894	1,496	18,500
Geneva	1,171,559	3,130	42,330	1,142,255	3,270	42,561	1,113,306	3,413	42,825	1,084,702	3,559	43,120	1,056,453	3,709	43,450
Lee	422,757	1,158	13,234	422,176	1,244	13,803	421,897	1,332	14,398	421,914	1,424	15,019	422,233	1,518	15,667
Manlius	2,273	6	93	2,273	6	93	2,273	6	93	2,273	6	93	2,273	6	93
Saugatuck	953	2	38	954	2	38	956	2	38	957	2	38	959	2	38
South Haven	192,696	570	5,890	249,611	749	7,857	306,528	929	9,825	363,445	1,109	11,792	420,364	1,288	13,759
South Haven, City of	225,334	705	5,775	253,166	778	6,611	280,998	850	7,448	308,828	923	8,284	336,659	995	9,121
Valley	713	2	18	713	2	18	713	2	18	713	2	18	713	2	18
Waverly	85,130	227	3,056	84,230	245	3,154	83,345	263	3,255	82,474	281	3,356	81,618	300	3,459
Total	*7,718,273*	*20,856*	*270,617*	*7,719,766*	*22,359*	*278,816*	*7,723,767*	*23,888*	*287,245*	*7,730,232*	*25,442*	*295,899*	*7,739,206*	*27,021*	*304,784*

Table B-4: Runoff volume (in acre-feet/year) per township under baseline conditions and build-out scenarios.

Municipality	Baseline	25%	50%	75%	100%
Arlington	2,540	2,606	2,674	2,744	2,816
Bangor	2,853	2,868	2,885	2,904	2,925
Bangor, City of	301	378	455	533	610
Bloomingdale	1,940	1,969	2,001	2,035	2,071
Casco	1,850	1,946	2,042	2,139	2,236
Cheshire	653	655	659	663	669
Clyde	2,181	2,225	2,270	2,318	2,367
Columbia	1,850	1,947	2,047	2,148	2,252
Covert	455	471	486	503	520
Ganges	1,289	1,320	1,351	1,382	1,414
Geneva	3,282	3,305	3,330	3,358	3,388
Lee	1,319	1,351	1,385	1,421	1,459
Manlius	6	6	6	6	6
Saugatuck	2	2	2	2	3
South Haven	587	829	1,071	1,313	1,555
South Haven, City of	665	770	875	980	1,085
Valley	3	3	3	3	3
Waverly	239	246	253	260	268
Total	*22,014*	*22,898*	*23,798*	*24,713*	*25,645*

BLACK RIVER WATERSHED BMP ANALYSIS

The following analysis was conducted by Kieser & Associates, LLC using the Black River Watershed Land Use Change and BMP Tool. The BMP Tool is a Microsoft Excel workbook developed to estimate the impact of land use change and zoning regulations on pollutant loads and runoff volumes. The tool can also be used to estimate general cost-efficiency of common urban best management practices. The tool is should not be used to provide site-specific BMP costs, pollutant loads or treatment design.

This workbook was designed as a separate tool from the Build-Out analysis report provided to SWMPC (K&A, 2009) and as such, it cannot be used to replicate results provided in the report. The workbook uses the same current and future land use categories to standardize comparisons between current and future land uses and to provide a better description and load estimation for urban areas (in the build-out analysis, current land use categories came from a 2001 Land Use layer).

DATA INPUT

The BMP analysis was conducted only for the total urban area in the Black River Watershed. Urban land use breakdown within the Black River Watershed was calculated using the 2001 IFMAP land use obtained from the Michigan Geographic Data Library[1]. The 2001 IFMAP urban land categories were then modified as follows to match land use categories used in the Black River Tool (Table 1).

Table 1: Land Use categories.

2001 Land Use categories	Area (acres)	Land Use categories used in Black River Tool	Area (acres)
Low Density Urban	2,661	Low Density Residential	2,661
High Density Urban (see note)	831	HD Residential	125
		Commercial	208
		Industrial	498
Roads/Parking Lots	6,281	Roads/Parking Lots	6,281

Note: High Density Urban was defined as 60% industrial, 25% commercial and 15% high density residential by SWMPC for the Paw Paw Watershed Management Plan (Kieser & Associates, 2008). These ratios were also used here.

Pollutant loads were calculated using the same methodology and equations used in the Black River Build-out Analysis; i.e., using event mean concentrations from the Michigan Trading Rules (MI-ORR, 2002) (or as defined by SWMPC) and runoff rates calculated by L-THIA (Section 2.2 in the Build-out report).

Because runoff rates vary by soil type, a simple visual analysis was conducted to verify the main hydrologic soil groups in urban areas. The two main urban areas (South Haven and Bangor) are entirely

[1] Available at: http://www.mcgi.state.mi.us/mgdl/

located on C soils. Therefore, load calculations for LD Residential, HD Residential, Commercial, and Industrial used runoff rates for hydrologic soil group C. Because roads and parking lots are spread out throughout the watershed, load calculations were completed using 50% of the acreage on A soils and 50% of the acreage on C soils (Table 2).

Table 2: STATSGO hydrologic soil group breakdown for the Black River Watershed.

	Hydrologic Soil Group				
	A	B	C	A/D	None
% of total area	17.4	2.6	44.5	30.8	4.7

BMP treatment efficiencies and total costs are estimated in Table 3 using various sources. BMP definitions are included in Appendix A.

Table 3: BMP efficiency and costs.

BMP	% Efficiency (1)			Base Cost(2)
	TP	TN	TSS	($ per acre treated)
Grass Swale	40%	90%	80%	3,000
Extended Dry Detention Basin	30%	20%	90%	3,000
Wet Retention Pond	90%	30%	90%	3,000
Rain Garden (Neighborhood)	100%	100%	100%	69,914
Constructed Wetlands	49%	30%	76%	42,254

(1) Efficiency values for extended dry detention basin, wet retention pond and grass swale are taken from the Michigan Trading Rules.

Efficiency values for constructed wetlands were taken from EPA (2005), rain gardens are assumed to trap 100% of runoff and pollutants.

(2) Base cost and cost adjustment values are provided in WERF's BMP and LID Whole Life Cost Worksheets (2009b).
The medium value of $3,000 per acre is used for retention, detention and swale.

For rain gardens, the cost per area treated is $16.05 (cost per sq. ft of rain garden) x 20% (rain garden area ratio to drainage area) =$3.21 per sq. foot treated (or $139,828 per acre treated). The assumption used in this tool is that rain gardens will be installed at a neighborhood scale, therefore providing economies of scale. The WERF neighborhood discount factor (50%) was applied to give a value per acre treated of $69,914.
The base facility cost of $42,254 per acre (effective drainage area) for curb-contained bioretention is used for constructed wetlands.

RESULTS

The following assumptions were used for obtaining results presented in Table 4 for watershed-wide BMP applications in the Black River Watershed:

- Grass swales, extended detention basins and wet retention basins were applied to treat 50% of the total urban area (all urban land uses included).
- Rain gardens were applied to treat 10% of the urban area including LD Residential, HD Residential, Commercial and Industrial. This BMP is not commonly used to treat runoff from roads/parking lots.
- Constructed wetlands were applied to treat 50% of the urban area including LD Residential, HD Residential, Commercial and Industrial. This BMP is not commonly used to treat runoff from roads/parking lots.

Table 4: BMP load reductions and costs in the Black River Watershed.

	Load Reductions (lbs/yr)			Total cost	Cost ($) per lb reduced		
BMP	**TP**	**TN**	**TSS**	**($)**	**TP**	**TN**	**TSS**
Grass Swale	1,433	22,509	889,391	18,326,250	12,783	814	21
Extended Dry Detention Basin	1,075	25,011	1,000,580	18,326,250	17,043	733	18
Wet Retention Pond	3,226	7,503	1,000,590	18,326,250	5,681	2,442	18
Rain Garden	135	1,417	31,594	25,147,108	186,131	17,747	796
Constructed Wetlands	331	2,126	120,056	92,221,996	278,612	43,389	768

Of the various BMPs examined here, the most cost-effective BMP for TP is a wet retention pond. The most cost-effective BMP for TN is a dry detention basin. The most efficient BMPs for TSS are extended dry detention and wet retention basins.

It should be noted that these results only provide coarse estimates of cost and load reductions as BMPs were applied watershed-wide without taking into account site-specific analyses, local construction costs nor land acquisition costs.

References

Kieser & Associates. 2008. *Urban Build-Out and Stormwater BMP Analysis in the Paw Paw River Watershed*. Prepared for the Southwest Michigan Planning Commission.

Kieser & Associates, LLC. 2009. *Urban Build-Out Analysis for the Black River Watershed (draft)*. Prepared for the Southwest Michigan Planning Commission (public release pending).

U.S. Environmental Protection Agency (EPA). 2005. National Management Measures to Control Nonpoint Source Pollution from Urban Areas.

State of Michigan Office of Regulatory Reform (MI-ORR). 2002. Part 30 - Water Quality Trading Rules. Available at: http://www.state.mi.us/orr/emi/arcrules.asp?type=Numeric&id=1999&subID=1999036+EQ&subCat=Admincode.

Water Environment Research Foundation. 2009a. User's Guide to the BMP and LID Whole Life Cost Models version 2.0. Available at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

Water Environment Research Foundation. 2009b. BMP and LID Whole Life Cost Models Excel Worksheets for Extended Detention Ponds, Retention Ponds, Swales. Available at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

APPENDIX A

DEFINITION OF BMPS

All definitions below were taken from the EPA "National Menu of Stormwater Best Management Practices" website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Wet Detention: Wet ponds (a.k.a. stormwater ponds, wet retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as stormwater best management practices.

Swales: The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows along these channels, it is treated through vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Rain garden: Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system.

Constructed wetlands: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

Appendix M: Watershed Inventory Sites of Concern

These sites are all labeled with the station number from MDEQ's road-stream crossing surveys. A table with location information for these station numbers is included at the end of this appendix.

Road-stream crossing sites of concern

Location	Priority area	Source	Cause	Pollutant of concern
BR-02	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BR-12	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BR-14	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BR-25	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BR-34	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-03	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-15	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-18	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-26	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-27	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-28	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-28	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-29	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-35	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-35	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-43	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-45	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-45	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-48	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-50	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-52	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRM-53	2	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-55	2	Road-stream crossing	Improper culvert sizing and placement	sediment
BRM-62	3	Road-stream crossing	Improper culvert sizing and placement	sediment
BRN-02	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRN-06	3	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRN-12	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRN-20	2	Road-stream crossing	Improper culvert sizing and placement	sediment
BRN-31	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRN-32	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRN-37	2	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-08	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-10	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-13	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-14	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-18	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-20	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-21	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-24	2	Road-stream crossing	Gravel road grading	sediment
BRS-26	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-30	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-31	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-45	2	Road-stream crossing	Improper culvert sizing and placement	sediment

BRS-53	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-55	1	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment
BRS-57	1	Road-stream crossing	Improper culvert sizing and placement; erosion from/around bridge, culvert or road	sediment
BRS-58	1	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-62	2	Road-stream crossing	Improper culvert sizing and placement	sediment
BRS-62	2	Road-stream crossing	Erosion from/around bridge, culvert or road	sediment

Streambank erosion sites of concern

Location	Priority area	Source	Causes	Pollutant of concern
BR-02	1	Streambank erosion	Human access	sediment
BR-03	1	Streambank erosion		sediment
BR-04	2	Streambank erosion		sediment
BR-05	2	Streambank erosion	Removal of streambank vegetation	sediment
BR-05 to BR-13	2	Streambank erosion		sediment
BR-08	2	Streambank erosion		sediment
BR-11	2	Streambank erosion		sediment
BR-13	2	Streambank erosion		sediment
BR-14	2	Streambank erosion		sediment
BR-18	1	Streambank erosion		sediment
BR-19	1	Streambank erosion		sediment
BR-21	1	Streambank erosion	Human access	sediment
BR-27	1	Streambank erosion		sediment
BRM-02	3	Streambank erosion	Human access	sediment
BRM-04	3	Streambank erosion		sediment
BRM-08	3	Streambank erosion		sediment
BRM-14	3	Streambank erosion		sediment
BRM-21	3	Streambank erosion		sediment
BRM-25	3	Streambank erosion		sediment
BRM-32	3	Streambank erosion		sediment
BRM-36	3	Streambank erosion		sediment
BRM-65	3	Streambank erosion	Removal of streambank vegetation	sediment
BRN-01	3	Streambank erosion		sediment
BRN-03	3	Streambank erosion	Site development and construction	sediment
BRN-04	3	Streambank erosion		sediment
BRN-05	3	Streambank erosion		sediment
BRN-11	2	Streambank erosion		sediment
BRS-02	1	Streambank erosion		sediment
BRS-19	1	Streambank erosion		sediment
BRS-26	2	Streambank erosion		sediment
BRS-27	2	Streambank erosion		sediment
BRS-30	1	Streambank erosion		sediment
BRS-32	1	Streambank erosion		sediment
BRS-36	1	Streambank erosion		sediment
BRS-42	2	Streambank erosion		sediment
BRS-55 to BRS-57	1	Streambank erosion		sediment
BRS-57	1	Streambank erosion	Removal of streambank vegetation; human access	sediment
BRS-60	1	Streambank erosion		sediment

BRS-63	2	Streambank erosion		sediment
BRS-64	2	Streambank erosion		sediment
BRS-40.5 (Lion's Park-Bangor)	2	Streambank erosion	Removal of streambank vegetation; human access	sediment

Agricultural sites of concern

Location	Priority area	Source	Pollutant
BR-09	2	Livestock	sediment, bacteria/pathogens, nutrients
BR-31	1	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BR-34	1	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRM-11	3	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRM-34	3	Livestock	sediment, bacteria/pathogens, nutrients
BRM-41	3	Livestock	sediment, bacteria/pathogens, nutrients
BRM-56	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRM-59	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRM-63	3	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRM-67	3	Livestock	sediment, bacteria/pathogens, nutrients
BRN-09	3	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-13	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-16	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-17	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-17 (downstream)	2	Livestock	bacteria/pathogens, nutrients
BRN-20	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-21	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-22	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-27	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-28	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-29	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-30	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-31	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-32	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-33	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRN-35	2	Livestock	sediment, bacteria/pathogens, nutrients
BRS-19	1	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRS-23	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRS-34	1	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRS-47	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRS-51	1	Livestock	sediment, bacteria/pathogens, nutrients
BRS-61	1	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
BRS-65	2	Lack of vegetative buffer	sediment, nutrients, chemical pollutants
Munn Lk. Drain/3850th St.	1	Livestock	nutrients, bacteria/pathogens

Residential and municipal sites of concern

Location	Priority area	Source	Causes	Pollutant of concern
BR-01	1	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BR-02	1	Stormwater runoff	Change in hydrology (increase in hardened surfaces)	sediment, nutrients, chemical pollutants
BR-12	2	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BR-32	1	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-10	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-13	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-29	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-43	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-64	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-69	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-72	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRM-73	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRN-10	3	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-16	1	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-30	1	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-30	1	Stormwater runoff	Poor stormwater management practices	sediment, nutrients, chemical pollutants
BRS-40.5	2	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-48	2	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-57	1	Lack of vegetative buffer	Poorly maintained vegetative buffers	sediment, nutrients, chemical pollutants
BRS-58	1	Stormwater runoff	Poor stormwater management practices	sediment, nutrients, chemical pollutants
BRS-66	2	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants
BRS-67	2	Lack of vegetative buffer	Removal of streambank vegetation	sediment, nutrients, chemical pollutants

Road-Stream Crossing Locations

County	Township	Station #	Road	Waterbody name	Latitude	Longitude
Van Buren	South Haven	BR-01	Blue Star Hwy	Black River	42.41537	-86.2578
Van Buren	South Haven	BR-02	73rd St			
Allegan	Casco	BR-03	Baseline Rd	Black River	42.25244	-86.14595
Van Buren	South Haven	BR-04	73.5th St	Black River	42.41688	-86.23991
Van Buren	Geneva	BR-05	70th St	Black River	42.4153	-86.22546
Van Buren	Geneva	BR-06	68th St	Butternut Creek	42.40632	-86.20744
Van Buren	Geneva	BR-07	67th St	Tripp and Extension Drain	42.41681	-86.19761
Van Buren	Geneva	BR-08	Baseline Rd	Tripp and Extension Drain	42.2515	-86.11639
Van Buren	Geneva	BR-09	66th St	Tripp and Extension Drain	42.24886	-86.11268
Van Buren	Geneva	BR-10	64th St	Tripp and Extension Drain	42.24757	-86.10098
Van Buren	Geneva	BR-11	CR 388	Butternut Creek	42.24238	-86.12206
Van Buren	Geneva	BR-12	CR 687	Butternut Creek	42.23599	-86.11261
Van Buren	Geneva	BR-13	CR 388	Black River	42.24242	-86.13162
Van Buren	Geneva	BR-14	8th Ave	Black River	42.23366	-86.12849
Van Buren	Geneva	BR-15	CR 384	Black River	42.22481	-86.1246
Van Buren	South Haven	BR-16	M-43	Unnamed Tributary to Main Branch Black Riv	42.21919	-86.13865
Van Buren	Geneva	BR-17	M-43	Unnamed Tributary to Main Branch Black Riv	42.21512	-86.13436
Van Buren	Geneva	BR-18	16th Ave	Cedar Creek	42.2164	-86.12283
Van Buren	Geneva	BR-19	CR 380	Cedar Creek	42.20776	-86.12124
Van Buren	Geneva	BR-20	M-43	Cedar Creek	42.20483	-86.12109
Van Buren	Geneva	BR-21	68th St	Cedar Creek	42.20185	-86.12423
Van Buren	Covert	BR-22	24th Ave	Cedar Creek	42.19897	-86.13209
Van Buren	Bangor	BR-23	68th St	Cedar Creek	42.3305	-86.2061
Van Buren	Bangor	BR-24	69th St	Cedar Creek	42.19528	-86.12996
Van Buren	Covert	BR-25	CR 378	Cedar Creek	42.18502	-86.14013
Van Buren	Covert	BR-26	32nd Ave	Cedar Creek	42.18061	-86.14206
Van Buren	Covert	BR-27	34th Ave	Cedar Creek	42.17632	-86.143
Van Buren	Covert	BR-28	70th St	Cedar Creek	42.28591	-86.22367
Van Buren	Bangor	BR-29	68th Ave	Cedar Creek	42.31119	-86.1869
Van Buren	Covert	BR-30	36th Ave	Cedar Creek	42.28654	-86.23765
Van Buren	Covert	BR-31	40th Ave	Cedar Creek	42.27226	-86.2429
Van Buren	Geneva	BR-32	M-43	Unnamed Tributary to Cedar Creek	42.20265	-86.11844
Van Buren	Bangor	BR-33	66th St	Unnamed Tributary to Cedar Creek	42.19457	-86.11221
Van Buren	Bangor	BR-34	CR 378	Unnamed Tributary to Cedar Creek	42.18494	-86.11169
Van Buren	Bangor	BR-35	34th Ave	Unnamed Tributary to Cedar Creek	42.17625	-86.12074
Allegan	Casco	BRM-01	70th St	Middle Branch Black River	42.25851	-86.13589
Allegan	Casco	BRM-02	68th St	Middle Branch Black River	42.25446	-86.12424
Allegan	Casco	BRM-03	103rd Ave	Unnamed Tributary to Middle Branch Black R	42.26454	-86.11717
Allegan	Casco	BRM-04	66th St	Unnamed Tributary to Middle Branch Black R	42.27305	-86.11258
Allegan	Casco	BRM-05	66th St	Middle Branch Black River	42.26375	-86.01125
Allegan	Casco	BRM-06	65th St	Middle Branch Black River	42.26604	-86.10682
Allegan	Casco	BRM-08	104th Ave	Middle Branch Black River	42.26873	-86.09833
Allegan	Casco	BRM-09	63rd St	Spicebush Creek	42.27005	-86.09493
Allegan	Casco	BRM-10	104th Ave	Spicebush Creek	42.26853	-86.08948
Allegan	Lee	BRM-11	60th St	Unnamed Tributary to Spicebush Creek	42.27203	-86.07743
Allegan	Casco	BRM-12	60th St	Unnamed Tributary to Spicebush Creek	42.26346	-86.0774
Allegan	Casco	BRM-13	102nd Ave	Spicebush Creek	42.26007	-86.08715
Allegan	Casco	BRM-14	60th St	Spicebush Creek	42.25376	-86.07715

Van Buren	Geneva	BRM-15	Baseline Rd	Spicebush Creek	42.25137	-86.06974
Van Buren	Geneva	BRM-16	Phoenix Rd	Spicebush Creek	42.24592	-86.06602
Van Buren	Geneva	BRM-17	CR 681	Spicebush Creek	42.24267	-86.06994
Van Buren	Geneva	BRM-18	58th St	Spicebush Creek	42.24051	-86.06613
Allegan	Casco	BRM-19	63rd St	Middle Branch Black River	42.27224	-86.09487
Allegan	Casco	BRM-20	62nd St	Middle Branch Black River	42.27676	-86.08889
Allegan	Lee	BRM-21	60th St	Middle Branch Black River	42.27738	-86.06575
Allegan	Lee	BRM-22	58th St	Middle Branch Black River	42.27349	-86.06585
Allegan	Lee	BRM-23	105th Ave	Middle Branch Black River	42.27738	-86.06575
Allegan	Lee	BRM-25	104th Ave	Middle Branch Black River	42.26875	-86.05286
Allegan	Lee	BRM-26	54th St	Middle Branch Black River	42.27092	-86.03652
Allegan	Lee	BRM-27	105th Ave	Spring Brook	42.27092	-86.03652
Allegan	Lee	BRM-28	50th St	Spring Brook	42.27233	-86.01912
Allegan	Lee	BRM-29	49th St	Spring Brook	42.27269	-86.01326
Allegan	Lee	BRM-30	48th St	Spring Brook	42.27045	-86.00749
Allegan	Lee	BRM-31	103rd Ave	Middle Branch Black River	42.26438	-86.03189
Allegan	Lee	BRM-32	51st St	Middle Branch Black River	42.25146	-86.00719
Allegan	Lee	BRM-34	Baseline Rd	Unnamed Tributary to Middle Branch Black R	42.25145	-86.00718
Allegan	Lee	BRM-35	48th St	Unnamed Tributary to Middle Branch Black R	42.4601	-86.00837
Allegan	Lee	BRM-36	102nd Ave	Unnamed Tributary to Middle Branch Black R	42.26011	-86.00835
Allegan	Cheshire	BRM-37	46th St	Unnamed Tributary to Middle Branch Black R	42.20473	-85.59565
Allegan	Cheshire	BRM-38	44th St	Unnamed Tributary to Middle Branch Black R	42.4441	-85.9735
Allegan	Cheshire	BRM-39	44th St	Unnamed Tributary to Middle Branch Black R	42.4333	-85.9736
Van Buren	Columbia	BRM-40	47.5th St	Melvin Creek	42.24548	-86.0055
Van Buren	Bloomingdale	BRM-41	46th St	Melvin Creek	42.24298	-85.58641
Van Buren	Bloomingdale	BRM-42	44th St	Unnamed Tributary to Melvin Creek	42.24298	-85.58638
Van Buren	Bloomingdale	BRM-43	44th St	Melvin Creek	42.23714	-85.58628
Van Buren	Bloomingdale	BRM-44	CR 665	Melvin Creek	42.2345	-85.57453
Allegan	Lee	BRM-45	Baseline Rd	Little Bear Lake Drain	42.25146	-86.00719
Van Buren	Columbia	BRM-46	2nd Ave	Little Bear Lake Drain	42.25146	-86.00719
Van Buren	Columbia	BRM-47	CR 388	Little Bear Lake Drain	42.24047	-86.01285
Van Buren	Columbia	BRM-48	48.5 St	Little Bear Lake Drain	42.25146	-86.00719
Van Buren	Columbia	BRM-49	8th Ave	Little Bear Lake Drain	42.25146	-86.00719
Allegan	Lee	BRM-50	55th St	Barber Creek	42.2675	-86.0484
Allegan	Lee	BRM-51	54th St	Barber Creek	42.43726	-86.06964
Van Buren	Columbia	BRM-52	Baseline Rd	Barber Creek	42.41891	-86.06147
Van Buren	Columbia	BRM-53	CR 388	Barber Creek	42.40431	-86.0518
Van Buren	Columbia	BRM-54	Silver Lake Rd	Barber Creek	42.39447	-86.04827
Van Buren	Columbia	BRM-55	54th St	Unnamed Tributary to Barber Creek	42.24274	-86.04823
Van Buren	Columbia	BRM-56	CR 388	Unnamed Tributary to Barber Creek	42.24276	-86.04824
Allegan	Lee	BRM-59	56th St	Middle Branch Black River	42.26949	-86.05405
Allegan	Lee	BRM-60	102nd Ave	Unnamed Drain to Lester Lake	42.26017	-86.05165
Allegan	Lee	BRM-61	102nd Ave	Unnamed Drain to Mud Lake	42.26011	-86.05884
Allegan	Casco	BRM-62	107th Ave	Scott Creek Drain	42.28188	-86.08425
Allegan	Lee	BRM-63	60th St	Unnamed Tributary to Scott Creek	42.28154	-86.07773
Allegan	Lee	BRM-64	60th St	Unnamed Tributary to Scott Creek	42.2836	-86.07752
Allegan	Lee	BRM-65	60th St	Scott Creek Drain	42.28809	-86.07754
Allegan	Casco	BRM-66	109th Ave	Unnamed Tributary to Scott Creek	42.29055	-86.08081
Allegan	Casco	BRM-67	61st St	Unnamed Tributary to Scott Creek	42.2921	-86.08346
Allegan	Casco	BRM-68	111th Ave	Unnamed Tributary to Scott Creek	42.29925	-86.08184

Allegan	Lee	BRM-69	109th Ave	Scott Creek Drain	42.29049	-86.06999
Allegan	Lee	BRM-70	58th St	Scott Creek Drain	42.29218	-86.06593
Allegan	Lee	BRM-71	109th Ave	Scott Creek Drain	42.29047	-86.06335
Allegan	Lee	BRM-72	56th St	Scott Creek Drain	42.28892	-86.05427
Allegan	Lee	BRM-73	109th Ave	Scott Creek Drain	42.29048	-86.05035
Allegan	Lee	BRM-74	55th St	Scott Creek Drain	42.29062	-86.08084
Allegan	Lee	BRM-75	109th Ave	Scott Creek Drain	42.29062	-86.08084
Allegan	Casco	BRN-01	103rd Ave	North Branch Black River	42.26237	-86.13856
Allegan	Casco	BRN-02	71st St	Unnamed Tributary to North Branch Black Ri	42.26997	-86.14178
Allegan	Casco	BRN-03	Blue Star Hwy	Unnamed Tributary to North Branch Black Ri	42.26808	-86.15038
Allegan	Casco	BRN-04	107th Ave	North Branch Black River	42.28171	-86.12747
Allegan	Casco	BRN-05	68th St	Unnamed Tributary to North Branch Black Ri	42.27972	-86.12431
Allegan	Casco	BRN-06	68th St	North Branch Black River	42.28602	-86.12425
Allegan	Casco	BRN-07	109th Ave	North Branch Black River	42.29049	-86.12009
Allegan	Casco	BRN-08	66th St	Unnamed Tributary to North Branch Black Ri	42.29087	-86.11252
Allegan	Casco	BRN-09	68th St	Unnamed Tributary to North Branch Black Ri	42.29641	-86.12424
Allegan	Casco	BRN-10	111th Ave	Unnamed Tributary to North Branch Black Ri	42.29904	-86.12053
Allegan	Casco	BRN-11	66th St	North Branch Black River	42.29675	-86.11265
Allegan	Casco	BRN-12	111th Ave	North Branch Black River	42.29901	-86.10988
Allegan	Ganges	BRN-13	66th St	Black River Drain	42.30405	-86.11296
Allegan	Ganges	BRN-14	113th ave	Black River Drain	42.30812	-86.10841
Allegan	Ganges	BRN-15	64th St	Black River Drain	42.31562	-86.10139
Allegan	Ganges	BRN-16	66th St	Black River Drain	42.31563	-86.11315
Allegan	Ganges	BRN-17	62nd St	Black River Drain	42.31656	-86.08983
Allegan	Ganges	BRN-19	118th Ave	Black River Drain	42.32963	-86.10768
Allegan	Ganges	BRN-20	66th St	Black River Drain	42.32505	-86.11335
Allegan	Ganges	BRN-21	116th Ave	Black River Drain	42.32104	-86.09283
Allegan	Ganges	BRN-22	119th Ave	Black River Drain	42.33404	-86.33404
Allegan	Ganges	BRN-23	120th Ave	Black River Drain	42.33724	-86.1022
Allegan	Ganges	BRN-24	120th St	Black River Drain	42.33833	-86.10509
Allegan	Ganges	BRN-26	62nd St	Black River Drain	42.33808	-86.09061
Allegan	Cheshire	BRN-27	120th Ave	Black River Drain	42.38869	-86.06822
Allegan	Ganges	BRN-28	62nd St	Black River Drain	42.3201	-86.08983
Allegan	Cheshire	BRN-29	118th Ave	Black River Drain	42.32995	-86.07863
Allegan	Cheshire	BRN-30	120th Ave	Black River Drain	42.33869	-86.06822
Allegan	Cheshire	BRN-31	57th St	Black River Drain	42.34301	-86.05951
Allegan	Cheshire	BRN-32	54th St	Black River Drain	42.33433	-86.04436
Allegan	Cheshire	BRN-33	60th St	Black River Drain	42.31908	-86.27813
Allegan	Cheshire	BRN-34	56th St	Black River Drain	42.32128	-86.05556
Allegan	Cheshire	BRN-35	116th Ave	Black River Drain	42.32124	-86.04679
Allegan	Cheshire	BRN-36	112th Ave	Black River Drain	42.3064	-86.03366
Allegan	Lee	BRN-37	53rd St	Black River Drain	42.30348	-86.03112
Allegan	Lee	BRN-38	50th St	Black River Drain	42.30264	-86.01944
Van Buren	Geneva	BRS-01	66th St	Eastman Creek	42.37138	-86.1873
Van Buren	Geneva	BRS-02	65th St	Eastman Creek	42.22288	-86.1125
Van Buren	Geneva	BRS-03	64th St	Eastman Creek	42.37482	-86.16792
Van Buren	Geneva	BRS-04	62nd St	Eastman Creek	42.38749	-86.14877
Van Buren	Geneva	BRS-05	8th Ave	Eastman Creek	42.38976	-86.14681
Van Buren	Geneva	BRS-06	60th St	Eastman Creek	42.39671	-86.12945
Van Buren	Geneva	BRS-07	62nd St	Eastman Creek	42.37989	-86.14868

Van Buren	Geneva	BRS-08	60th St	Eastman Creek	42.38364	-86.12943
Van Buren	Geneva	BRS-09	59th St	Eastman Creek	42.387	-86.11977
Van Buren	Geneva	BRS-10	66th St	Unnamed Tributary to South Branch Black Ri	42.36622	-86.18731
Van Buren	Geneva	BRS-11	65th St	Unnamed Tributary to South Branch Black Ri	42.3648	-86.17767
Van Buren	Geneva	BRS-12	64th St	Unnamed Tributary to south Branch Black Ri	42.37522	-86.1673
Van Buren	Geneva	BRS-13	16th Ave			
Van Buren	Geneva	BRS-14	66th St	Unnamed Tributary to South Branch Black Ri	42.35985	-86.18732
Van Buren	Geneva	BRS-15	65th St	Unnamed Tributary to South Branch Black Ri	42.35891	-86.17769
Van Buren	Geneva	BRS-16	64th St	Unnamed Tributary to South Branch Black Ri	42.35895	-86.17764
Van Buren	Geneva	BRS-17	65th St	Unnamed Tributary to South Branch Black Ri	42.35464	-86.17765
Van Buren	Geneva	BRS-18	64th St	Unnamed Tributary to South Branch Black Ri	42.35461	-86.1777
Van Buren	Geneva	BRS-19	66th St	South Branch Black River	42.35427	-86.18761
Van Buren	Geneva	BRS-20	CR 380	South Branch Black River	42.34618	-86.18688
Van Buren	Bangor	BRS-21	M-43	Drain to Merriman Lake	42.33118	-86.15606
Van Buren	Bangor	BRS-22	63rd St	Drain to Merriman Lake	42.32461	-86.15788
Van Buren	Bangor	BRS-23	CR 378	Drain to Merriman Lake	42.3087	-86.17194
Van Buren	Bangor	BRS-24	34th Ave	Drain to School Section Lake	42.29417	-86.1722
Van Buren	Bangor	BRS-25	CR 687	South Branc.033h Black River	42.3307	-86.14828
Van Buren	Geneva	BRS-26	24th Ave	Unnamed Tributary to South Branch Black Ri	42.33221	-86.13137
Van Buren	Geneva	BRS-27	20th Ave	Unnamed Tributary to South Branch Black Ri	42.34661	-86.12781
Van Buren	Geneva	BRS-28	59.5th St	Unnamed Tributary to South Branch Black Ri	42.33236	-86.12399
Van Buren	Bangor	BRS-29	M-43	Maple Creek	42.18962	-86.07381
Van Buren	Bangor	BRS-30	30th Ave	Maple Creek	42.18519	-86.06941
Van Buren	Bangor	BRS-31	34th Ave	Cedar Drain	42.17673	-86.07362
Van Buren	Bangor	BRS-32	36th Ave	Cedar Drain	42.17236	-86.07119
Van Buren	Bangor	BRS-33	CR 376	Cedar Drain	42.16381	-86.07679
Van Buren	Arlington	BRS-34	CR 681	Unnamed Tributary to Cedar Drain	42.16653	-86.06531
Van Buren	Arlington	BRS-35	CR 681	Maple Creek	42.18026	-86.06534
Van Buren	Arlington	BRS-36	56th St	Nelson Extension Drain	42.17313	-86.0546
Van Buren	Arlington	BRS-37	CR 215	Nelson Extension Drain	42.17204	-86.04305
Van Buren	Arlington	BRS-38	56th St	Unnamed Tributary to Nelson Extension Drai	42.17941	-86.05473
Van Buren	Arlington	BRS-39	CR 681	Unnamed Tributary to Maple Creek	42.1849	-86.0654
Van Buren	Arlington	BRS-40	56th St	Unnamed Tributary to Maple Creek	42.18321	-86.05481
Van Buren	Bangor	BRS-40.5	Hamilton Ave			
Van Buren	Arlington	BRS-41	CR 681	South Branch Black River	42	-86
Van Buren	Arlington	BRS-42	55.5th St	Unnamed Tributary to South Branch Black Ri	42.1992	-86.05183
Van Buren	Columbia	BRS-43	CR 215	Unnamed Tributary to South Branch Black Ri	42.19924	-86.04364
Van Buren	Columbia	BRS-44	CR 380	Unnamed Tributary to South Branch Black Ri	42.20799	-86.05159
Van Buren	Columbia	BRS-45	55th St	Unnamed Tributary to South Branch Black Ri	42.21078	-86.04911
Van Buren	Columbia	BRS-46	56th St	Unnamed Tributary to South Branch Black Ri	42.21342	-86.05492
Van Buren	Columbia	BRS-47	16th Ave	Unnamed Tributary to South Branch Black Ri	42.36095	-86.08433
Van Buren	Columbia	BRS-48	54th St	South Branch Black River	42.34531	-86.07243
Van Buren	Columbia	BRS-49	52nd St	South Branch Black River	42.34348	-86.05295
Van Buren	Columbia	BRS-50	20th Ave	Great Bear Lake Drain	42.20795	-86.03121
Van Buren	Columbia	BRS-51	51st St	Great Bear Lake Drain	42.21225	-86.02587
Van Buren	Columbia	BRS-53	49th St	Great Bear Lake Drain	42.21624	-86.01428
Van Buren	Columbia	BRS-54	46.5 St	Great Bear Lake Drain	42.22152	-86
Van Buren	Bloomingdale	BRS-55	45th St	Haven and Max Lake Drain	42.22494	-85.59226
Van Buren	Bloomingdale	BRS-56	15th Ave	Haven and Max Lake Drain	42.21866	-85.57927
Van Buren	Bloomingdale	BRS-57	42nd St	Haven and Max Lake Drain	42.22567	-85.57435

Van Buren	Bloomingdale	BRS-58	41st St	Haven and Max Lake Drain	42.22814	-85.56865
Van Buren	Bloomingdale	BRS-59	CR 388	Haven and Max Lake Drain	42.3608	-85.9108
Van Buren	Bloomingdale	BRS-60	8th Ave	Haven and Max Lake Drain	42.23397	-85.55681
Van Buren	Bloomingdale	BRS-61	6th Ave	Haven and Max Lake Drain	42.23843	-85.55675
Van Buren	Columbia	BRS-62	50th St	Black River Extension Drain	42.33183	-86.03305
Van Buren	Arlington	BRS-63	24th Ave	Black River Extension Drain	42.33204	-86.03532
Van Buren	Arlington	BRS-64	50th St	Black River Extension Drain	42.3319	-86.03305
Van Buren	Arlington	BRS-65	28th Ave	Black River Extension Drain	42.31578	-86.01941
Van Buren	Arlington	BRS-66	52nd St	Black River Extension Drain	42.18847	-86.03136
Van Buren	Arlington	BRS-67	30th Ave	Black River Extension Drain	42.18539	-86.03428
Van Buren	Arlington	BRS-68	48th St	Black River Extension Drain	42.19543	-86.00809
Van Buren	Arlington	BRS-69	28th Ave	Black River Extension Drain	42.18957	-86.01187
Van Buren	Arlington	BRS-70	M-43	Black River Extension Drain	42.18095	-86.00852
Van Buren	Arlington	BRS-71	CR 673	Black River Extension Drain	42.18103	-86.01955
Van Buren	South Haven	BRS-72	M-43	Black River Extension Drain	42.18108	-85.59381
Van Buren	Arlington	BRS-73	CR 673	Black River Extension Drain	42.17544	-86.01955

Appendix N: Black River Watershed Hydrologic Study

Michigan's Nonpoint Source Program

Dave Fongers
Hydrologic Studies Unit
Land and Water Management Division
Michigan Department of Environmental Quality
October 11, 2004

Table of Contents

Summary 104
Project Goals 106
Watershed Description and Model Parameters 106
Model Results 116
Appendix A-132
  Appendix A: Black River Hydrologic Model Parameters A-132

For comments or questions relating to this document, contact Dave Fongers at:

MDEQ, LWMD, P.O. Box 30458, Lansing, MI 48909
fongersd@michigan.gov
517-373-0210

Michigan's Nonpoint Source Program

The Black River hydrologic study was funded by a Part 319 grant from the United States Environmental Protection Agency to MDEQ's Nonpoint Source program. For more information, go to www.michigan.gov/deqnonpointsourcepollution.

Summary

A hydrologic model of the Black River watershed was developed by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The hydrologic model was developed to help determine the effect of land use changes on the Black River's flow regime and to provide design flows for streambank stabilization Best Management Practices (BMPs). Watershed stakeholders may combine this information with other determinants, such as open space preservation, to decide what locations are the most appropriate for wetland restoration, stormwater detention, in-stream BMPs, or upland BMPs. Local governments within the watershed could also use the information to help develop stormwater ordinances.

The hydrologic model has two scenarios corresponding to land uses in 1800 and 1978. General land use trends are illustrated in Figure 1. More detailed land use information is provided in Table 1 in the Watershed Description and Model Parameters section of this report.

Because of the land use changes, the model shows increases in runoff volumes and peak flows from 1800 to 1978 for the 50 percent chance (2-year) and 4 percent chance (25-year) 24-hour design storms, as shown in Figures 8 through 11. Additional flow details are in the Model Results section of this report. Increases in the runoff volume and peak flow from the 4 percent chance, 24-hour storms could cause or aggravate flooding problems unless mitigated through the use of effective stormwater management techniques. Increases in the 50 percent chance, 24-hour storm will increase channel-forming flows. The channel-forming flow in a stable stream usually has a one- to two-year recurrence interval. These relatively modest storm flows, because of their higher frequency, have more effect on channel form than extreme flood flows.

Hydrologic changes that increase this flow can cause the stream channel to become unstable. Stream instability is indicated by excessive erosion at many locations throughout a stream reach. Stormwater management techniques used to mitigate flooding can also help mitigate projected channel-forming flow increases. However, channel-forming flow criteria should be specifically considered in the stormwater management plan so that the selected BMPs will be most effective. For example, detention ponds designed to control runoff from the 4 percent chance, 24-hour storm may do little to control the runoff from the 50 percent chance, 24-hour storm, unless the outlet is specifically designed to do so.

One way to compare runoff from different subbasins is to calculate the yield, which is the peak flow divided by the drainage area. The area-weighted average yield from the 50 percent chance (2-year), 24-hour storm for the Black River watershed is 0.006 cubic feet per second per acre (cfs/acre) for 1978 land use scenario. This value may be used to guide stakeholders' fish habitat and stream stability management decisions. The area-weighted average yield from the 4

percent chance (25-year), 24-hour storm for the Black River watershed is 0.03 cfs/acre for 1978 land use scenario. This value may be used to guide stakeholders' flood control management decisions. Additional details are shown in Figures 12 and 13 and in the Model Results section of this report.

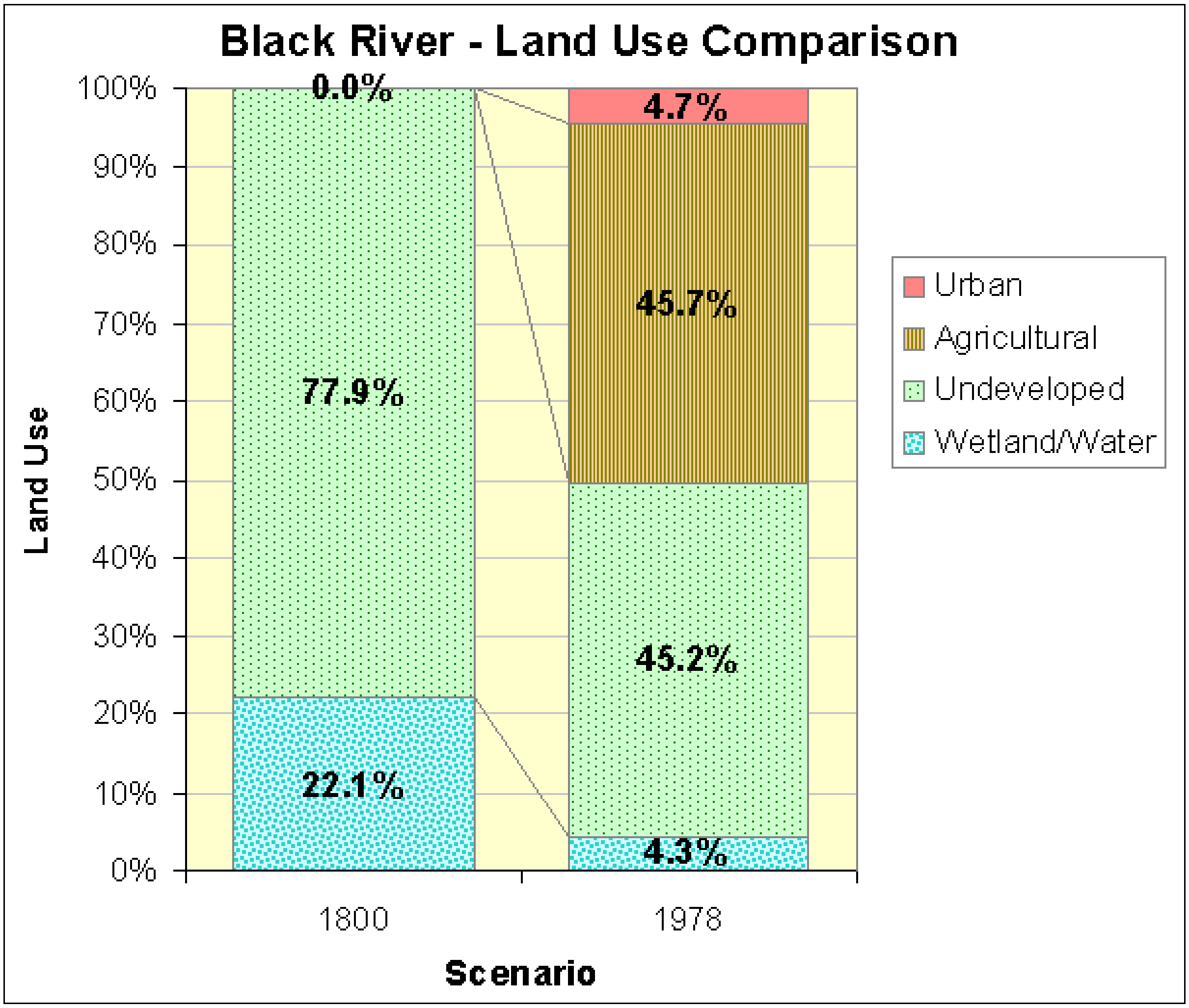


Figure 1: Land Use Comparison

Project Goals

The Black River hydrologic study was initiated in support of the Black River Watershed Planning project, which is funded in part by a United States Environmental Protection Agency (USEPA) Part 319 grant administered by the MDEQ. The goals of this Black River study are:

- To better understand the watershed's hydrologic characteristics and the impact of hydrologic changes in the Black River watershed

- To facilitate the selection and design of suitable BMPs

- To provide information that can be used by local units of government to develop or improve stormwater ordinances

- To help determine the watershed management plan's critical areas – the geographic portions of the watershed contributing the majority of the pollutants and having significant impacts on the waterbody

Watershed Description and Model Parameters

The 286 square mile Black River watershed, Figure 2, outlets to Lake Michigan at South Haven and is located in Allegan and Van Buren counties. Black River's profile, Figure 3, is typical - steeper in the headwaters, flattening out toward the mouth.

This Black River study divides the watershed into 24 subbasins, as shown in Figure 4.
Our analysis of the watershed uses the curve number technique to calculate surface runoff volumes and peak flows. This technique, developed by the Natural Resources Conservation Service (NRCS) in 1954, represents the runoff characteristics from the combination of land use and soil data as a runoff curve number. The curve numbers for each subbasin, listed in Appendix A, were calculated from digital soil and land use data using Geographic Information Systems (GIS) technology.

Runoff curve numbers were calculated from the land use and soil data shown in Figures 5 through 7. Land use maps based on the MDEQ GIS data for 1800 and 1978 are shown in Figures 5 and 6, respectively. The 1800 land use information is provided at the request of the Black River project manager. The MDEQ Nonpoint Source program does not expect or recommend that the flow regime calculated from 1800 land use be used as criteria for BMP design or as a goal for watershed managers.

The NRCS soils data for the watershed is shown in Figure 7. Where the soil is given a dual classification, B/D for example, the soil type was selected based on land use. In these cases, the soil type is specified as D for natural land uses or the

alternate classification (A, B, or C) for developed land uses. The runoff curve numbers calculated from the soil and land use data are listed in Appendix A. The percent impervious field is left at 0.0, because it is already incorporated in the curve numbers. The initial loss field is left blank so that HEC-HMS uses the default equation based on the curve number.
The time of concentration for each subbasin, which is the time it takes for water to travel from the hydraulically most distant point in the watershed to the design point, was calculated from the United States Geological Survey (USGS) quadrangles. The storage coefficients, which represent storage in the subbasin, were iteratively adjusted to provide a peak flow reduction equal to the ponding adjustment factors described further in Appendix A.

The reach routing method is the lag method. Lag is the travel time of water within each section of the stream. The method translates the flood hydrograph through the reach without attenuation. It is not appropriate for reaches that have ponds, lakes, wetlands, or flow restrictions that provide storage and attenuation of floodwater. Lag values for each reach were calculated using USGS quadrangles and are listed in Appendix A.

The selected precipitation events were the 50 and 4 percent chance (2- and 25-year), 24-hour storms. Design rainfall values for these events are tabulated in *Rainfall Frequency Atlas of the Midwest*, Bulletin 71, Midwestern Climate Center, 1992, pp. 126-129, and summarized for this site in Appendix A. These values have been multiplied by 0.914 to account for the size of the watershed.

These parameters were then incorporated into a HEC-HMS model to compute runoff volume and flow.

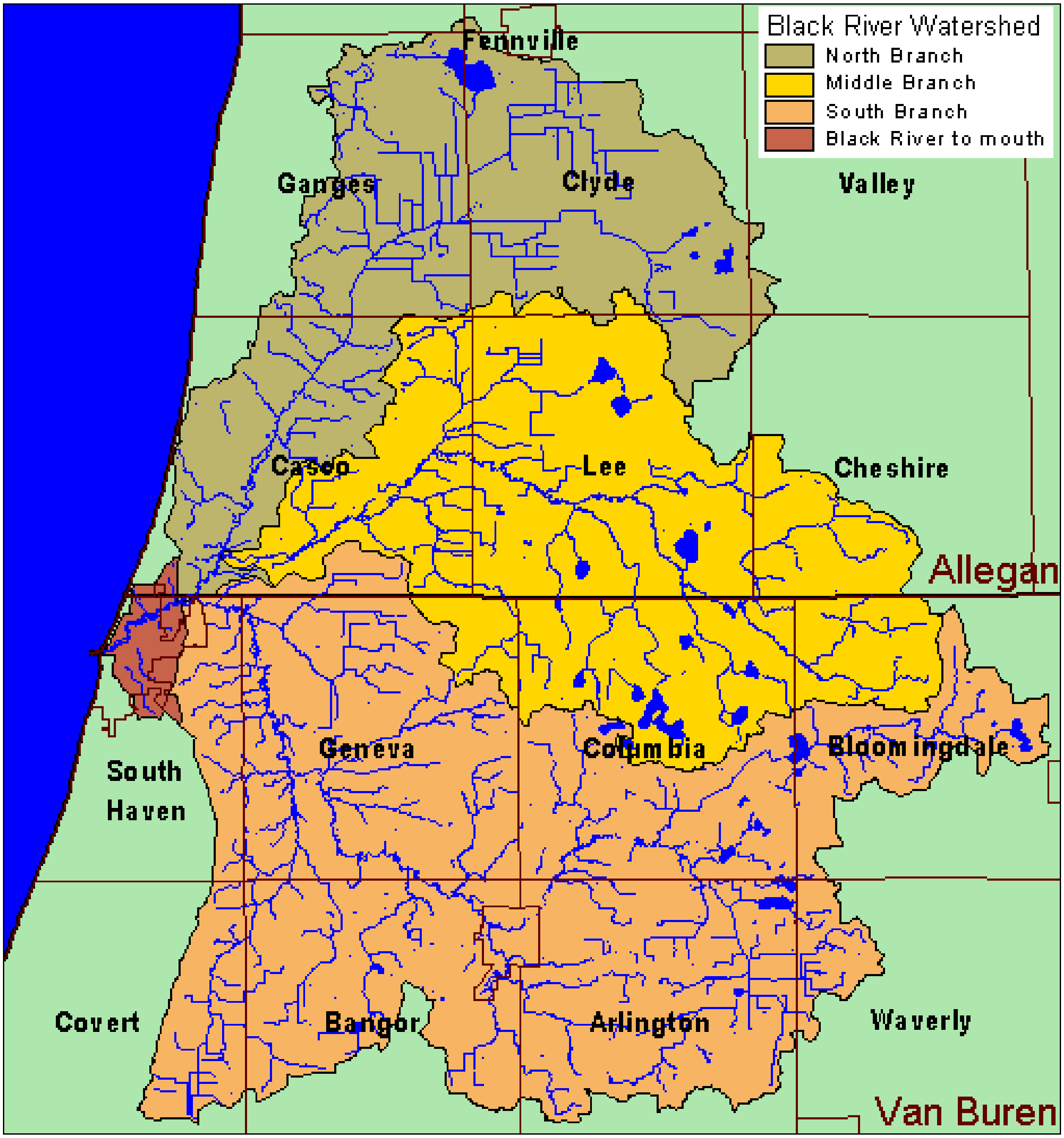


Figure 2: Delineated Black River Watershed

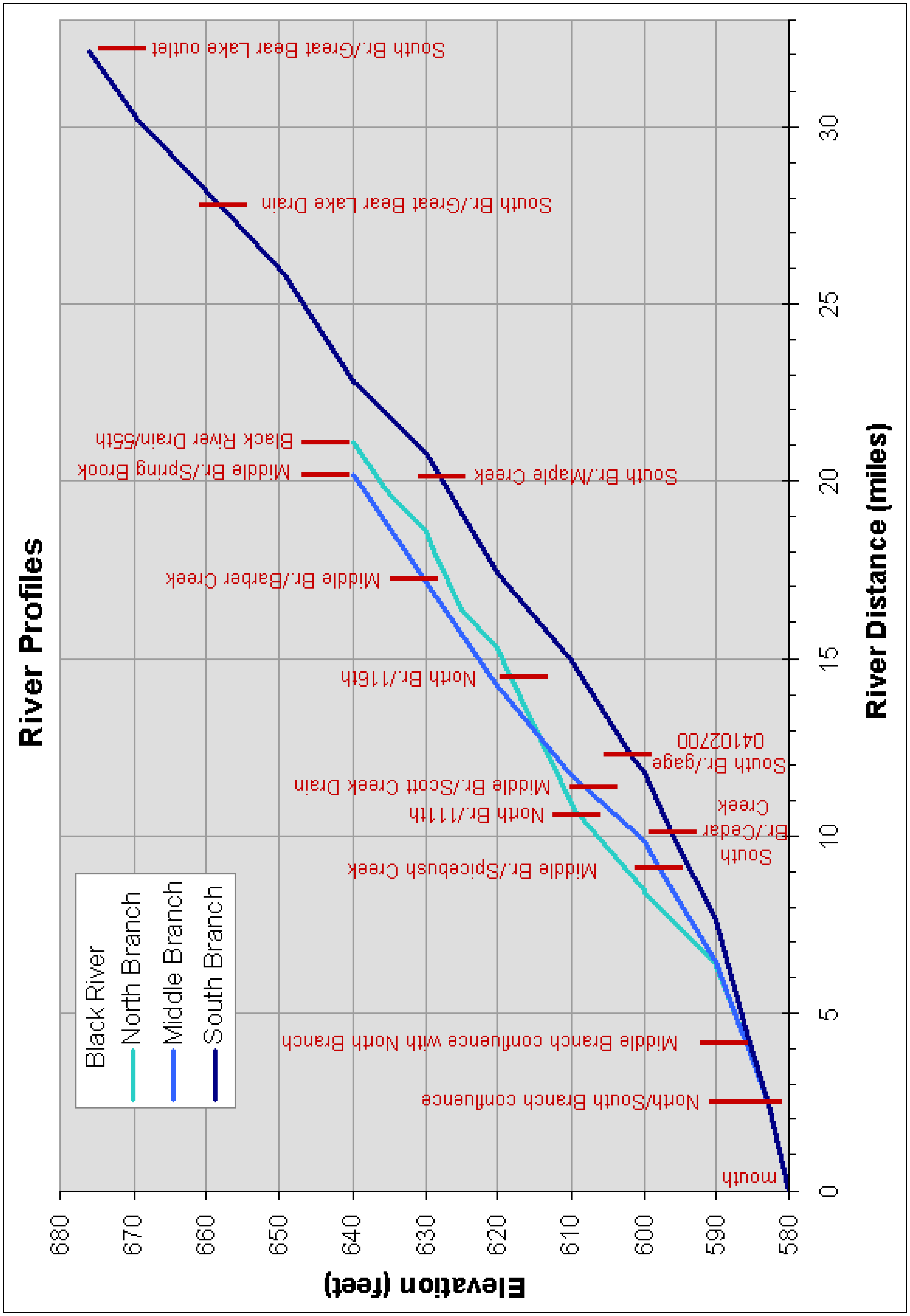


Figure 3: Black River Profile

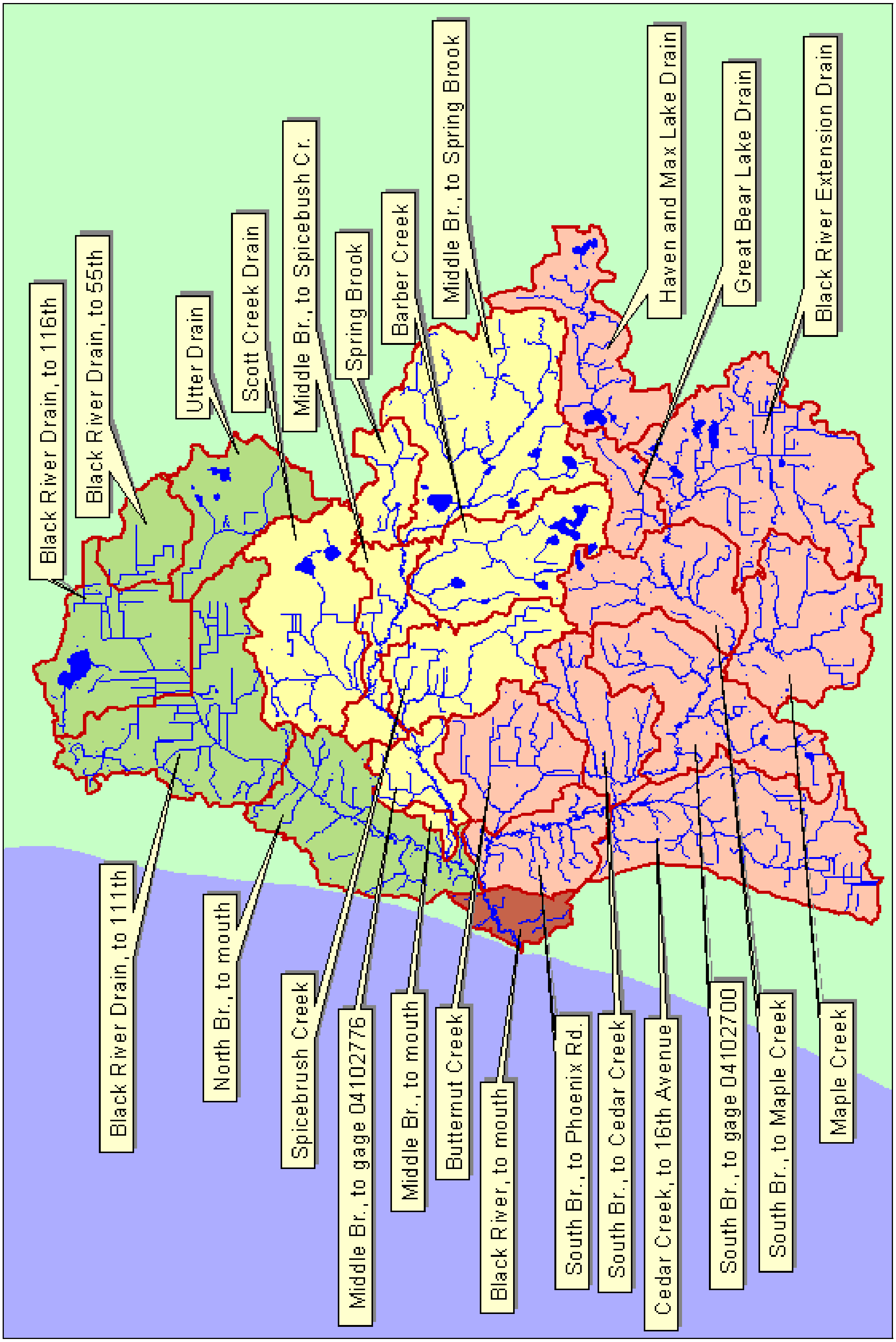

Black River Drain, to 116th
Black River Drain, to 55th
Utter Drain
Scott Creek Drain
Middle Br., to Spicebush Cr.
Spring Brook
Barber Creek
Middle Br., to Spring Brook
Haven and Max Lake Drain
Great Bear Lake Drain
Black River Extension Drain
Black River Drain, to 111th
North Br., to mouth
Spicebrush Creek
Middle Br., to gage 04102776
Middle Br., to mouth
Butternut Creek
Black River, to mouth
South Br., to Phoenix Rd.
South Br., to Cedar Creek
Cedar Creek, to 16th Avenue
South Br., to gage 04102700
South Br., to Maple Creek
Maple Creek

Figure 4: Subbasin Identification

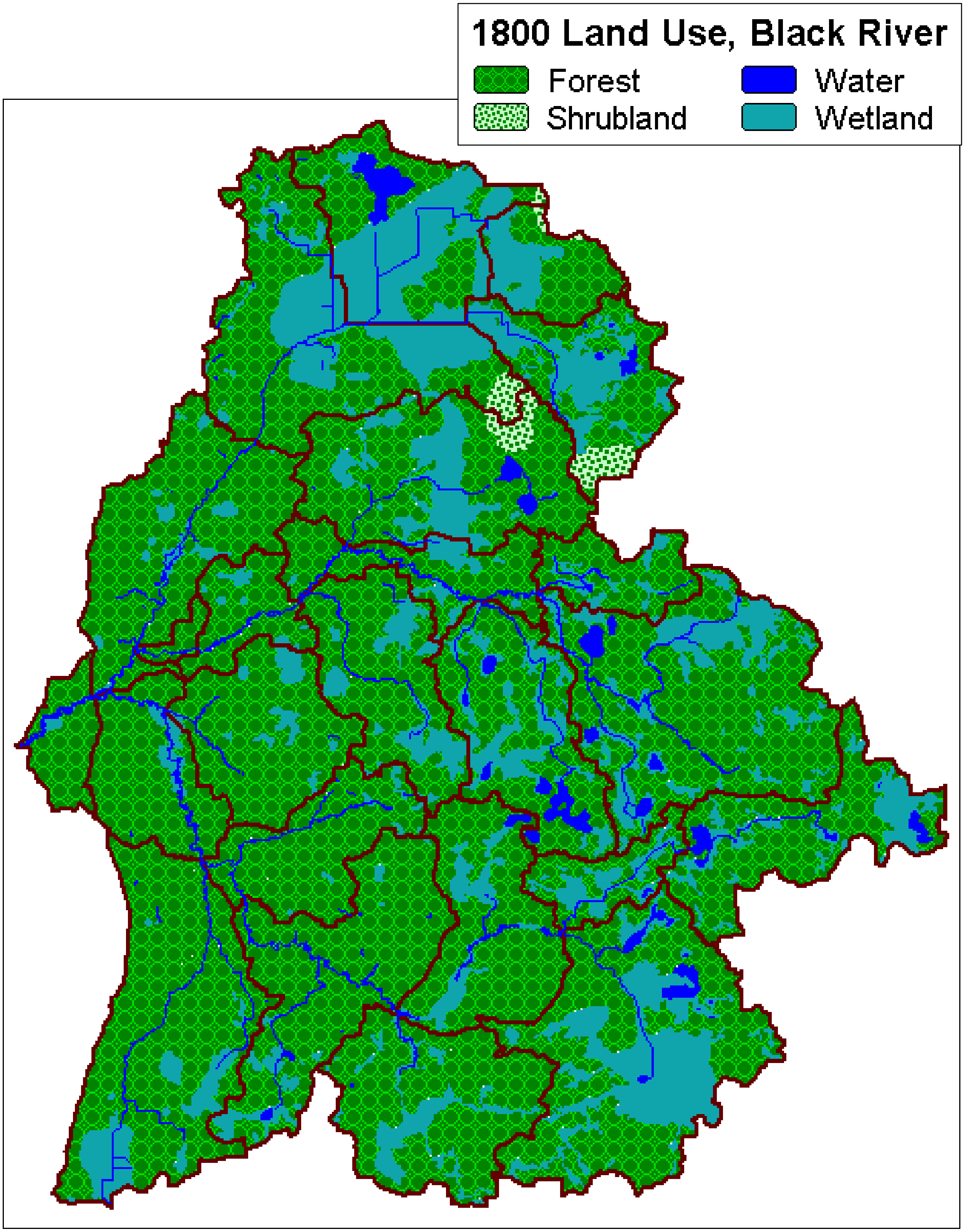


Figure 5: 1800 Land Use Data

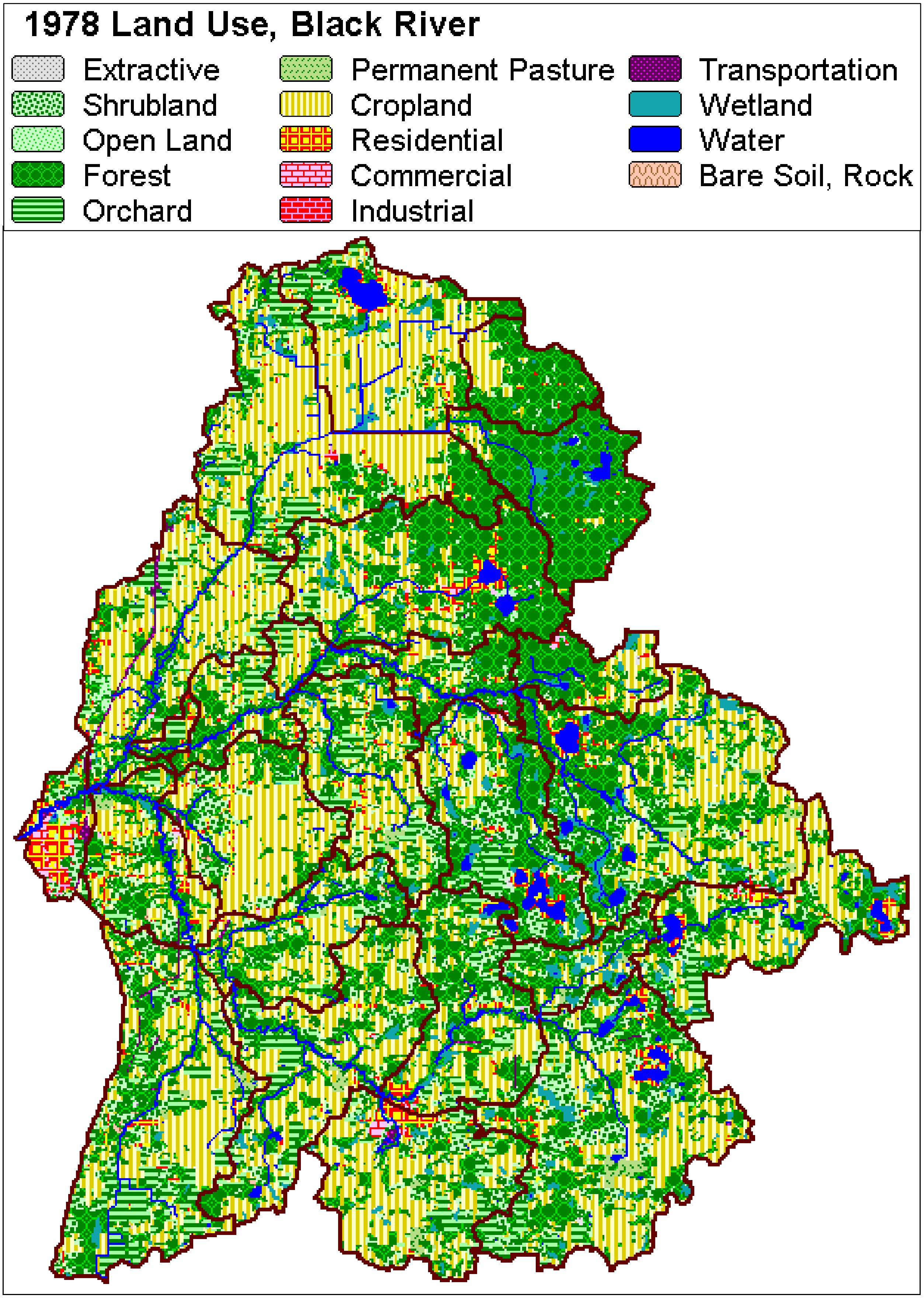


Figure 6: 1978 Land Use Data

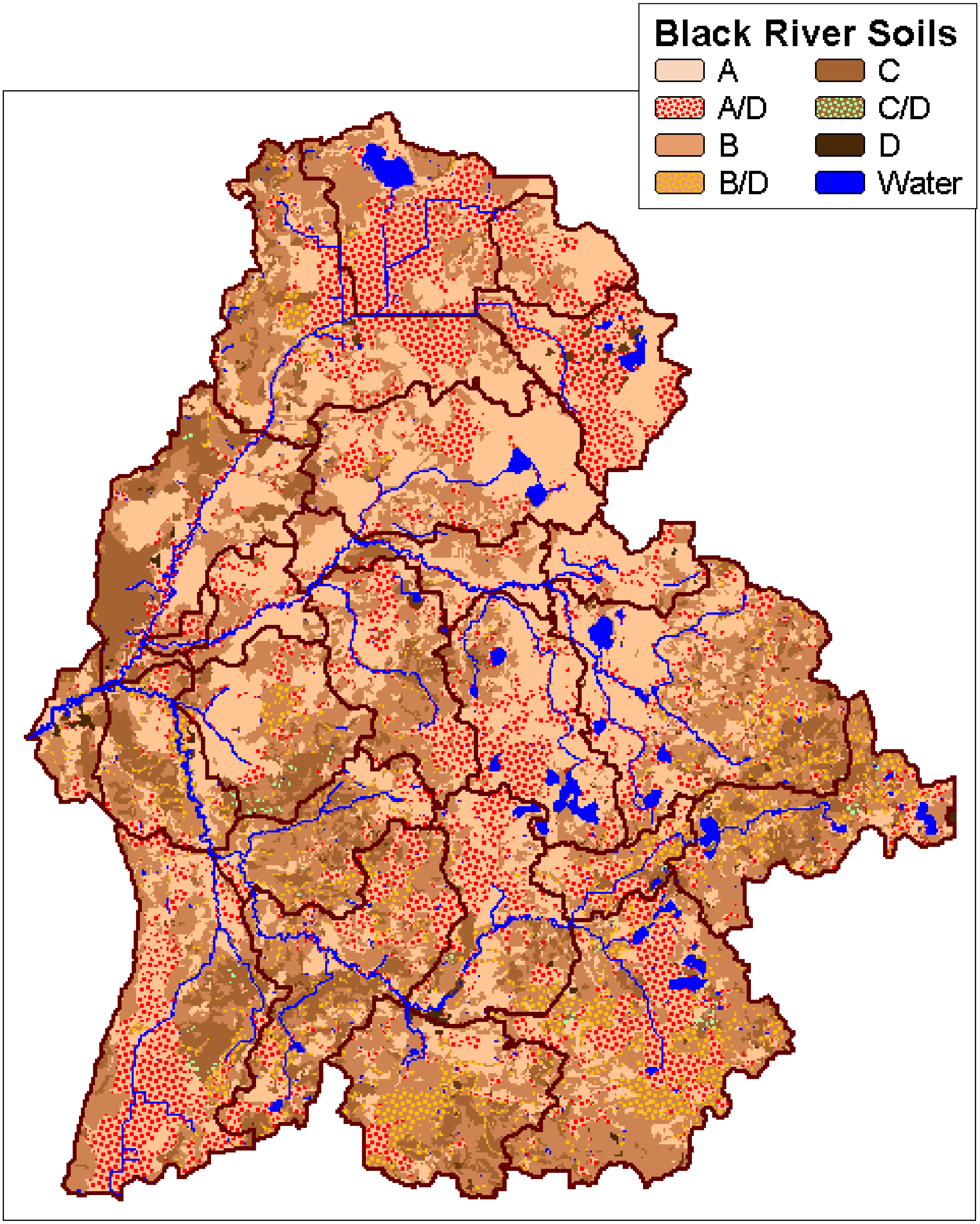


Figure 7: NRCS Soils Data

Table 1: Land Use by Subbasins (Land uses less than 0.5 percent are not listed because all percentages are rounded to the nearest percent)

Description	Scenario	Residential	Commercial	Industrial	Utilities	Gravel Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
B1	1800											94%	3%	3%
	1978	32%	10%	3%	7%	1%	5%	4%	6%	1%	15%	13%	3%	1%
BM1	1800											100 %		
	1978	9%						18%	26%		7%	40%		
BM2	1800											92%		8%
	1978	3%						30%	13%		6%	46%		1%
BM2SC	1800											80%		20%
	1978	3%						38%	18%	1%	8%	30%		2%
BM3	1800											85%		15%
	1978	3%	1%					26%	11%		5%	51%		1%
BM3aSCD	1800										5%	71%	2%	23%
	1978	6%					1%	23%	6%		4%	55%	2%	3%
BM3bBC	1800											71%	6%	22%
	1978	4%				1%		16%	9%		13%	44%	5%	6%
BM4	1800											75%	3%	22%
	1978	2%						36%	3%	1%	10%	41%	3%	5%
BM4SB	1800											83%	1%	17%
	1978	2%	2%					27%	1%		3%	60%		4%
BN1	1800											94%		6%
	1978	3%			3%		1%	51%	12%		4%	23%		1%
BN2	1800										3%	66%		31%
	1978	2%						54%	11%		4%	25%		2%
BN3	1800										1%	43%	6%	50%
	1978	3%						55%	9%		6%	17%	4%	5%
BN4	1800										10%	52%	2%	37%
	1978	1%						5%			1%	85%	2%	5%
BN4UD	1800										3%	60%		36%
	1978	1%						20%			5%	73%		1%
BS1	1800											91%	1%	8%
	1978	7%	1%		1%			33%	6%	2%	12%	36%		1%
BS1aBC	1800											91%		9%
	1978	3%						58%	4%		11%	22%		
BS2	1800											96%		3%
	1978	1%						40%	4%		10%	42%		2%
BS2CC	1800											87%		13%
	1978	2%			1%			37%	18%	1%	12%	28%		1%
BS3	1800											92%	1%	7%
	1978	1%						42%	12%	1%	7%	33%	1%	2%
BS3MC	1800											84%		15%
	1978	4%	1%		1%			45%	10%	1%	10%	24%		3%

Description	Scenario	Residential	Commercial	Industrial	Utilities	Gravel Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
BS4	1800											85%	1%	14%
	1978	4%						29%	11%		11%	39%	1%	3%
BS5ed	1800											64%	3%	34%
	1978	3%						34%	8%	2%	15%	32%	2%	3%
BS5GBLD	1800											69%	1%	31%
	1978							19%	7%	3%	18%	42%	1%	10%
BS6GBL	1800											74%	4%	22%
	1978	4%		1%				37%	8%		8%	32%	4%	4%

Model Results

Model results are illustrated in Figures 8 through 17 and detailed in Tables 2 and 3. Table 2 and Figures 8 and 10 show the computed peak flows and runoff volumes from each subbasin. These values represent the peak flow contribution from the subbasins, not the flow in the river. Table 3 and Figures 9 and 11 show the computed peak flows and runoff volumes at locations in the river.

The increases in stormwater runoff volume and peak flows conditions from 1800 to 1978 are due to changes in land use and loss of storage. The hydrologic model shows significant increases in runoff volumes and peak flows for both design storms. Peak flows and runoff volumes from the 50 percent chance 24-hour storm are predicted to increase more, on a percentage basis, than flows from the 4 percent chance, 24-hour storm. Increases in runoff volumes and peak flows from the 50 percent chance storm increase channel-forming flows, which will increase streambank erosion. Channel-forming flow is the flow that is most effective at shaping the channel. In a stable stream, the channel-forming flow has a one- to two-year recurrence interval and is the bankfull flow. Increases in runoff volumes and peak flows from the 4 percent chance storm will aggravate flooding. These projected increases can be moderated through the use of effective stormwater management techniques.

A model stormwater ordinance adopted by nearby Kent County, which is also being considered for adoption by other local units of government, calls for a maximum release rate of 0.05 cfs/acre for runoff from the 50 percent chance, 24-hour storm for Zone A areas, the most environmentally sensitive of the three management zones. Currently, the area-weighted average yield from this storm for the Black River Watershed is 0.006 cfs/acre, with no subbasin greater than 0.012 cfs/acre, as shown in Figure 12. The ordinance also calls for a maximum release rate of 0.13 cfs/acre for runoff from the 4 percent chance, 24-hour storm for Zones A and B. Currently, the average yield from this storm is 0.03 cfs/acre, with no subbasin greater than 0.08 cfs/acre, as shown in Figure 13. Additional details are listed in Table 2. If the Black River watershed stakeholders use the

Kent County model ordinance as a basis for a Black River stormwater ordinance, they should consider whether the Kent County model ordinance standards will adequately protect the Black River and its tributaries.

Significant portions of the Black River and its tributaries are designated trout streams, as shown in Figure 14. In our Pigeon River watershed study, we compared the flows from the 50 percent chance, 24-hour storm to flows based on a target yield of 0.0075 cfs/acre. This target yield was selected as criteria for a good trout fishery based on Mike Wiley and Paul Seelbach's November 1998 report titled "*An ecological assessment of opportunities for fisheries rehabilitation in the Pigeon River, Ottawa County*." Although clearly not the sole factor determining fish habitat quality, the good quality trout habitat there corresponds to the locations with yields less than the target yield. Impaired habitat corresponds to locations with yields less than about 1.4 times the target yield. Locations with higher yields generally did not have trout. These same thresholds were applied to the Black River results. For the 1800 scenario, all 17 river locations would be good. For the 1978 scenario, Black River would be impaired above the Great Bear Lake Drain and poor above the Great Bear Lake. Complete results are shown in Figure 15 and listed in Table 9.

The Black River has three main tributaries – the North, Middle, and South Branches. In the Macatawa River watershed, a hydrologic study revealed that the three main tributaries peaked at about the same time (page 8, *A Hydrologic Study of the Macatawa River Watershed*, MDEQ's Hydrologic Studies Unit). A project to alter the timing of one of the three tributaries, and reduce downstream flooding, is in progress. In the Black River, the three tributaries do not peak at the same time, as shown in Figures 16 and 17. Projects that reduce this timing differential have the potential to disproportionately increase peak flows in the main stem of the Black River.

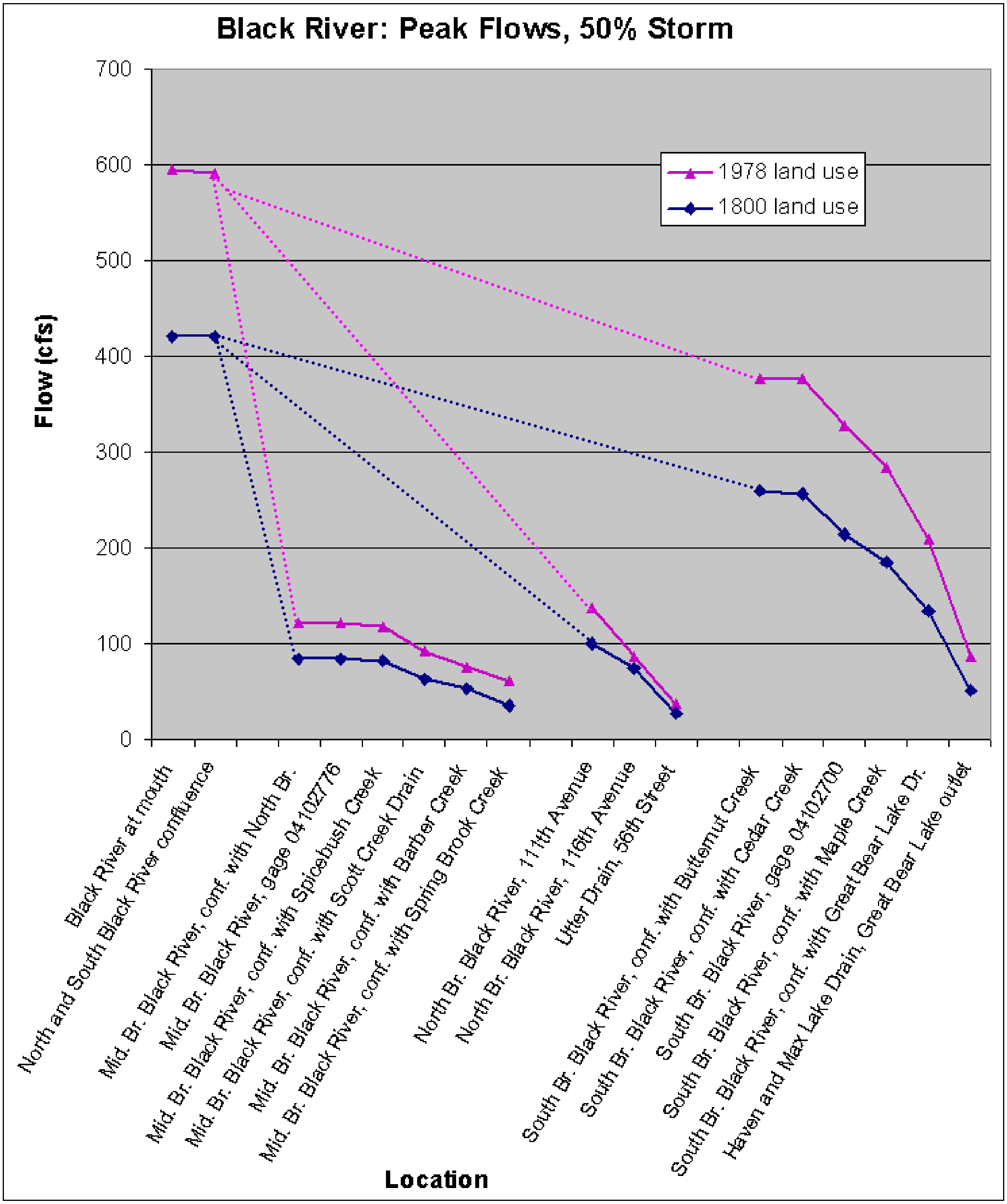


Figure 8: Predicted peak flows for river locations, 50 percent chance storm

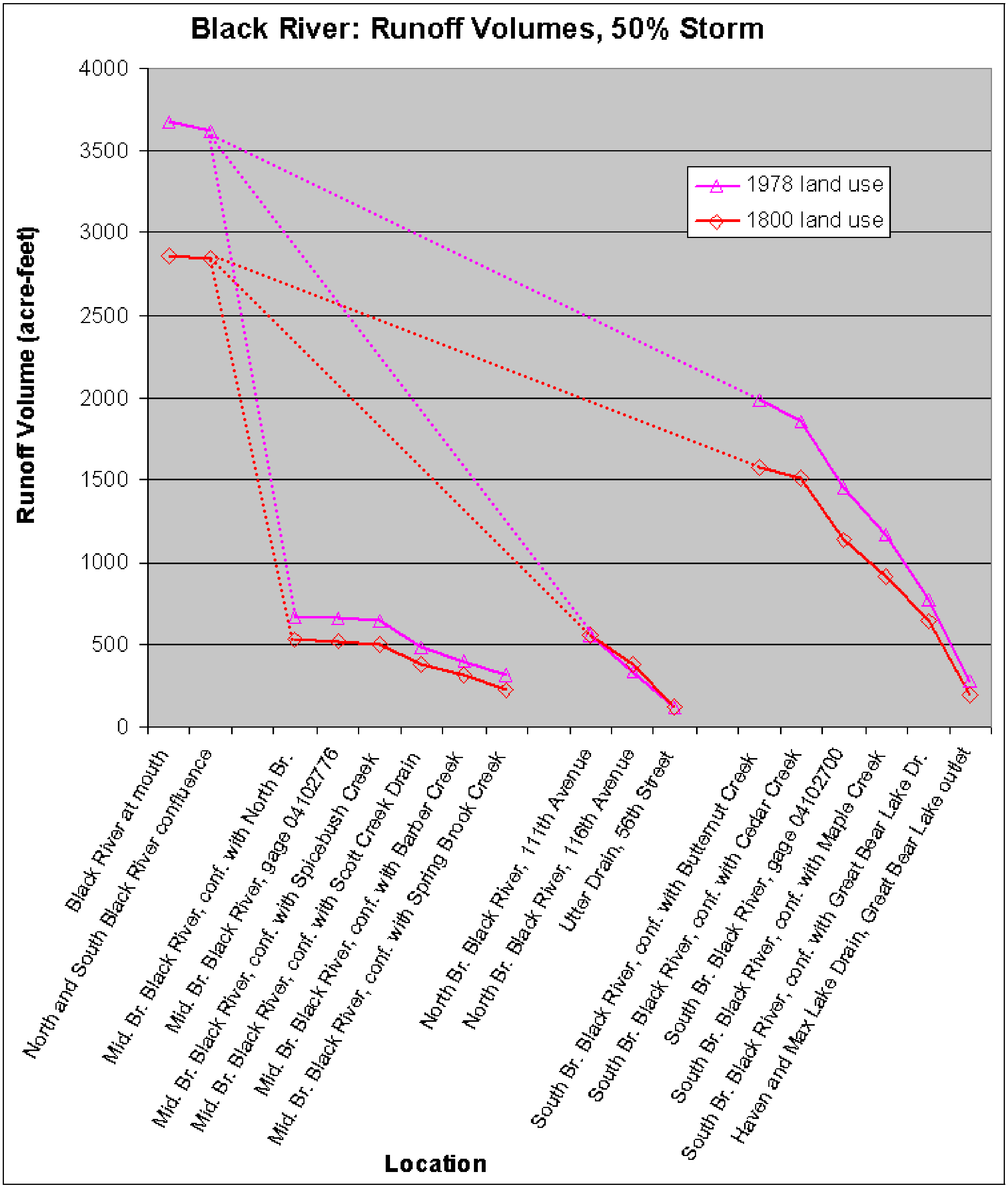


Figure 9: Predicted runoff volumes, 50 percent chance storm

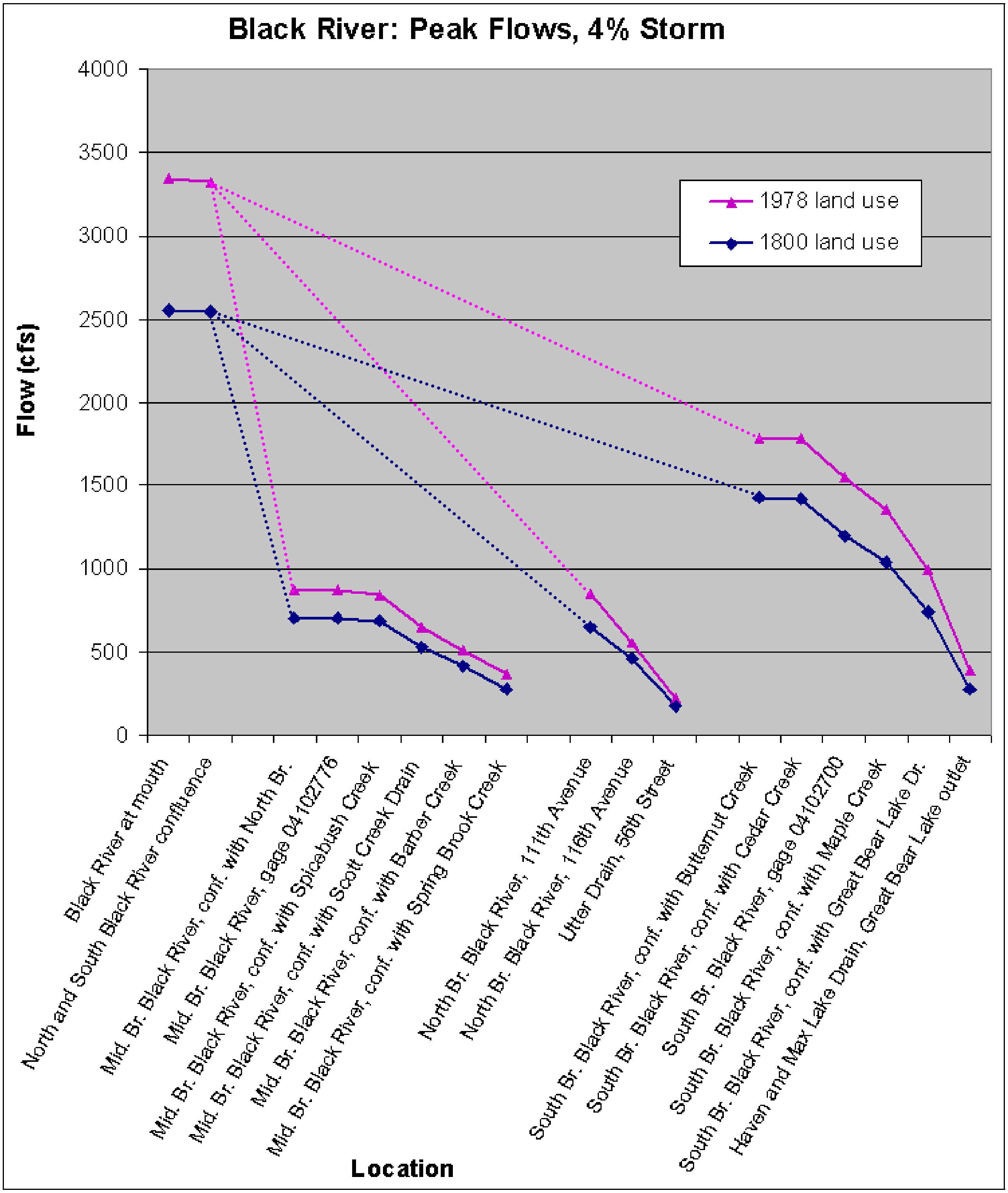


Figure 10: Predicted peak flows for river locations, 4 percent chance storm

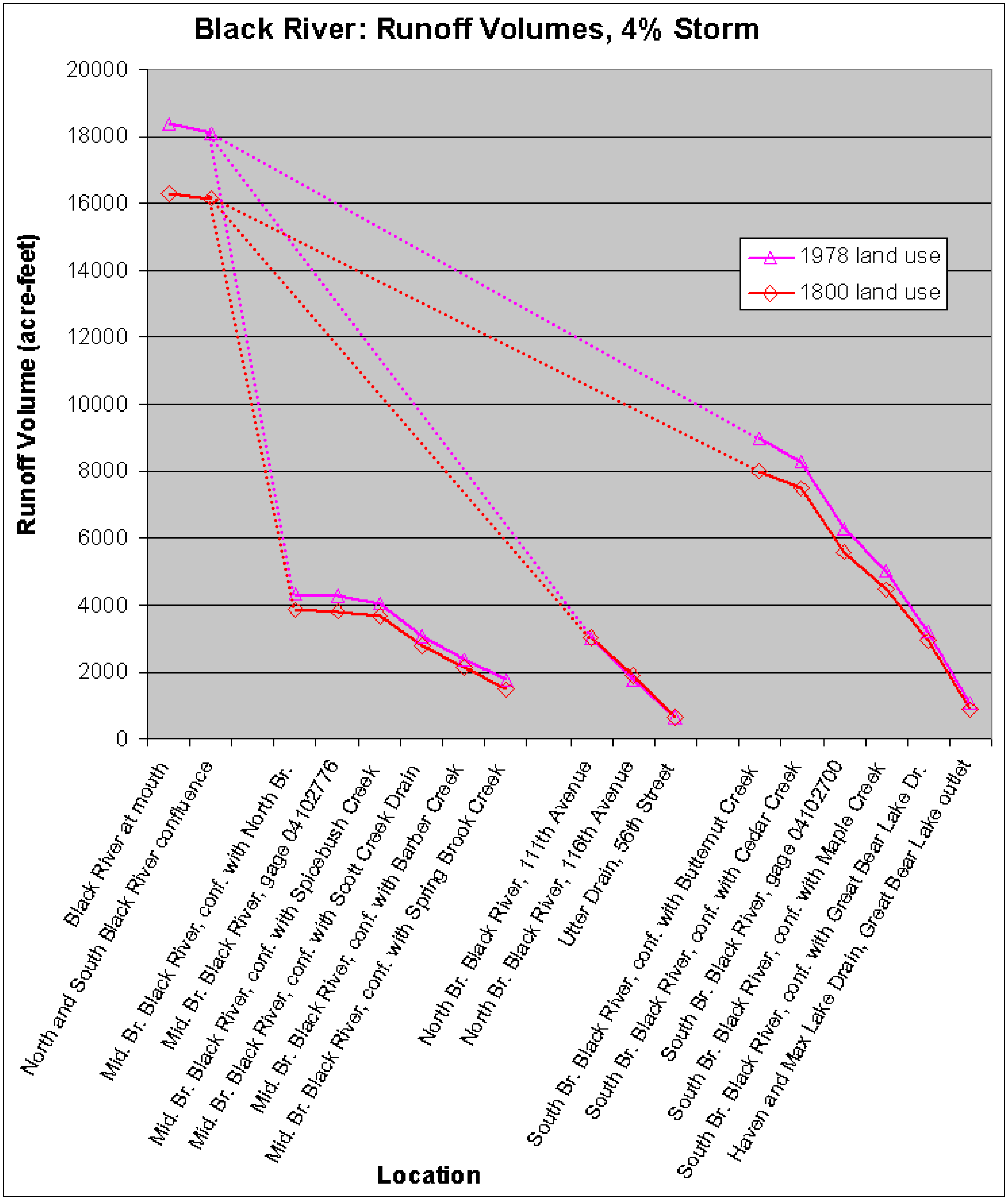


Figure 11: Predicted runoff volumes, 4 percent chance storm

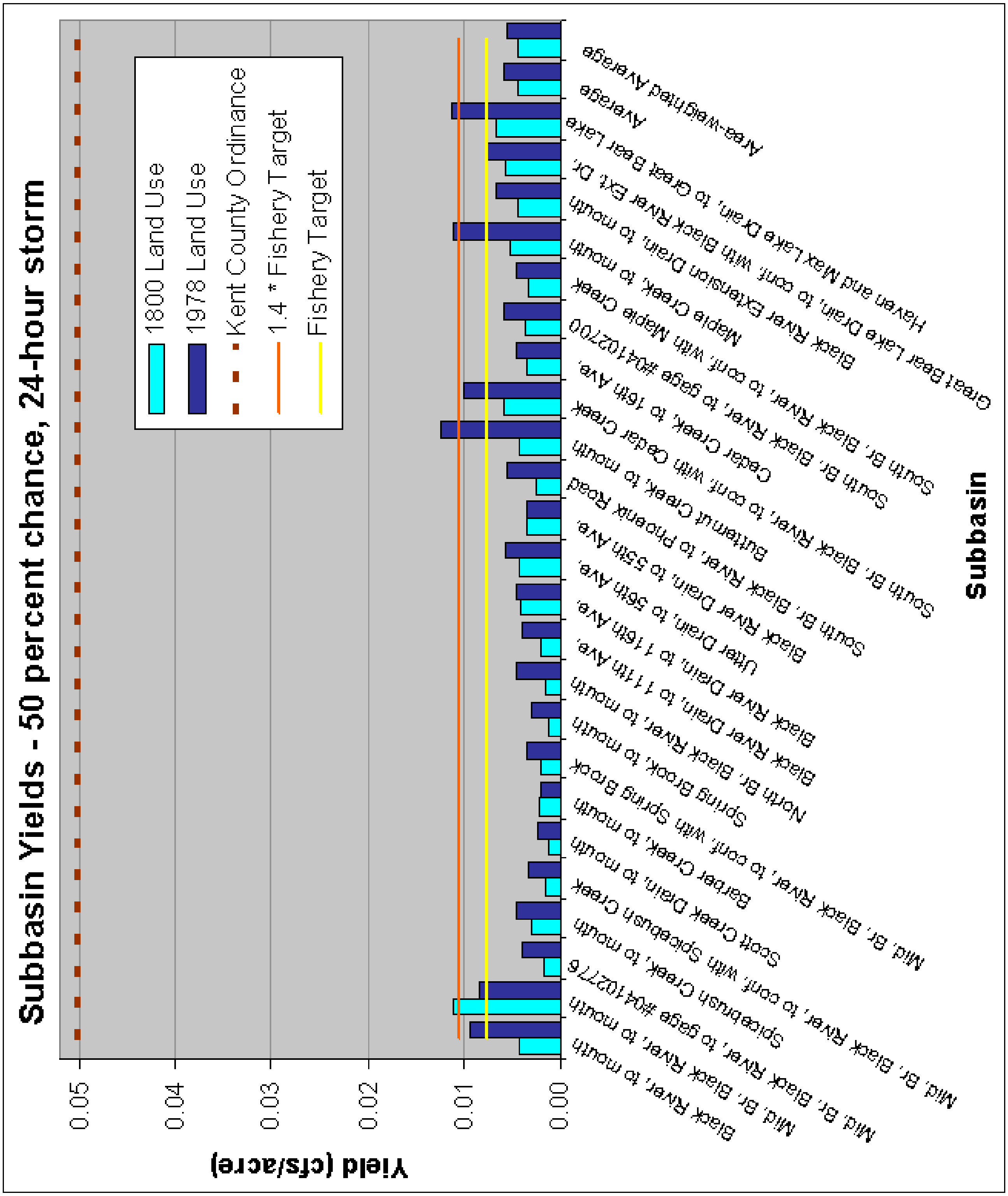


Figure 12: Subbasin Yields, 50 percent chance, 24-hour storm

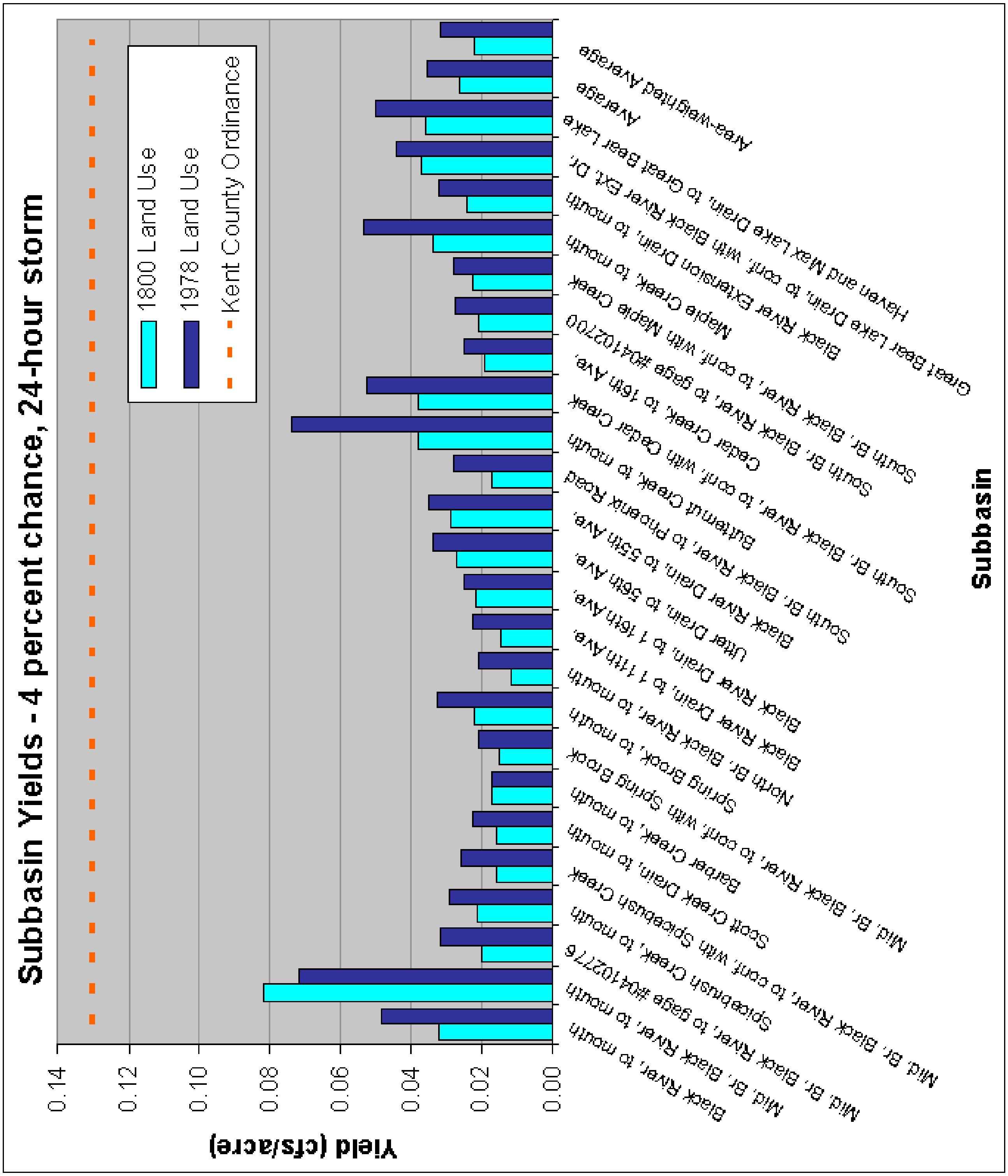


Figure 13: Subbasin Yields, 4 percent chance, 24-hour storm

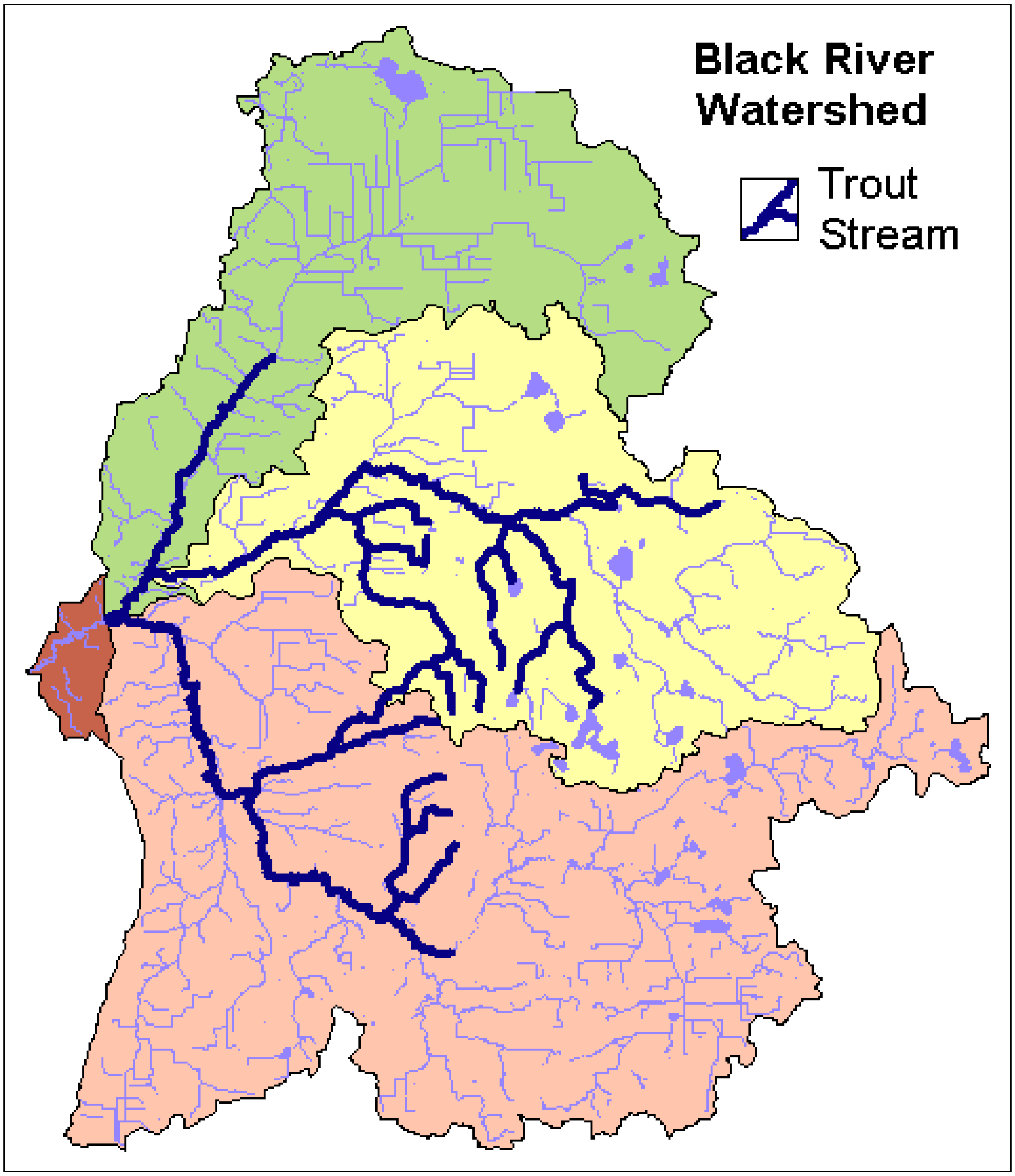


Figure 14: Black River Watershed Trout Streams

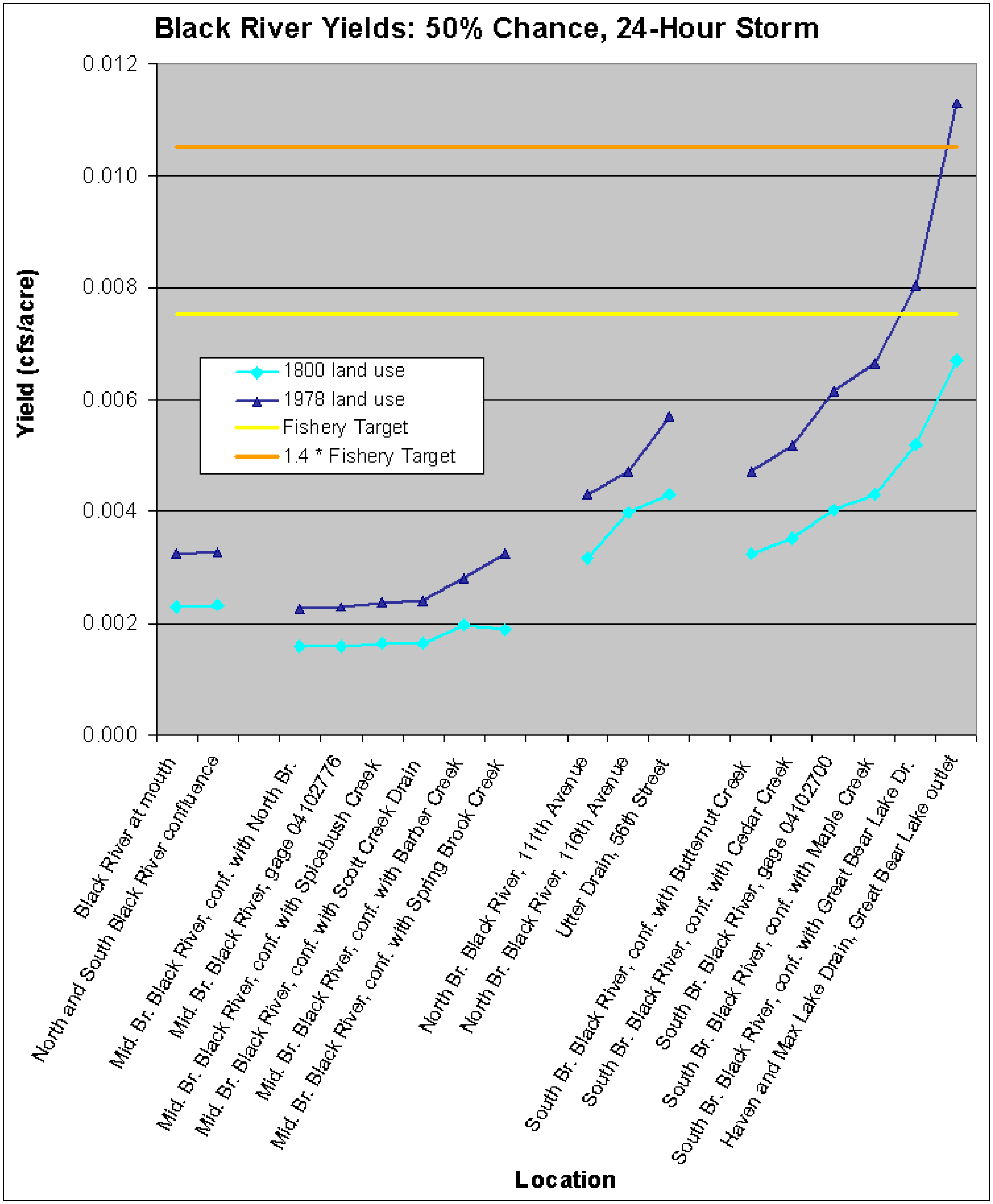


Figure 15: Black River Yields, 50 percent chance, 24-hour storm

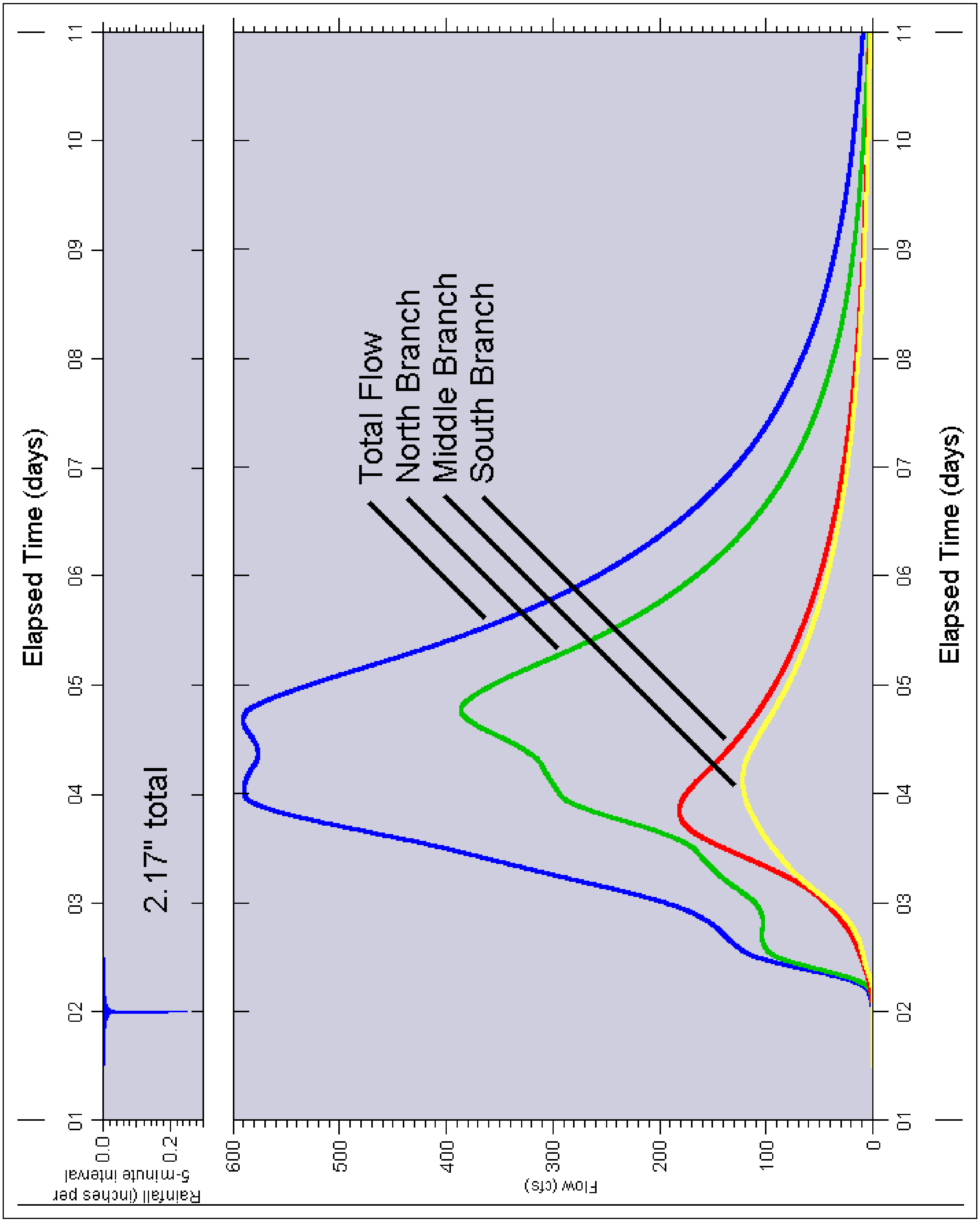


Figure 16: 50 percent chance, 24-hour storm hydrograph for Black River

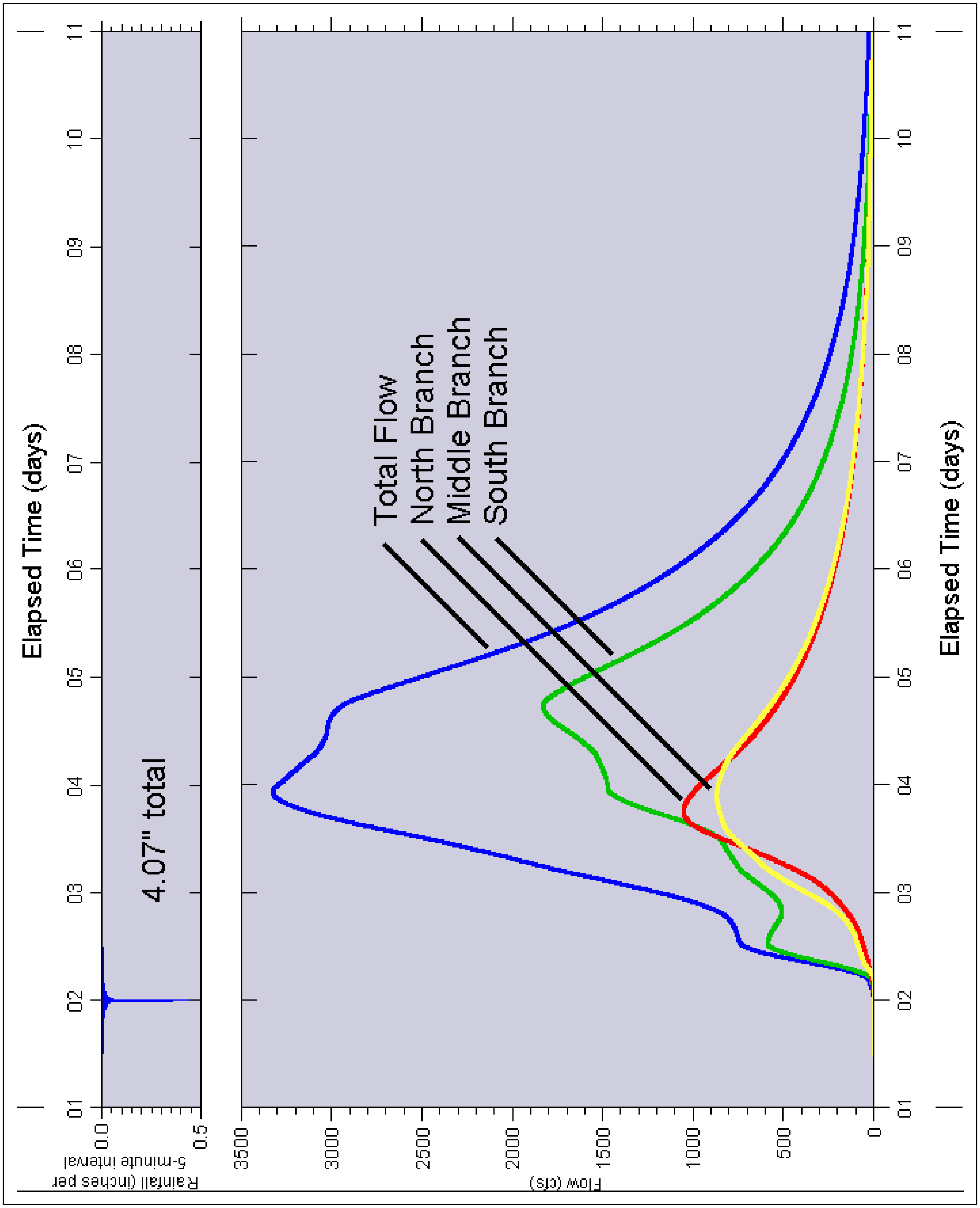


Figure 17: 4 percent chance, 24-hour storm hydrograph for Black River

Table 2: Peak flows and runoff volumes per subbasin

Subbasin			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
B1	Black River, to mouth	3.6	1800	10	75	0.004	0.03	28	186
			1978	22	113	0.009	0.05	60	267
BM1	Mid. Br. Black River, to mouth	0.9	1800	7	49	0.011	0.08	8	50
			1978	5	43	0.008	0.07	6	45
BM2	Mid. Br. Black River, to gage #04102776	4.6	1800	5	59	0.002	0.02	16	169
			1978	11	92	0.004	0.03	27	206
BM2SC	Spicebush Creek, to mouth	11.2	1800	21	151	0.003	0.02	98	606
			1978	33	209	0.005	0.03	110	640
BM3	Mid. Br. Black River, to conf. with Spicebush Creek	7.1	1800	7	72	0.001	0.02	30	284
			1978	16	119	0.003	0.03	48	343
BM3aSCD	Scott Creek Drain, to mouth	17.1	1800	14	174	0.001	0.02	60	637
			1978	26	247	0.002	0.02	85	728
BM3bBC	Barber Creek, to mouth	13.3	1800	19	148	0.002	0.02	101	677
			1978	17	147	0.002	0.02	77	601
BM4	Mid. Br. Black River, to conf. with Spring Brook	24.7	1800	33	239	0.002	0.02	210	1318
			1978	56	326	0.004	0.02	300	1563
BM4SB	Spring Brook, to mouth	4.9	1800	4	70	0.001	0.02	11	158
			1978	10	103	0.003	0.03	21	195
BN1	North Br. Black River, to mouth	16.0	1800	16	116	0.002	0.01	116	786
			1978	47	214	0.005	0.02	283	1217
BN2	Black River Drain, to 111th Ave.	20.6	1800	26	192	0.002	0.01	173	1094
			1978	51	299	0.004	0.02	226	1236
BN3	Black River Drain, to 116th Ave.	13.7	1800	35	189	0.004	0.02	218	995
			1978	40	220	0.005	0.03	185	910
BN4	Utter Drain, to 56th Ave.	10.3	1800	28	178	0.004	0.03	126	650
			1978	37	222	0.006	0.03	126	650
BN4UD	Black River Drain, to 55th Ave.	5.4	1800	12	99	0.003	0.03	41	274
			1978	12	121	0.004	0.04	23	214
BS1	South Br. Black River, to Phoenix Road	8.3	1800	14	92	0.003	0.02	80	469
			1978	29	146	0.006	0.03	124	579
BS1aBC	Butternut Creek, to mouth	10.9	1800	30	263	0.004	0.04	73	523
			1978	86	514	0.012	0.07	133	689
BS2	South Br. Black River, to conf. with Cedar Creek	9.1	1800	34	221	0.006	0.04	89	516
			1978	58	304	0.010	0.05	135	633
BS2CC	Cedar Creek, to 16th Ave.	21.6	1800	48	264	0.003	0.02	287	1426
			1978	64	347	0.005	0.03	264	1367
BS3	South Br. Black River, to gage #04102700	16.4	1800	39	216	0.004	0.02	220	1090
			1978	62	286	0.006	0.03	295	1263
BS4	South Br. Black River, to conf. with Maple Creek	12.0	1800	26	174	0.003	0.02	118	685
			1978	35	215	0.005	0.03	132	723

Subbasin			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
BS4MC	Maple Creek, to mouth	14.1	1800	47	303	0.005	0.03	156	851
			1978	100	481	0.011	0.05	254	1088
BS5ED	Black River Extension Drain, to mouth	24.2	1800	70	373	0.005	0.02	391	1770
			1978	103	500	0.007	0.03	434	1858
BS5GBLD	Great Bear Lake Drain, to conf. with Black River Ext. Dr.	4.4	1800	16	104	0.006	0.04	54	281
			1978	21	126	0.008	0.04	60	295
BS6GBL	Haven and Max Lake Drain, to Great Bear Lake	12.2	1800	52	280	0.007	0.04	200	894
			1978	88	390	0.011	0.05	281	1071
	Average		1800			0.004	0.026		
			1978			0.006	0.036		
	Area-weighted Average		1800			0.004	0.022		
			1978			0.006	0.032		

Table 3: Peak flows and runoff volumes in Black River

River Location			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
J1	Black River at mouth	286	1800	421	2555	0.002	0.014	2864	16281
			1978	594	3340	0.003	0.018	3676	18358
J2	North and South Black River confluence	283	1800	420	2544	0.002	0.014	2847	16126
			1978	591	3325	0.003	0.018	3620	18102
JM 1	Mid. Br. Black River, conf. with North Br.	84	1800	84	705	0.002	0.013	528	3883
			1978	122	869	0.002	0.016	671	4313
JM 2	Mid. Br. Black River, gage 04102776	83	1800	84	705	0.002	0.013	521	3834
			1978	122	869	0.002	0.016	665	4268
JM 3	Mid. Br. Black River, conf. with Spicebush Creek	78	1800	82	684	0.002	0.014	507	3671
			1978	119	846	0.002	0.017	640	4066
JM 3a	Mid. Br. Black River, conf. with Scott Creek Drain	60	1800	63	529	0.002	0.014	379	2783
			1978	92	647	0.002	0.017	482	3083
JM 3b	Mid. Br. Black River, conf. with Barber Creek	43	1800	53	417	0.002	0.015	321	2151
			1978	77	511	0.003	0.019	398	2358
JM 4	Mid. Br. Black River, conf. with Spring Brook Creek	30	1800	36	279	0.002	0.015	221	1476
			1978	61	375	0.003	0.020	321	1758
JN 2	North Br. Black River, 111th Avenue	50	1800	100	654	0.003	0.020	557	3011
			1978	138	853	0.004	0.027	560	3011
JN 3	North Br. Black River, 116th Avenue	29	1800	74	464	0.004	0.025	385	1919
			19	8	56	0.0	0.0	33	1775

			78	8	1	05	30	3	
JN 4a	Upper Black River Drain, 55th Street	5	1800	12	99	0.003	0.029	41	274
			1978	12	121	0.004	0.035	23	214
JN 4b	Utter Drain, 56th Street	10	1800	28	178	0.004	0.027	126	650
			1978	37	222	0.006	0.034	126	650
JS 1	South Br. Black River, conf. with Butternut Creek	125	1800	260	1430	0.003	0.018	1574	8003
			1978	376	1783	0.005	0.022	1986	8986
JS 2	South Br. Black River, conf. with Cedar Creek	114	1800	257	1420	0.004	0.019	1509	7499
			1978	376	1783	0.005	0.024	1855	8298
JS 3	South Br. Black River, gage 04102700	83	1800	214	1198	0.004	0.022	1135	5560
			1978	329	1549	0.006	0.029	1455	6297
JS 4	South Br. Black River, conf. with Maple Creek	67	1800	184	1040	0.004	0.024	917	4476
			1978	284	1355	0.007	0.032	1161	5034
JS 5	South Br. Black River, conf. with Great Bear Lake Dr.	41	1800	135	739	0.005	0.028	645	2945
			1978	209	993	0.008	0.038	775	3224
JS 6	Haven and Max Lake Drain, Great Bear Lake outlet	12	1800	52	280	0.007	0.036	200	894
			1978	88	390	0.011	0.050	281	1071

Appendix

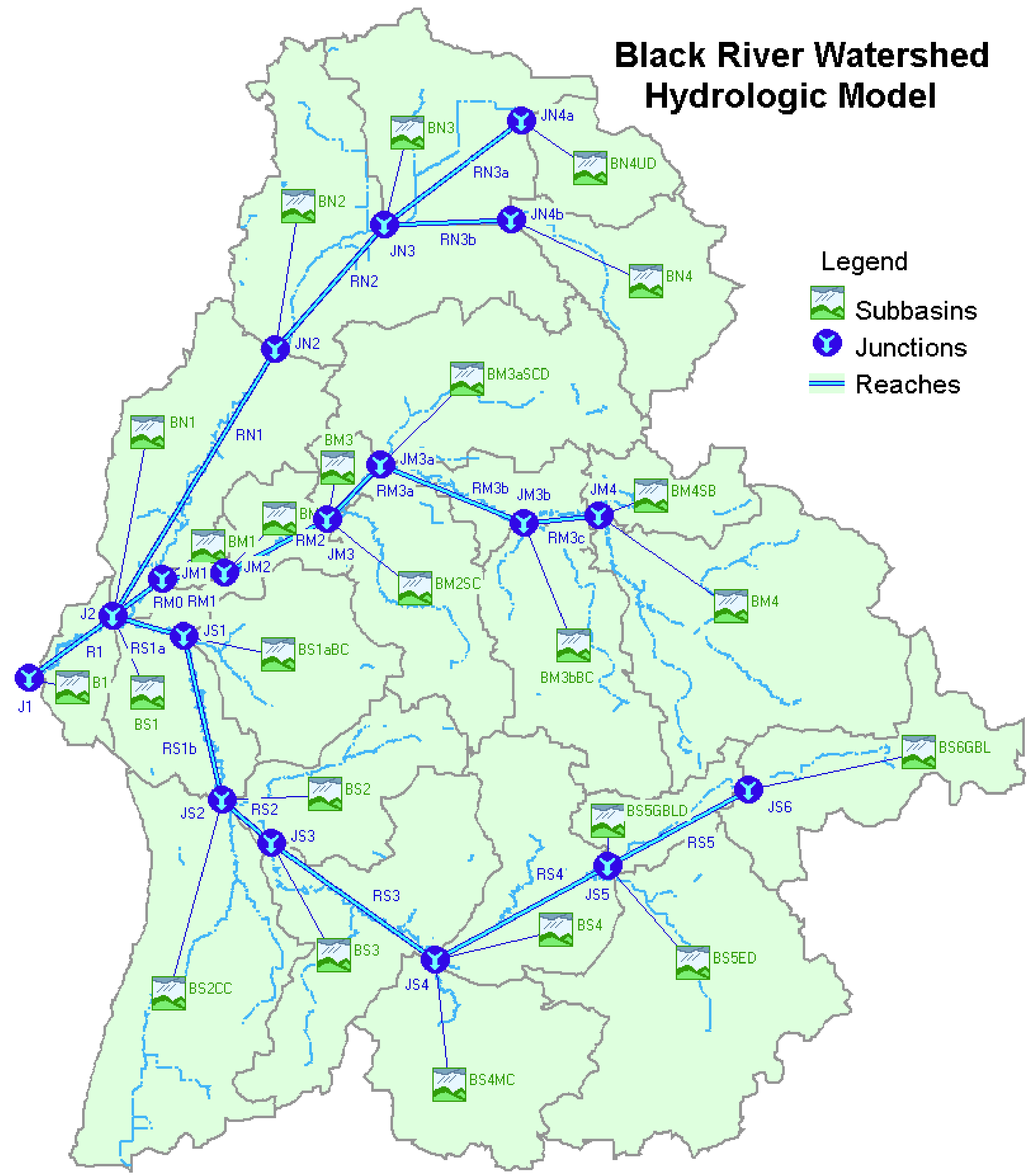
Appendix A: Black River Hydrologic Model Parameters

This appendix is provided so that the model may be recreated. Table A1 provides the design rainfall values specific to the region of the state where the Black River is located. Figure A1 summarizes the hydrologic elements in the HEC-HMS model. Tables A2 and A3 provide the parameters that were specified for each of these hydrologic elements. The initial loss field in HEC-HMS is left blank so that the default equation based on the curve number is used. Table A4 provides the reach parameters for the lag routing method. HEC-HMS was run for a ten-day duration using a five-minute computation interval.

Table A1: Design Rainfall Values

SCS Type II Precipitation Event	**Precipitation**	**Area-adjusted Precipitation ***
50% chance (2-year), 24-hour storm	2.37 inches	2.17 inches
4% chance (25-year), 24-hour storm	4.45 inches	4.07 inches

*standard values were multiplied by 0.914 to account for the watershed size



B1, Black River, to mouth
BM1, Mid. Br. Black River, to mouth
BM2, Mid. Br. Black River, to gage #04102776
BM2SC, Spicebrush Creek, to mouth
BM3, Mid. Br. Black River, to conf. with Spicebush Creek
BM3aSCD, Scott Creek Drain, to mouth
BM3bBC, Barber Creek, to mouth
BM4, Mid. Br. Black River, to conf. with Spring Brook
BM4SB, Spring Brook, to mouth
BN1, North Br. Black River, to mouth
BN2, Black River Drain, to 111th Ave.
BN3, Black River Drain, to 116th Ave.
BN4, Utter Drain, to 56th Ave.
BN4UD, Black River Drain, to 55th Ave.
BS1, South Br. Black River, to Phoenix Road
BS1aBC, Butternut Creek, to mouth
BS2, South Br. Black River, to conf. with Cedar Creek
BS2CC, Cedar Creek, to 16th Ave.
BS3, South Br. Black River, to gage #04102700
BS4, South Br. Black River, to conf. with Maple Creek
BS4MC, Maple Creek, to mouth
BS5ED, Black River Extension Drain, to mouth
BS5GBLD, Great Bear Lake Drain, to conf. with Black River Ext. Dr.
BS6GBL, Haven and Max Lake Drain, to Great Bear Lake

Figure A1: Hydrologic Elements defined for HEC-HMS model

Table A2: Subbasin Parameters – Area, Curve Number, Initial Loss

Subbasins		Drainage Area (sq. mi.)	Runoff Curve Number		Initial Loss
ID	Description		1800	1978	
B1	Black River to mouth	3.64	63	70	
BM1	Middle Branch Black River to mouth	0.93	64	62	Default
BM2	Middle Branch Black River at gage #04102776	4.56	58	61	Default
BM2SC	Spicebush Creek to mouth	11.23	64	65	Default
BM3	Middle Branch Black River at confluence with Spicebush Creek	7.14	59	62	Default
BM3aSCD	Scott Creek Drain to mouth	17.14	58	60	Default
BM3bBC	Barber Creek to mouth	13.28	63	61	Default
BM4	Middle Branch Black River to confluence with Spring Brook	24.70	64	67	Default
BM4SB	Spring Brook to mouth	4.91	56	59	Default
BN1	North Branch Black River to mouth	15.96	63	71	Default
BN2	Black River Drain to 111th Avenue	20.55	64	66	Default
BN3	Black River Drain to 116th Avenue	13.66	70	68	Default
BN4	Utter Drain to 56th Avenue	10.26	67	67	Default
BN4UD	Black River Drain to 55th Avenue	5.38	63	59	Default
BS1	South Branch Black River to Phoenix Road	8.27	65	69	Default
BS1aBC	Butternut Creek to mouth	10.87	62	67	Default
BS2	South Branch Black River to confluence with Cedar Creek	9.05	65	69	Default
BS2CC	Cedar Creek to 16th Avenue, gage #04102720	21.58	68	67	Default
BS3	South Branch Black River to Gage #04102700	16.42	68	71	Default
BS4	South Branch Black River to confluence with Maple Creek	12.01	65	66	Default
BS4MC	Maple Creek to mouth	14.14	66	71	Default
BS5ed	Black River Extension Drain to mouth	24.16	70	71	Default
BS5GBLD	Great Bear Lake Drain to confluence with Black River Extension Drain	4.43	67	68	Default
BS6GBL	Haven and Max Lake Drain to Great Bear Lake	12.18	70	74	Default
	Total	286			

Table A3: Subbasin Parameters – Times of Concentration and Storage Coefficients

Subbasin ID	Land Use Scenario	Time of Concentration (hours)	Storage Coefficient	
			50% chance, 24-hour storm	4% chance, 24-hour storm
B1	1800	11.18	23.41	19.03
	1978		21.52	18.03
BM1	1800	5.35	5.35	5.35
	1978		5.35	5.35
BM2	1800	12.53	27.61	22.86
	1978		17.72	15.99
BM2SC	1800	17.18	43.30	35.40
	1978		27.21	24.43
BM3	1800	17.33	40.97	34.23
	1978		24.36	22.21
BM3aSCD	1800	14.48	39.35	31.66
	1978		27.59	23.55
BM3bBC	1800	18.95	51.28	41.44
	1978		42.29	35.68
BM4	1800	24.39	62.28	51.51
	1978		49.19	42.41
BM4SB	1800	7.64	22.19	16.65
	1978		16.53	12.80
BN1	1800	37.51	72.77	63.45
	1978		51.83	48.03
BN2	1800	24.40	65.81	53.76
	1978		38.01	34.64
BN3	1800	20.03	63.21	49.65
	1978		42.17	36.15
BN4	1800	13.58	41.29	31.97
	1978		28.53	23.77
BN4UD	1800	9.38	31.23	22.56
	1978		12.44	11.19
BS1	1800	25.45	53.09	45.74
	1978		34.58	32.13
BS1aBC	1800	7.37	19.25	13.91
	1978		8.73	8.00
BS2	1800	11.03	20.61	17.51
	1978		17.14	14.96
BS2CC	1800	25.98	57.45	49.38
	1978		33.77	31.72
BS3	1800	25.86	52.01	45.08
	1978		40.92	37.40
BS4	1800	17.52	40.94	34.26
	1978		31.88	27.83
BS4MC	1800	11.30	28.41	22.70
	1978		19.56	16.95
BS5ed	1800	19.16	54.25	43.65
	1978		36.68	31.66

Subbasin ID	Land Use Scenario	Time of Concentration (hours)	Storage Coefficient	
			50% chance, 24-hour storm	4% chance, 24-hour storm
BS5GBLD	1800	9.43	29.44	21.62
	1978		22.97	17.89
BS6GBL	1800	12.46	34.33	27.09
	1978		26.73	22.19

Table A4: Channel Reach Parameters

ID	Reach	Lag (minutes)
R1	Black River, to mouth	398
RN1	North Branch Black River, to confluence with South Branch	924
RN2	North Branch Black River, to 111th Avenue	454
RN3a	North Branch Black River, to 116th from Upper Black River Drain	562
RN3b	North Branch Black River, to 116th from Utter Drain	194
RM0	Middle Branch Black River, to confluence with South Branch	238
RM1	Middle Branch Black River, to confluence with North Branch	71
RM2	Middle Branch Black River, to gage 04102776	533
RM3a	Middle Branch Black River, to confluence with Spicebush Creek	200
RM3b	Middle Branch Black River, to confluence with Scott Creek Drain	564
RM3c	Middle Branch Black River, to confluence with Barber Creek	225
RS1a	South Branch Black River, to confluence with North Branch	299
RS1b	South Branch Black River, to confluence with Butternut Creek	809
RS2	South Branch Black River, to confluence with Cedar Creek	247
RS3	South Branch Black River, to gage 04102700	788
RS4	South Branch Black River, to confluence with Maple Creek	738
RS5	South Branch Black River, to confluence with Great Bear Lake Drain	380

Appendix O: Black River Morphology Report

Black River Morphology Report
Kregg Smith, Michigan Department of Natural Resources
April 2005

For most of Michigan's streams, the physical and ecological processes that determine channel conditions have been degraded by human activities to the detriment of the aquatic resource. Most watersheds have been perturbed to some extent. Civilization's modern requirements for a host of different resource uses have placed great stress on many flowing river systems. Balancing these resource activities of the river and the ability to predict the response of the river to imposed damage requires reliable predictions to clearly understand the functions of the river and the physical variables which influence river behavior. Clearly, it is impossible to restore entire river systems to their conditions prior to initial settlement of the watershed. However, restoration can be defined as movement of an ecosystem toward an approximation (not necessarily a re-creation) of its condition prior to disturbance.

An assessment of the morphological stability of a river system is an important step in selecting remediation techniques for water quality and fisheries impairments. Morphologically described stream types based on field measurements are described by Rosgen (1994, 1996). The use of reference reach data, characteristic of the stable channel morphology in a particular valley type, can provide design variables for applications in stream restoration. Rosgen describes an assortment of stream types delineated by slope, channel material, width/depth ratios, sinuosity, and entrenchment ratio. Entrenchment ratio is the ratio of the width of the flood-prone area to the surface width of the bankfull channel, and provides a quantitative description of the vertical containment of the river. Sinuosity is the measurement of a streams meandering pattern and defined as the ratio of stream length to valley length. Width/depth ratios are described as the ratio of the bankfull surface width to the mean depth of the bankfull channel and an important variable to understand the distribution of available energy within a channel. Width/depth ratios are the most sensitive and positive indicator of trends in channel stability and can be used to interpret shifts in channel stability following disturbances to channels or watersheds. The stream types are described at the morphological description stage (Level II) of Rosgen's hierarchical classification system. This classification system groups variables of similar stream morphology to reduce statistical variance between the groups. Rosgen utilizes four fundamental principles of river systems: bankfull discharge; stream channel dimension, pattern, and profile.

Several objectives of the Black River Watershed Management Plan and watershed stakeholders involve achievement of a natural stream channel to restore the Black River to a functioning river system. The stability of a stream is a major determinant of its condition and a prerequisite for its optimum functioning. Stream stability as defined by Rosgen (1996) as the ability of the stream to maintain, over time, its dimension, pattern, and profile in such a manner that it is neither aggrading nor degrading. Therefore we used the Rosgen classification system to describe the current state of six locations of the Black River in Allegan and Van Buren Counties. An assessment of condition was determined by the level III and IV Rosgen methodology. The study design was established to assist in the assessment of cumulative watershed impacts, provide a method to utilize sediment data, bank erosion, and stability predictions for future implementation phases and will be integrated with inventories of fish habitat potential.

We used the Shield's threshold of motion equation to calculate the sediment particle size that would be transported given bankfull discharges. The following equation summarizes our calculations:

$$Ds = t / ((p_s - p)\ g\ 0.06)\ (304.8)$$

Ds=diameter sediment particle (mm)
t=shear stress= (pg) (depth) (slope) (lb/ft2) (N/m2)
p_s =density of sediment (5.15 slugs/ft3) or (2560 kg/m3)
p=density of water (1.94 slugs/ft3) (1000 kg/m3)
g=gravitational acceleration (32.2 ft/s2) (9.81 m/s2)
0.06 = Shield's parameter typically in the range of 0.04 to 0.07
Conversion Constant 304.8 mm/ft or 1000 mm/m

The first site selected was in the North Branch Black River near the 68th Street and 108th Avenue intersection. This location is in section 16 of Casco Township, Allegan County. The second location was in the Middle Branch Black River near the 60th Street and 106th Avenue intersection. The second location is centrally located between Casco and Lee Townships, Allegan County. The third location was in the South Branch Black River below Hamilton Street in the city of Bangor, Van Buren County. These three locations were surveyed on the 13 and 14 May, 2004. During the fall of 2004 three additional sites were surveyed. Another location in the Middle Branch at 68th Street was surveyed in section 27 of Casco Township, Allegan County. A stream reach in the Haven and Max Lake Drain located in section 16 of Bloomingdale Township, Van Buren County was also surveyed. The third fall survey was conducted in the South Branch at the Phoenix Road crossing in section 6 of Geneva Township, Van Buren County.

Spring Reaches:

The North Branch reach was classified as E5 (Table 1). This reach is located within a lacustrine valley dominated by small sediment particle sizes. Stream types with an E classification are defined as the developmental "end-point" of channel stability and fluvial process efficiency for certain alluvial streams undergoing a natural dynamic sequence of system evolution (Rosgen, 1996). It should be noted that these classifications have been widely justified in other parts of the U.S. but has not been justified for Michigan streams and therefore the following descriptions are based on Rosgen's delineative criteria. The E stream types are typically slightly entrenched with an entrenchment ratio greater than 2.2, these streams exhibit low channel width/depth ratios (<12), and display very high channel sinuosity (>1.5). The North Branch was slightly entrenched (19.7) as it flowed through a forested floodplain. The width/depth ratio was 10.7 with a lower channel sinuosity (1.1) than is typical for this type of stream. The slope (0.002) and channel bed material (Glendora Loamy Sand) classify the stream as E5. Rosgen (1996) notes that the E5 stream type are hydraulically efficient channel forms and they maintain a high resistance to form adjustment that results in channel stability without significant downcutting. Shear stress calculated for this stream reach indicated a high (0.77 lbs/ft. sq.) near bank stress rating (Table 1). At the measured channel slope and average bankfull depth, the particle diameter mobilized at bankfull discharges was calculated at 25 mm. Stream channels of type E are stable unless compromised by disturbances that change sediment supply or streamflow. A hydrology study currently being done could provide valuable information to the validity of these findings.

Both the Middle (60th Street) and South Branch (Hamilton St.) reaches were classified as C5 (Table 1). The Middle Branch flows through a lacustrine valley dominated by sand, while the South Branch reach was located in a valley with surface geology types consisting of fine textured glacial till and end Moraines of fine textured till. Upstream of this reach in the South Branch Black River coarser material of glacial till and end moraines are found, where presently the Bangor and Breedsville Dams are located. Rosgen describes the C stream type as having a well developed floodplain, relatively sinuous, and having a low relief channel. The South Branch reach had a slope of 0.0028, while the Middle Branch had a slope of 0.003. These stream reaches had lower than average width/depth ratios of 13.39 for the Middle Branch and 14.83 for the South Branch. Sinuosity's for both reaches were also lower than average for the Middle Branch (1.57) and particularly the South Branch (1.2). The Middle Branch reach was dominated by channel bed material of the Glendora Loamy Sand association identifying this reach as C5. The downstream section of the South Branch reach was dominated by channel bed materials associated with the Glendora Sandy Loam association, however, evidence of cobble was observed at the upstream section of the reach below the Hamilton Street Bridge. Shear stress calculations for the South Branch (0.45 lbs/ft.sq.) and Middle branch (0.47 lbs/ft.sq.) reaches indicated a moderate near bank stress rating (Table 1). At the measured channel slope and average bankfull depth, the particle diameter mobilized at bankfull discharges was calculated at 22 and 23 mm, respectively. Stream channels with a classification of C5 typically have a higher width/depth ratio than preceding C stream types because of the depositional nature of these streambed materials and the susceptibility for active lateral migration. Rates of lateral migration are influenced by the presence and condition of the riparian vegetation, in which sediment supply could be high unless stream-banks are in a very low erodibility condition. Maintenance of the riparian vegetation along this stream reach is important. Establishing a native prairie buffer would reduce sediment supply and therefore reduce the abrasive power applied to the eroding streambank locations. Attempts to stabilize the eroding banks at Lion's Park in the city of Bangor would be best accomplished using the information and data collected during this survey. According to the stream channel dimension and profiles in this reach, appropriate structures include a cross-vane, soil lifts, and regrading. The C5 stream type is very susceptible to changes in lateral and vertical stream stability caused by direct channel disturbances that change the flow and sediment regimes of the watershed.
Restoring natural stability using design criteria collected during this initial survey will ensure that channel adjustments will be limited to the predicted conditions of the stream channel characteristics and existing flow regime.

Fall Reaches:

Haven and Max Lake Drain flows within a valley with surface geology consisting of coarse textured glacial till. This reach was classified as E5 (Table 1). Shear stress calculations indicated a moderate near bank stress rating (0.54 lbs/ft. sq.). At the measured channel slope and average bankfull depth, the particle diameter mobilized at bankfull discharges was calculated at 27 mm. Width to depth ratio for this stream was measured at an expected low ratio (<12) for this stream type. Stream reaches with lower width to depth ratios generally do not experience stress placed within the near bank region. Sinuosity for this reach was normal for a type E stream classification. Evidence of lateral migration of the stream bank was present at this site, but could be related to anthropogenic factors. Stream bank stabilization structures that are engineered to restore the natural stability of this stream reach would allow for the function of the stream to be achieved along with reaching societal values at the land use site. Information and data collected during this survey can be used to determine the departure of existing conditions from previous conditions and to determine the channel dimensions that need to be restored. Appropriate structures that we propose to achieve the stability at this stream reach are soil lifts and stone toe protection wrapped in natural materials and seeded with native grass plantings. Several land use problems located at this site could be preventing the stream from achieving a stable form, including an inappropriately designed road crossing structure at 42nd Street and the parking lot adjacent to the stream. Most of the instream changes in stream channel design could be a result of stormwater runoff that is transporting excess sediment to the Haven and Max Lake Drain. Wetland filters and native prairie buffers would allow for the infiltration of stormwater runoff and deposit sediment so that it does not enter the stream at excessive rates.

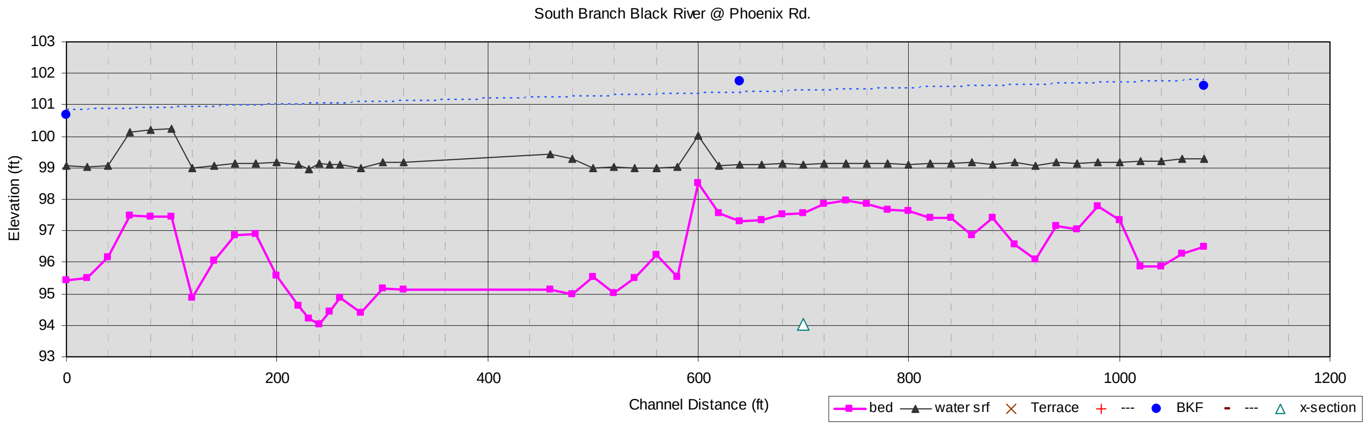
The Middle Branch reach at 68th Street was confined as it flowed through a valley with surface geology consisting of lacustrine sand. This stream reach was classified as a type F5 (Table 1). The F5 stream type is sand dominated, entrenched, meandering channel, resulting in the abandonment of former floodplains. Sediment supply in this stream type is generally moderate to high. Therefore, the ecology of this stream reach depends on downstream floodplains to dissipate stream power and deposit its suspended sediment load. Width to depth ratios in this stream reach were moderate (11.2) with moderate sinuosity measured at 1.32. Shear stress calculations for this reach were 0.57 lbs./ft^2. Stream bank erosion rates can be moderate to high in this reach as side slope rejuvenation and mass-wasting processes attempt to enhance the fluvial entrainment of eroded bank materials. At the measured channel slope and average bankfull depth, the particle diameter mobilized at bankfull discharges was calculated at 19 mm. This particle size can be easily transported with only minor changes to the hydrology in the watershed.

The South Branch reach at Phoenix Road flows through a valley with lacustrine sand deposits. This stream reach was classified as an F6 stream type (Table 1). Upstream of the measured channel reach the streambed sediment consists of cohesive sand deposits. However, the measured stream reach consisted of unconsolidated silts and sands, likely a result of anthropogenic disturbance. The F6 stream type is associated with depositional soils involving a combination of river downcutting and/or uplift of the valley walls (Rosgen 1996). F6 stream systems produce relatively low bedload, but high suspended load, sediment yields because of the lack of coarse material in the channels. Shear stress calculations at this reach were 1.17 lbs./ft^2, indicating a high erodibility force. At the measured channel slope and average bankfull depth, the particle diameter mobilized at bankfull discharges was calculated at 12 mm. This stream reach illustrates the impacts that poor land use practices have on stream profile and dimension. The stream crossing at Phoenix Road has a steel sheet-piling wall that directs the stream flow under the structure. The longitudinal profile illustrates an example of unstable streambed conditions typically called a dune and anti-dune effect (Figure 1). This condition results in excessive stream sediment transport as the streambed attempts to recover after disturbance. These stream types are very sensitive to disturbance and adjust rapidly to changes in flow regime and sediment supply from the watershed. Future data collection at this site will allow for the determination of impacts to stream habitat and changes in stream profile after disturbance.

Table 1. River delineation data collected at six stream reaches in the Black River watershed.

Waterbody	location	Entrenchment Ratio	Width/depth Ratio	Sinuosity	Slope Ft./ft.	Channel Material	Stream Type	Shear Stress Lbs./ft.sq.
North Branch	68 St.	19.7	10.7	1.1	0.002	Glendora Loamy Sand	E5	0.77
Middle Branch	60St.	>2.2	13.39	1.57	0.002	Glendora Loamy Sand	C5	0.47
South Branch	Hamilton St.	>2.2	14.83	1.2	0.002	Glendora Sandy Loam	C5	0.45
Haven/Max Lake Drain	42 St.	>2.2	8.41	1.47	0.003	Algansee-Cohoctah	E5	0.54
South Branch	Phoenix Rd.	<1.4	6.2	1.13	0.0004	Algansee-Cohoctah	F6	1.17
Middle Branch	68 St.	<1.4	11.2	1.32	0.0013	Glendora Loamy Sand	F5	0.57

Figure 1. Longitudinal profile of the South Branch Black River at Phoenix Road.



Appendix P: National Pollutant Discharge Elimination System (NPDES) Permits

Name	City	County	Expiration Date	Permit Type
Organic/LaGrange Inc	Fennville	Allegan	10/1/2008	NPDES
Fennville WWSL	Fennville	Allegan	4/1/2009	NPDES
MDEQ-RRD-Pullman	Pullman	Allegan	10/1/2003	NPDES
Inverness Castings-Bangor	Bangor	Van Buren	10/1/2008	NPDES
Bangor Electronics-Bangor	Bangor	Van Buren	4/1/2008	NPDES
Bangor WWSL	Bangor	Van Buren	4/1/2009	NPDES
Pullman Ind Inc-Bloomingdale	Bloomingdale	Van Buren	4/1/2008	NPDES
CECO-Palisades Power Plant	Covert	Van Buren	10/1/2003	NPDES
Covert Gen Co/South Haven WTP	Covert	Van Buren	10/1/2003	NPDES
Covert Public Schools WWSL	Covert	Van Buren	4/1/2009	NPDES
Country Holiday Estates MHP	Paw Paw	Van Buren	4/1/2009	NPDES
South Haven WWTP	South Haven	Van Buren	10/1/2003	NPDES
Trelleborg YSH Inc-S Haven	South Haven	Van Buren	10/1/2008	NPDES
MDEQ-RRD-Jericho	South Haven	Van Buren	10/1/2008	NPDES
Application Engineering Inc	South Haven	Van Buren	4/1/2008	NPDES
Mich Aluminum Alloys LTD	South Haven	Van Buren	4/1/2008	NPDES
Port of Call West MHC	South Haven	Van Buren	4/1/2009	NPDES
Bangor Electronics-Bangor	Bangor	Van Buren	4/1/2009	NPDES Stormwater
Michigan Slip-Bangor	Bangor	Van Buren	4/1/2009	NPDES Stormwater
Bangor Plastics-Bangor	Bangor	Van Buren	4/1/2009	NPDES Stormwater
Covert Generating Company	Covert	Van Buren	4/1/2009	NPDES Stormwater
All Seasons Marine-South Haven	South Haven	Van Buren	4/1/2007	NPDES Stormwater
B & K Machine Prod-South Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Consumers Concrete-224-S Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Consumers Concrete-7-S Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Clarion Tech Inc-South Haven	South Haven	Van Buren	4/1/2004	NPDES Stormwater
Epworth Mfg Co Inc	South Haven	Van Buren	4/1/2004	NPDES Stormwater
M-140 Auto Parts-South Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Pullman Ind Inc-South Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
South Haven Regional Airport	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Howard Motors-S Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater
Mich Aluminum Alloys LTD	South Haven	Van Buren	4/1/2009	NPDES Stormwater
DSM Pharma Chem-South Haven	South Haven	Van Buren	4/1/2009	NPDES Stormwater

Source: MDEQ 2004

Appendix Q: Education Plan: Black & Paw Paw River Watersheds

Introduction

The Black River Watershed and Paw Paw River Watershed Information & Education (I&E) Plan was formulated through the efforts of the joint information & education sub-committee. This sub-committee consisted of members from both watershed Steering Committees. The purpose of the plan is to provide a framework to inform and motivate the various stakeholders, residents and other decision makers within the Black River and Paw Paw River watersheds to take appropriate actions to protect water quality. This working document will also provide a starting point for organizations within the watersheds looking to provide educational opportunities or outreach efforts.

The geography of the Black River and Paw Paw River watersheds lend themselves to a partnership approach, which has been a focal point for all information and education efforts to date within the watersheds. With both watersheds sharing multiple municipal boundaries as well as many similar water quality concerns, a partnership approach to education and outreach enables both watershed projects to maximize their resources and effectively reach a larger audience than could be accomplished alone.

Information & Education Goal

The I&E plan will help to achieve the watershed management goals by increasing the involvement of the community in watershed protection efforts through awareness, education and action. The watershed community can become involved only if they are informed of the issues and are provided information and opportunities to participate.

The I&E plan lists specific tasks to be completed. These tasks will increase the general awareness of watersheds and water quality issues for all audiences, educate target audiences on specific issues and motivate target audiences to implement practices to improve and protect water quality. These practices may include homeowner activities such as reducing fertilizer use, maintaining septic systems, installing a rain garden or maintaining stream buffers. Practices for governmental units or officials may include incorporating watershed protection language into master plans and zoning ordinances, reducing the amount of salt used for deicing and utilizing low impact development techniques on public property.

Target Audiences

The level of understanding of watershed concepts and management, the concerns, values and level of enthusiasm can all vary between different audience groups. Recognizing differences between groups of target audiences is critical to achieving success through education and outreach efforts. Educational messages may need to be tailored to effectively reach different audiences. It is important to understand key motivators of each target audience to establish messages that will persuade them to adopt behaviors or practices to protect and improve water quality. The table below lists and describes the major target audiences for the Paw Paw and Black River Watersheds and specific messages and activities that could be used to reach each audience.

Target Audiences	Description of Audience	General Message Ideas	Potential Activities
Businesses	This audience includes businesses engaging in activities that can impact water quality such as lawn care companies, landscapers, car washes, etc.	Clean water helps to ensure a high quality of life that attracts workers and other businesses.	Workshops and presentations Brochures/flyers/fact sheets One-on-one contact
Developers / Builders / Engineers	This audience includes developers, builders and engineers.	Water quality impacts property values.	Newsletter articles Workshops and presentations Watershed tours Brochures/flyers/fact sheets Trainings
Farmers	This audience includes both agricultural landowners and those renting agricultural lands and farming them.	Protecting water quality is a long-term investment by saving money by decreasing inputs (fuel, fertilizer)	Workshops and presentations Brochures/flyers/fact sheets One-on-one contact Watershed tours Newsletter articles
Government Officials and Employees	This audience includes elected (board and council members) and appointed (planning commissions and zoning board of appeals) officials of cities, townships, villages and the county. This audience also includes the drain commission and road commission staff. It also includes state and federal elected officials.	Water quality impacts economic growth potential. Water quality impacts property values and the tax revenue generated in my community to support essential services. Clean drinking water protects public health.	One-on-one contact Trainings Workshops and presentations Brochures/flyers/fact sheets Watershed tours Educational videos Watershed Management Plan User Guide
Kids / Students	This audience includes any child living or going to school in the watershed.	Clean water is important for humans and wildlife. We all depend on water.	Student stream monitoring Teacher training workshops Curriculum Educational videos
Property Owners	This audience includes any property owner in the watershed.	Water quality impacts my property value and my health.	PSAs and press releases Display/materials at festivals Workshops and presentations Watershed Tours Tax/utility bill inserts Website/YouTube video Workshops and presentations Brochures/flyers/fact sheets One-on-one contact "Entering the watershed" signs
Riparian Property Owners	This audience includes those property owners that own land along a river, stream, drain or lake.	Water quality impacts my property value and my health.	Newsletter articles Door knob hangers One-on-one contact Videos Workshops and presentations
Recreational Users	This audience includes any person who engages in recreational activities.	Water quality is important for enjoying recreational activities.	Website/YouTube video Kiosks Newsletter articles Brochures/flyers/fact sheets

Watershed Issues

To begin formulating education and outreach strategies, it is important to identify the major issues, which need to be addressed to improve and protect water quality. The priority issues for the Black and Paw Paw River Watersheds are described below. Each of these issues relate back to the goals and actions in the Watershed Management Plans for the Black and Paw Paw Rivers.

Each issue is tied to pollutants of concern in the watersheds. For each issue, the audience(s) will need to not only understand the issue, but also the solutions or actions needed to protect or improve water quality. For each major issue, priority target audiences have been identified. The priority audiences were selected because of their influence or ability to take actions, which would improve or protect water quality.

1. Watershed Awareness

The Paw Paw and Black River Watersheds both have unique natural resources, but also have significant problems with water quality. Watershed residents need to understand that their every day activities affect the quality of those resources. All watershed audiences need to be made aware of the priority pollutants and their sources and causes in each of the watersheds. Lastly, education efforts should, whenever possible, offer audiences solutions to improve and protect water quality.

One effective way to increase general watershed awareness is through recreational activities. These activities can help instill a sense of stewardship of the resources needed to enjoy the activities. Rivers, lakes and streams can provide many enjoyable recreational activities such as fishing, paddling, boating and swimming. It is important for recreational users to understand and appreciate the natural resources within the watershed and to gain a level of knowledge about the protection of those natural resources. Water trails and public access to water bodies can ensure that the public is offered an opportunity to enjoy and recreate on the water resources within the watersheds.

Priority Target Audiences: All , with focus on kids/students

Major Pollutants of Concern: sediment, nutrients, bacteria and pathogens, temperature, oil, grease and metals, pesticides

Priority Area: Entire watershed

2. Land Use Change

Land use change can disrupt the natural hydrologic cycle in a watershed. Natural vegetation, such as forest cover, usually has high infiltration capacity and low runoff rates. Whereas, urbanized land cover has impervious areas (buildings, parking lots, roads) and networks of ditches, pipes and storm sewer, which augment natural drainage patterns. Impervious surfaces reduce infiltration and the recharge of groundwater while increasing the amount of runoff. Local governmental officials and builders/developers need to understand the water quality benefits of smart growth, low impact development, open space and farmland preservation and protection of wetlands, floodplains and riparian areas.

Current and past wetland loss in both urban and agricultural areas is a major concern in both the Paw Paw and Black River Watersheds. The loss of wetlands result in disrupted hydrology and degraded water quality. Further, many agricultural areas have been drained with extensive ditching to move water off the land quickly. While this helps with food production in these areas, water quality suffers. The high flow amounts and velocity can cause increased streambank erosion and sediment delivery. Educational efforts should target drain commissioners and farmers to better understand the water quality benefits of ditch naturalization techniques and the need for wetland protection and restoration.

Priority Target Audiences: Farmers, Governmental Officials and Employees, Developers/Builders/Engineers

Major Pollutant of Concern: sediment

Priority Area: Paw Paw River Watershed High and Medium Priority Protection Areas

3. Stormwater Runoff

Stormwater runoff is caused when rain, snowmelt or wind carries pollutants off the land and into water bodies. Education efforts should increase awareness of stormwater pollutants, sources and causes, especially the impacts of impervious (paved or built) surfaces and their role in delivering water and pollutants to water bodies. Everyday homeowner and business actions are often the source and cause of stormwater pollution. These activities include lawn care practices, household hazardous waste and oil disposal, pet waste disposal and car and equipment care. Local government activities impacting stormwater runoff include land use planning, road and parking lot maintenance and construction, lawn care practices, oversight of construction sites and identification and correction of illicit discharges and connections.

Educational efforts should target property owners and businesses about the many best practices that can decrease the amount of water and pollutants coming from their property. In addition, local governmental units can be encouraged to implement low impact development and smart growth techniques in their plans and zoning ordinances. Local governments can also be encouraged to enact regulations such as a stormwater ordinance and a phosphorus ban for non-agricultural fertilizer use. Educational efforts can also promote municipal operations and maintenance best practices, which are important for reducing polluted runoff. These include best practices for road and parking lot construction and maintenance, lawn care and vehicle maintenance.

Priority Target Audiences: Property Owners, Builders/Developers/Engineers, Businesses, Governmental Officials and Employees

Major Pollutants of Concern: sediment, nutrients, bacteria and pathogens, temperature, oil, grease and metals, pesticides

Priority Area: Paw Paw River Watershed High and Medium Priority Urban Management Areas

4. Natural Resources Management and Preservation

Preserving land and managing natural resources is crucial for effective watershed management. Preservation and management of open space, wetlands, farmland and other natural features helps to reduce the amount of stormwater runoff entering water bodies, preserve natural ecosystems, endangered species as well as the services that the natural systems provide to us such as filtering drinking water and retaining storm water.

Invasive species, both aquatic and terrestrial; pose a threat to water quality and biodiversity in both watersheds. Education efforts should focus on identification and control techniques as well as the prevention of additional invasive species. Education efforts should also encourage the use of native Michigan plants for landscaping, wildlife habitat and other uses.

Recreational activities can often have a negative impact on sensitive areas. It may be necessary to understand carrying capacities for boats on lakes and rivers. In sensitive areas, there may be a need to limit recreational activities to ensure water quality and natural resources are protected. In addition, best management practices should be utilized to limit the impacts of recreational use on water and other natural resources. BMPs could include proper woody debris management for clearing rivers for navigation and installing and maintaining proper access sites to rivers and streams for fishing and canoeing.

Education efforts should instill a sense of understanding and appreciation for natural features. Property owners, developers and local governmental officials and employees need to be presented with options for preservation and management of natural resources. Educational efforts promoting smart growth, low impact and open space development and green infrastructure should target local government officials and employees and builders, developers and engineers.

Priority Target Audiences: Property Owners, Governmental Officials and Employees, Recreational Groups/Users, Developers/Builders/Engineers

Major Pollutants of Concern: sediment, temperature

Priority Area: Paw Paw River Watershed High and Medium Priority Protection Areas

5. Agricultural Runoff

Agricultural lands cover most of the area in the Black and Paw Paw River Watersheds, If not properly managed, runoff from agricultural lands can impact the watershed by delivering pollutants such as sediment and nutrients. Education efforts should seek to help audiences understand the impacts of agricultural runoff. A key concept is the need to reduce soil erosion from agricultural lands. It is also important to understand that soil particles also carry nutrients and chemicals to water bodies. There are many best management practices for addressing soil erosion from agricultural lands. Best management practices include conservation tillage, filter strips, cover crops, grassed waterways, ditch naturalization and wetland restoration.

Erosion is an intrinsic natural process, but in many places it is increased by human land use. A certain amount of erosion is natural and, in fact, healthy. Excessive erosion, however, does cause problems, such as sedimentation of streams and lakes, ecosystem damage and outright loss of soil. Soil erosion on agricultural fields can be caused by water, wind and tillage practices. Soil loss, and its associated impacts, is of great concern to farmers.

Drain maintenance activities, which often remove vegetation from riparian areas, contribute to soil erosion problems in agricultural areas. Drain maintenance projects should ensure as much riparian vegetation is left intact as possible and replace the vegetation with native grasses, shrubs and trees if it needs to be removed. Another major concern is manure being applied to fields in the watershed especially fields with drain tiles, which connect to ditches and streams. For nutrients and bacteria and pathogens, agricultural best management practices include methane digesters, manure and/or nutrient management, restricting livestock access to water bodies, wetland restoration and soil testing. Lastly, for pesticide concerns, best management practices include organic production and integrated pest management techniques. Cost share and technical assistance programs are available to assist agricultural landowners in implementing many of these practices.

Priority Target Audiences: Farmers

Major Pollutants of Concern: sediment, nutrients, bacteria and pathogens, pesticides

Priority Area: Paw Paw River Watershed High and Medium Priority Agricultural Management Areas

6. Septage Waste

Septage waste is both an urban and rural issue. In more rural areas and around lakes, failing or incorrectly installed septic systems impact water quality by adding excess nutrients, bacteria or other pollutants to the system. Education activities should seek to educate audiences about the impacts of septic systems on water quality. Proper maintenance of septic systems is a key practice for homeowners. Educational efforts should also target governmental units to encourage them to enact point of sale septic system inspection ordinances and to plan and zone for higher density development only in areas served by municipal sewer systems.

For urban areas, the proper operation and maintenance of municipal sewer infrastructure is necessary for protecting water quality. There is a widespread problem with aging infrastructure in urban areas, with some sewer systems dating over 100 years. Municipalities must ensure that combined sewer overflow events and other untreated releases of septage waste do not impact water quality. Educational efforts should target municipal officials and employees to encourage planning for adequate capacity, management, operation, and maintenance of sewer collection and treatment systems.

Priority Target Audiences: Governmental Officials and Employees, Riparian Property Owners

Major Pollutants of Concern: bacteria and pathogens, nutrients

Priority Area: Paw Paw River Watershed High and Medium Priority Urban Management Areas and E.coli TMDL watersheds (Pine and Mill Creek watersheds)

Distribution Formats

Because of the differences between target audiences, it will sometimes be necessary to utilize multiple formats to successfully get the intended message across. Distribution methods include the media, newsletters and direct mailings, email lists and websites, and passive distribution of printed materials. Below is a brief description of each format with some suggestions on specific outlets or methods.

1. Media

Local media is a key tool for outreach to several audience groups. The more often an audience sees or hears information about watershed topics, the more familiar they will become and the more likely they will be to use the information in their daily lives. Keeping the message out in front through press releases and public service announcements is essential to the success of education and outreach efforts.

Newspapers include: the Herald Palladium, the Kalamazoo Gazette (including the Hometown Gazette), the Courier Leader, the Bangor Reminder, the South Haven Tribune, the South Bend Tribune, the Decatur Republican, the Tri-City Record, Michigan Farm News and the Farmer's Exchange.

Radio outlets include WMUK, WCSY, WKZO, WBCT, Michigan Farm Radio Network , WKMI – Kalamazoo, WDOW – Dowagiac

Television outlets include WWMT Channel 3, WOOD Channel 8, WZZM Channel 13, WGVU Channel 35 and WXMI FOX Channel 17.

2. Newsletters and other direct mailings

Several municipalities, governmental agencies, utilities, County offices and non-profit organizations send out newsletters or other mailings which may be coordinated with various outreach efforts such as fact sheets or "Did you Know" messages. Currently identified mailings include Van Buren County Drain Office, Village and City utility bills, Van Buren, Allegan and Berrien County Farm Bureau newsletters, USDA Farm Service Agency newsletters, Van Buren, Allegan and Berrien Conservation District newsletters, Sarett Nature Center, The Southwest Michigan Land Conservancy newsletters, MSUE, Southwest Michigan Planning Commission newsletters and The Stewardship Network.

3. E-Mail lists and Websites:

The Van Buren Conservation District and the Southwest Michigan Planning Commission maintain active websites and email lists which can be used to reach residents of the watersheds as well as elected officials and businesses. As part of the Information and Education plan, other organizations should be encouraged to supply watershed related educational materials through their websites where appropriate. Enviro-mich provides an opportunity to advertise events and workshops to a large audience. Enviro-mich is a list serve for those in Michigan interested in environmental issues.

4. Passive Distribution:

This method relies on the target audience picking up a brochure, fact sheet, or other information. This can occur by placing materials at businesses, libraries, township/city/village halls and community festivals and events, An example would be to place information on reducing fertilizer use at a store that sells fertilizer.

Plan Administration and Implementation

An information and education implementation strategy is laid out for the Black and Paw Paw River Watersheds in the table found at the end of this report. This table lists specific tasks or activities, a potential lead agency and partners, timeframe, milestones and costs to educate target audiences for each watershed issue.

Roles and Responsibilities

The Southwest Michigan Planning Commission and the Van Buren Conservation District will continue to oversee the implementation of the Information and Education Plan as well as make adjustments to the plan when necessary. An Information & Education committee will meet as needed to advise on educational efforts.

There are efforts underway to establish a non-profit organization called the Two Rivers Coalition to implement the watershed plans for the Black and Paw Paw River Watersheds. Once this group is established, it may be most appropriate for this organization to oversee the implementation of the I&E Plan and convene the I&E committee.

Existing Efforts

It is important to understand current education efforts being offered or resources that are available for use or adaptation in the Paw Paw and Black River Watersheds. In some cases, existing efforts may need additional advertisement or updating to more effectively transmit their intended message. A few existing efforts that could be supplemented or utilized in the Paw Paw and Black River Watersheds are described below.

MSU Extension sponsors a Citizen Planner Course each year in Southwest Michigan. The target audiences for this course are municipal and planning officials as well as citizens. Topics presented during each course include various land use planning topics and techniques.

The Stewardship Network, Sarett Nature Center, Conservation Districts, Southwest Michigan Planning Commission, MSUE and lake associations periodically host educational workshops related to watershed and water quality topics.

The Southwest Michigan Planning Commission provides educational resources about stormwater and water quality to Berrien and Cass County Phase II communities. These resources are available on the Internet at www.swmpc.org/pep_materials.asp and could easily be adapted for use in the Black and Paw Paw River Watersheds.

The St. Joseph River Basin has produced a DVD about septic systems that could be distributed in the Black and Paw Paw River Watersheds.

The Southeast Michigan Council of Governments is facilitating a committee to develop a Statewide Low Impact Development manual, which will be extremely useful for educating and implementing LID.

Priorities

Project priorities will be established to direct resources to the areas that will gain the most benefit from the designated outreach activity. These priorities should be re-evaluated over time by the Education & Outreach sub-committee and changed as necessary.

Highest priority activities include:

- Activities that promote or build on existing efforts and expand partnerships with neighboring watershed projects, municipalities, conservation organizations and other entities.
- Activities that promote general awareness and understanding of watershed concepts and project goals.
- Activities that leverage external funding from local, state or federal sources.
- Activities that lead to actions (especially those in the watershed management plan), which help to improve and/or protect water quality.

Evaluation

Ultimately, evaluation should show if water quality is being improved or protected in the watershed due to education efforts being implemented. Since watersheds are dynamic systems, this can be difficult to accomplish. For the education efforts, one level of evaluation is documenting a change in knowledge or increase in awareness and participation. Measures and data collection for this level can take place in three specific ways:

1. A large-scale social survey effort to understand individual watershed awareness and behaviors impacting water quality.
2. A pre- and post-test of individuals at workshops focused on specific water quality issues in the PPRW.
3. The tracking of involvement in a local watershed group or increases in attendance at water quality workshops or other events.

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
Watershed awareness	All	Produce and distribute 3- 4 public service announcements/press releases per year	VBCD, BCD	SWMPC, MSUE, TRC	current - on-going (3-4 PSAs/year)	number of news articles	5 hours staff time/press release
		Maintain a website that makes watershed information easily available to the public	TRC	VBCD, SWMPC	current - on-going	website traffic - number of hits monthly	$20 per month hosting fees + 20 hours staff time/month
		Develop 4 videos for website (stories about watershed protection/management - Farmer, Landowner, Municipal Official, etc.)	TRC	SWMLC, TNC, VBCD, SWMPC	short-term (2 videos/ year)	website traffic - number of hits monthly	$600/video for production 100 hours staff time/video
		Create a display and participate in 2-3 community festivals/year	TRC	VBCD, SWMPC	current - on-going (2-3 festivals/ year)	number of participants	$200 per event + 30 hours staff time to develop
		Develop and install "Entering the watershed" signs at watershed boundaries	Road Commission	TRC	long-term (5 signs/ year)	number of installed signs	$200 per sign for printing and installation
	Kids/ Students	Develop a student stream monitoring program	VBISD	VBCD, Math & Science Center (Allegan ISD)	long-term (1 school/ year)	number of schools participating in program	$1500 for program materials (nets, waders, etc) + 20 hours/month staff time
		Plan and offer 1 teacher training workshop/year	VBCD	VBISD	long-term (1 training/ year)	attendance at workshop and incorporation of watershed topics into curriculum	$200/workshop + 40 hours staff time/year
		Distribute curriculum materials on watersheds and water quality to teachers (use materials from Great Lakes Alliance)	VBISD	VBCD, Math & Science Center	medium-term (4 schools/ year)	number of schools incorporating curriculum materials	$200/school + 60 hours staff time

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
Land Use Change	Drain Commission	Meet one-on-one with drain commissioners to discuss alternative drain maintenance methods and ditch naturalization techniques and stormwater standards/ordinance	VBCD, SWMPC	TRC, Drain Commissioner	medium-term (3 commissioners/year)	miles of County Drains converted and improvements in stormwater standards	80 hours staff time
		Promote trainings being offered that relate to drain maintenance and construction methods that protect water quality	TRC	Drain Commissioner, VBCD, SWMPC	short-term (1 training/ year)	improvements in drain maintenance and construction practices, reduced sediment	5 hours staff time/training
Agricultural runoff and Land Use Change	Farmers	Produce and distribute brochures/flyers/fact sheets to farmers about best management practices, cost share programs, wetland protection/restoration opportunities	VBCD	MSUE, Drain Commissioner, VBCD, NRCS	short-term (2 printed pieces/year)	number of practices installed, amount of Farm Bill $ spent in the watershed, reduction in pollutants	$1500 per direct mailing + 30 hours staff time/distribution
		Plan and host at least 1 workshop per year and host a tour/field site visit at least every 2-3 years addressing agricultural runoff, best management practices, wetland protection and restoration	VBCD, BCD, ACD	MSUE, NRCS	current - on-going (1 workshop/ year and 1 tour/2-3 years)	number of attendees and evaluations completed	$200-$600/workshop + 80 hours/year
		Develop and provide 1 newsletter article per year to Farm Bureau or other agencies on agricultural BMPs and wetland restoration/protection	MSUE, VBCD	NRCS	short-term (1 article/ year)	number of readers (circulation of publication)	10 hours/year
		Contact farmers in TMDL areas on a one-on-one basis to discuss best management practices and wetland restoration and distribute printed materials	VBCD	NRCS, MSUE, Drain Commissioner	medium-term (15-20 farmers/ year)	number of practices installed, reduction of pollutants	$400 printing + 400 hours staff time
Land use change, stormwater	Government units-officials	Promote trainings being offered on water quality, land use planning and LID	TRC	VBCD, MSUE, SWMPC	current - on-going (2 trainings/ year)	increase in use of LID techniques	5 hours staff time/training

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
runoff and natural resource management and preservation		Promote the adoption of a county-wide phosphorus ban in Van Buren and Berrien Counties and assist with educational efforts in Berrien, Van Buren and Allegan counties	TRC	Lake Assoc, Drain Commissioner, VBCD, SWMPC, ACD	current - on-going (1 adoption/ year)	adoption of ordinance	$1000 (printing materials) + 120 hours staff time
		Plan and host at least 1 workshop or summit per year on land use and water quality related issues and to share successes in watershed protection efforts and host a watershed tour every 2-3 years focusing on low impact development.	SWMPC	MSUE, VBCD, Planning Commission	long-term (1 workshop/ year and 1 tour/2-3 years)	incorporation of watershed topics into land use planning	$600/year + 80 hours staff time
		Produce and distribute a Watershed Management Plan user guide	TRC	VBCD, SWMPC	short-term (1 user guide/ year)	number of guides distributed or requested	200 hours staff time +$800 printing
		Produce and distribute brochures/flyers/fact sheets on land use and water quality, low impact development, smart growth, green infrastructure etc.	SWMPC	VBCD, MSUE, TRC, SWMLC	current - on-going (2 printed pieces/year)	increased use of LID practices	$800/printing & postage 80 staff hours/item
		Work one-on-one with planning commissions to improve plans and zoning ordinances for water quality protection ordinances, smart growth and low impact development and green infrastructure	SWMPC	VBCD, TRC.	current - on-going (3 municipalities/year)	number of improvements to plans and ordinances	200 hours staff time/municipality
Land use change, stormwater runoff and natural resource management and preservation	Developers/ builders/ engineers	Develop and distribute newsletter articles and brochures, flyers and fact sheets on low impact development to SW Michigan realtor and builders associations	SWMPC	SWMHBA, SWMAR	medium-term (1 printed piece/year)	increased use of LID practices	30 hours staff time/item
		Plan and host a watershed tour to showcase LID every 2-3 years	TRC	VBCD, MSUE, SWMPC	medium-term (1 tour/2-3 years)	tour attendance and evaluations	100 hours/event + $50/person

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
		Promote statewide LID manual and trainings offered	SWMPC	SWMHBA / SWMAR	short-term (1 training/ year)	attendance at trainings	80 hours staff time
Stormwater runoff and natural resource management and preservation	Property owners	Print and distribute fact sheets from SWMPC's stormwater campaign at www.swmpc.org/water.asp	TRC	SWMPC, VBCD	current - on-going (50 fact sheets/year)	number distributed	$300 printing/postage 20 hours staff time
		Install storm drain markers and place door knob hangers to educate residents about stormwater runoff	VBCD, BCD	Lake Associations, TRC	current - on-going (2 municipalities/year)	number installed	40 hours staff time to coordinate volunteers
		Produce a direct mailing on land protection options - focus on property owners in high priority protection areas and high priority wetland protection/restoration areas	SWMLC	Land Preservation Board, VBCD, BCD, SWMPC	short-term (1mailing/ 2-3 years)	increased landowner interest in land preservation options	$1000/printing and postage + 100 hours staff time
		Host workshops/tours for property owners in high priority protection areas	SWMLC	VBCD, BCD, TRC, SWMPC	short-term (1 tour/ 2-3 years)	attendance and evaluations completed	$100-$500/workshop + 80 staff hours
		Distribute printed materials on what can be done to protect water quality and on land protection options for private landowners in tax or utility bills	County and Townships	SWMLC, VBCD, BCD, SWMLC, TRC	long-term (1 mailing/ year)	number of mailings	$300 printing/postage 40 hours staff time
Stormwater runoff	Government units-employees	Promote trainings on municipal operations (including road maintenance and construction) and best management practices to protect water quality	Drain Commissioner Municipalities	Road Commission, VBCD, SWMPC	medium-term (1 training/ year)	number of governmental employees attending trainings	20 hours/training opportunity

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
		Distribute brochures/flyers/fact sheets about municipal operations and road construction and maintenance best practices for water quality	Road Commission, Municipalities	SWMPC	medium-term (1 printed piece/year)	number adopting watershed friendly practices	$150/item printing and postage + 20 hours staff time/item
Stormwater runoff	Businesses	Give presentations at local business gatherings about what businesses can do to protect water quality	VBCD	MSUE, Drain Commissioner	medium-term (1 presentation/ year)	number of business adopting watershed friendly practices	40 hours staff time/presentation
		Distribute brochures/flyers/fact sheets about business operations best practices for water quality - focus on lawn care companies	MSUE	VBCD	medium-term (1 distribution/ year	number of business adopting watershed friendly practices	$200-$500 printing/postage 30 hours staff time/item
Natural resource management and preservation	Recreation groups/users	Develop and install kiosks at parks along the rivers about water quality and natural features	Municipalities	BSHWTA, VBCD, SWMPC, Sarett Nature Center, TRC	medium-term (1 kiosk/ 2 years)	number of kiosks installed	$1,000/kiosk + 120 hours staff time/kiosk
		Develop water trails, public access sites and walking trails along the river	Municipalities	BSHWTA, Sarett Nature Center, SWMPC, Road Commission	long-term (1access site/ 2-3 years)	number of access sites; use of trails	$100/mile for water trail $1,000-$8,000/access site
		Develop and distribute 1 newsletter article per year for recreation groups	VBCD	BSHWTA, Lake Associations SWMLC	medium-term (1 article/ year)	number of readers (circulation of publication)	10 hours staff time/article
Septage waste	Riparian property owners	Develop 1 newsletter article per year for lake associations to utilize in their newsletters	VBCD	Health Dept, MSUE, SWMPC	medium-term (1 article/ year)	number of readers (circulation of publication)	10 hours staff time/article

Issue	Priority Target Audience*	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
		Develop and work with lake associations to distribute door knob hangers about septic system maintenance	Lake Assoc.	VBCD, TRC	medium-term (2 lakes/year)	number of households in distribution area	$0.50each printing + 100 hours staff time/lake association
		Encourage lake association members to meet with lake owners on a one-on-one basis to discuss septic system maintenance	Lake Assoc.	VBCD, MSUE	medium-term (2 lakes/year)	improved septic maintenance and reduced pollutants	3 hours/household
		Obtain and distribute a video on septic systems and water quality to Lake Associations (video available from St. Joseph River Basin Commission)	Lake Assoc.	SWMPC, St Joe River Basin Commission	medium-term (3 lakes/year)	improved septic maintenance and reduced pollutants	100 hours staff time
	Government unit-employees	Promote trainings about municipal sewer infrastructure planning and management	TRC	VBCD, SWMPC, Health Dept.	medium-term (1 training/ year)	number of municipal officials and employees attending trainings	10 hours/training
Septage waste	Government units-officials	Develop and distribute brochures/flyers/fact sheets about the impacts of failing septic systems and what local governments can do	VBCD	MSUE, Health Dept, TRC	medium-term (1distribution/ 4 years)	increased number of septic related ordinances	$400 printing/postage 80 hours staff time
		Obtain and distribute a video on septic systems and water quality to governmental units (video available from St. Joseph River Basin Commission)	SWMPC	St. Joe Basin Commission, VBCD, MSUE	medium-term (5 governmental units/year)	number of municipalities receiving video	100 hours staff time
		Work one-on-one with planning commissions to improve plans and zoning ordinances relating to septic systems	SWMPC	VBCD, MSUE	current - on-going (3 municipalities/year)	increased number of septic related ordinances	80 hours/municipality

*Note: Primary audiences are listed; there may be additional audiences that could benefit as well
** short-term - within one year; medium-term - within 2-3 years; long-term - within 4-6 years

Acronyms
ACD: Allegan Conservation District
BCD: Berrien Conservation District
BSHWTA" Bangor-South Haven Heritage Water Trail Association
MSUE: Michigan State University Extension
NRCS: Natural Resources Conservation Service
SWMAR: Southwest Michigan Association of Realtors
SWMHBA: Southwest Michigan Home Builder's Association
SWMLC: Southwest Michigan Land Conservancy
SWMPC: Southwest Michigan Planning Commission
TNC: The Nature Conservancy
TRC: Two Rivers Coalition: An Alliance for the Black and Paw Paw River Watersheds
VBCD: Van Buren Conservation District
VBISD: Van Buren Intermediate School District

Appendix R: Tasks for Watershed Management Plan Objectives

Goals	Objectives	Tasks
1. Improve water quality and habitat for fish, indigenous aquatic life and wildlife in the watershed by reducing the amount of nutrients, sediment, and chemical pollutants entering the system	1 A. Stabilize priority streambank erosion sites through the installation of corrective measures	1. Work with engineering firm to design appropriate stabilization techniques (soil lifts, regrading, cross vanes, coir logs, native vegetative buffers) 2. Acquire funding from local sources 3. Acquire necessary permits and permissions 4. Coordinate process for stabilizing streambank 5. Identify additional sites
	1 B. Establish a road/stream crossing improvement program to correct identified problems	1. Work with road commissions to initiate this program 2. Distribute list of problem areas to road commissions 3. Develop a plan for road/culvert/bridge issues
	1 C. Work to limit or control direct livestock access to the river and tributaries	1. Locate sources of funding for improving livestock access to water 2. Contact livestock farmers with access issues 3. Coordinate process for improving livestock access at 8 sites in the watershed
	1 D. Install corrective measures to reduce runoff at agricultural sites of concern	1. Locate sources of funding for reducing agricultural runoff 2. Contact farmers in sites of concern 3. Coordinate process
	1 E. Encourage farmers to participate in the Michigan Agriculture Environmental Assurance Program (MAEAP)	1. Identify facilities by their commodity (Livestock system, Farmstead system, Cropping system) 2. Contact producers to initiate progressive planning process for MAEAP verification
	1 F. Reestablish greenbelts/conservation buffers at sites in critical areas	1. Contact riparian landowners in urban/residential critical areas 2. Provide education 3. Identify funding sources 4. Work with landowners and municipalities to install
	1 G. Work with communities to reduce polluted stormwater entering local waterways	1. Determine which municipalities know locations of storm drain inlets and outlets, and which municipalities have these mapped 2. Map storm drain system, including inlets and outlets; map surrounding land use of inlets and rank for risk 3. Work with communities (as well as developers and businesses) to use bioinfiltration and other on-site stormwater treatment methods 4. Locate and fix illicit connections 5. Replace inlet covers with ones with imprinted “Don’t dump – drains to stream” message (see

		http://www.ejiw.com/products.phtml?catid=36) 6. Coordinate with goal 7
	1 H. Identify and improve failing septic systems	1. Work with Health Departments to identify failing septic systems 2. Subsidize septic system inspections for waterfront property owners 3. Coordinate with goal 7
	1 I. Encourage the creation of local sanitary sewer systems on densely populated inland lakes	1. Contact lake associations to determine level of interest/ feasibility 2. Contact municipalities to determine level of interest/ feasibility 3. Provide education
2. Continue/increase watershed monitoring efforts and stewardship	2 A. Perform water quality monitoring for potential pollutants to monitor the current quality of the river as well as to monitor changes over time	1. Coordinate with agencies to perform studies (road-stream crossing surveys, macroinvertebrate studies, water quality monitoring, etc.) 2. Devise quality assurance project plans (QAPP) 3. Contact landowners to obtain permission to access river 4. Train volunteers 5. Carry out studies
	2 B. Continue monitoring stream bank erosion	1. Devise quality assurance project plan 2. Contact landowners to obtain permission to access river 3. Train volunteers 4. Carry out study
	2 C. Continue geomorphologic assessments of river	1. Work with Michigan Department of Natural Resources to develop assessment plan 2. Assist Michigan Department of Natural Resources in carrying out assessments
	2 D. Perform hydraulic / hydrologic analysis of river	1. Work with Michigan Department of Environmental Quality and Michigan Department of Natural Resources to develop assessment plan 2. Research hiring a contractor to complete work
3. Improve the hydrology and morphology of the river	3 A. Reduce volume and rate of runoff using recommendations from hydrologic study (see Appendix N). BMPs include wetland creation, detention, bioretention, buffer strips and infiltration practices	1. Use hydrology study (Appendix N) to identify volume and rate reduction targets for each subwatershed 2. Identify properties and work with landowners to implement BMPs 3. Locate funding for BMPs 4. Design/install BMPs
	3 B. Restore river channel to stable condition	1. Identify channelized and unstable stream reaches 2. Determine stable stream configuration through local reference reaches, regional reference curves, or similar process 3. Prepare a stable channel design for the identified reaches 4. Implement the designs

4. Provide long term protection of the Black River Watershed through improved local land use policies and conservation practices	4 A. Assess the current adequacy level of local community planning and zoning controls	1. Contact municipalities and request participation in review process 2. Compare existing controls against standards 3. Perform build-out analysis 4. Identify areas needing improvement based on assessment results and local potential for problems 5. Notify communities of these results
	4 B. Develop model ordinances and language for adoption into existing master plans and zoning ordinances	1. Obtain/create ordinance language and master plans that address identified problems 2. Conduct an alignment check with County/State planning requirements 3. Verify that proposed examples will address known problems 4. Obtain necessary support and permission 5. Prepare standard ordinances and recommended language in an organized form that is easily transmittable (i.e. by e-mail)
	4 C. Assist local communities in updating master plans and/or adopting ordinances or "smart growth" techniques that will protect water quality	1. Prepare "how to" outlines to use as examples of how changes should take place 2. Prepare examples that will demonstrate benefits to local communities 3. Conduct workshops for local community leaders 4. Identify grants and other funding sources for local communities 5. Provide assistance to local communities with grant applications 6. Sponsor workshops and training sessions to increase local understanding of regulations 7. Assist local communities with adoption process
	4 D. Permanently protect identified sensitive areas through conservation easements, purchase of development rights, and land purchases	1. Perform GIS-based natural resource assessment to identify and assess sensitive areas 2. Plan and prioritize sites for protection 3. Contact landowners in sensitive areas (headwaters, wetlands, and riparian zone) 4. Hold workshops on different methods of land protection 5. Obtain commitment from landowners to protect land 6. Work with local land conservancy to coordinate projects 7. Coordinate with municipalities to include information in master plans and site review process
	4 E. Support efforts to protect prime farmland from development	1. Develop map/model of high priority areas for protection 2. Work with Allegan and Van Buren County Purchase of Development Rights (PDR) programs 3. Provide education on the PDR programs
	4 F. Promote Low Impact Development (LID) techniques	1. Work with Southwest Michigan Planning Commission to develop LID newsletter

		2. Present 1 workshop per year for three years
5. Improve the navigability of the Black River for canoes, kayaks, and other self-propelled watercraft, by reducing sedimentation and reducing excess woody debris	5 A. Remove or cut through downed trees that inhibit navigation by canoes and kayaks and increase bank erosion	1. Locate snags that are impassable by canoe/kayak 2. Train volunteers on proper methodology for cutting through snags based on woody debris best management practices 3. Contact riparian landowners
	Stabilize priority streambank erosion sites through the installation of corrective measures (see objective 1 A)	[see tasks for objective 1 A]
	Establish a road/stream crossing improvement program to correct identified problems (see objective 1 B)	[see tasks for objective 1 B]
	Work to limit or control direct livestock access to the river and tributaries (see objective 1 C)	[see tasks for objective 1 C]
6. Enhance recreational access sites to prevent the degradation of water quality	6 A. Increase the number of legal access sites	1. Work with local governments to locate potential legal access points 2. Assist in design of access points to minimize river sedimentation
	6 B. Provide educational kiosks and signage at launch sites that educate people about the watershed and good river etiquette	1. Work with Bangor/South Haven Heritage Trail Association and lake associations 2. Locate sites for kiosks and obtain permission from landowners 3. Develop language and signs for kiosks
7. Increase knowledge and participation in programs regarding nonpoint source pollution and means of prevention	7 A. Hire staff to implement watershed management plan, including a project manager and a land use planner	1. Identify sources of funding 2. Develop job description 3. Interview and hire staff
	7 B. Implement Information & Education Plan (see Appendix Q)	(see Appendix Q)
8. Prevent or reduce the introduction and spread of invasive species	8 A. Establish or work with existing invasive species control programs to prevent the spread of exotic species in the watershed	1. Research existing invasive species control programs 2. Work with coordinating agencies to develop or support invasive species control programs 3. Create educational programs and materials (coordinate with I&E Plan)

Appendix S: Phosphorus Sampling in the Great Bear Lake Watershed

Phosphorus Sampling in the Great Bear Lake Watershed, Van Buren County, MI

Final Report
4/30/09

Prepared by Erin Fuller, Van Buren Conservation District
Black River Watershed Implementation Project
Tracking # 2005-0108
1035 E. Michigan Avenue
Paw Paw, MI 49079

Table of Contents

Table of Contents 1
Acknowledgements 2
Introduction 3
Methods 3
Study Sites 3
Sample/data collection and analysis procedures 4
Quality Control Requirements 4
Results 5
Site #1: Mill Lake Drain @ 37th St. 5
Site #2: Road ditch @ 37th St. 5
Site #3: Mill Lake Drain @ CR 388 5
Site #4: Munn Lake Drain @ CR 388 6
Site #5: Mill Lake Drain (just upstream of Remington & Powers Drain) 6
Site #6: Remington & Powers Drain @ CR 388 7
Site #7: Haven Drain @ 41st St. 7
Site #8: Haven Drain @ Bloomingdale sewage lagoons 7
Site #9: Haven Drain @ 45th St. 8
Site #10: Great Bear Lake Drain @ 46 ½ St. 8
Discussion 9
References 10
Appendix A: Site Map 11
Appendix B: Map of Results 12
Appendix C: Phosphorus Data Power Analysis 14

Acknowledgements

The success of this project is due to the dedication of volunteer Tom Barczak, who collected all of the water samples. In addition, Chris Bauer and Joe Rathbun of the Michigan Department of Environmental Quality provided essential assistance throughout the entire course of the project. We also thank the Paw Paw Wastewater Treatment Plant for their dedication in analyzing the samples in the laboratory.

Introduction

As part of the Black River Watershed Project, dry weather sampling was performed to collect and analyze water samples for total phosphorus and ortho phosphorus at ten locations in the Black River Watershed in Van Buren County. In this study, dry weather sampling required that all samples be taken when there had been less than ¼ inch of rain in the antecedent 48 hours. All sample sites were in the subwatershed that drains into Great Bear Lake in Bloomingdale and Columbia Townships. Phosphorus has been determined to be one of the critical issues in this watershed, but information as to the source and location of inputs is lacking. In addition to helping locate areas where phosphorus is entering the system, this study will provide a baseline against which to evaluate best management practice (BMP) effectiveness in the future. The project will add to existing water quality information contained in the Black River Watershed Management Plan and a total Maximum Daily Load for Phosphorus that has been prepared for Great Bear Lake.

Surface water grab samples were collected approximately weekly at nine locations upstream of Great Bear Lake and one location downstream of the lake, for a total of ten sample sites. One volunteer collected all samples, beginning on September 3, 2008 and ending on October 22, 2008 for a total of 8 sampling events.

The Black River Watershed Coordinator analyzed results and acted as project manager. Laboratory analyses were performed by a licensed operator at the Paw Paw Wastewater Treatment Plant.

Methods

Study Sites

Ten locations were chosen for sampling, as shown below:

01: Mill Lake Drain @ 37th St. (upstream of culvert under 37th)
02: Road ditch @ 37th St. (ditch runs parallel to 37th St.; samples were collected upstream of where it meets Mill Lake Drain)
03: Mill Lake Drain @ CR 388 (just upstream of where Munn Lake Drain enters)
04: Munn Lake Drain @ CR 388 (upstream of culvert under CR 388)
05: Mill Lake Drain (just upstream of Remington & Powers Drain)
06: Remington & Powers Drain @ CR 388 (just upstream of the culvert under CR 388)
07: Haven Drain @ 41st St. (just upstream of culvert under 41st St.)
08: Haven Drain @ Bloomingdale sewage lagoons (upstream of culvert under access road)
09: Haven Drain @ 45th St. (upstream of culvert under 45th St.)
10: Great Bear Lake Drain @ 46 ½ St. (downstream of Great Bear Lake, upstream of culvert)

These locations were selected because they bracket areas of potential concern. Additionally, most sites are at road-stream crossings for ease of volunteer access. See Appendix A for a map of these locations.

Sample/data collection and analysis procedures

Surface water grab samples were collected using the following protocol:

- the person taking the sample entered the stream in such as way as to minimize disturbance of sediments
- the person taking the sample faced upstream while sampling and submerged the bottle approximately six inches below the water surface to avoid collecting film from the water surface.
- all samples were kept on ice or in a refrigerator until delivered to the lab.

Samples were analyzed using the standard analytical methods for total phosphorus and ortho phosphorus shown in Table 1.

Table 1: Analytical procedures

Parameter	Method	Detection Limit	Sample Volume (mL)	Bottle type	Preservative	Hold time
Total phosphorus	4500-P*	.01 mg/L	500 mL	Plastic (HDPE)	None	48 hours
Ortho phosphorus	4500-P*	.01 mg/L	500 mL	Plastic (HDPE)	None	48 hours

**Standard Methods for the Examination of Water and Wastewater*

After samples were analyzed, bottles were cleaned in the lab with Alconox Liqui-Nox phosphate free cleaner. In the field, each bottle was double rinsed with stream water prior to sample collection. Because sample collection bottles were reused, a field blank sample was collected using distilled water (once per sampling survey).

A unique number was assigned to each field sample collected. Sample identification included a site identifier, the date, sample type (investigative sample [I] or duplicate sample [D]. For example, the code 01-09/18/08 (I) refers to an investigative sample taken on September 18, 2008 at Mill Lake Drain @ 37th St. (the location 01).

Chain of custody forms were kept with the samples during transport and at the lab.

Quality Control Requirements

Laboratory instrument calibration: A standard and blank are run each time phosphorus is tested in the laboratory, at least three times per week. The Paw Paw Wastewater Treatment lab undergoes a NSI DMRQA Lab Performance Evaluation two times per year.

One field duplicate was collected and tested each week. The site at which a duplicate sample was taken was chosen randomly. The relative percent difference (RPD) for duplicate samples was recorded and stored with the rest of the data collected throughout the project.

Results

Note: NA indicates no sample was taken at the site due to low/no water conditions.

Site #1: Mill Lake Drain @ 37th St.

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	NA	NA	NA
9/11/2008	0.09	0.09	100.0%
9/18/2008	0.03	0.03	100.0%
9/23/2008	0.01	0.01	100.0%
9/29/2008	0.02	0.02	100.0%
10/7/2008	0.07	0.05	71.4%
10/14/2008	0.05	0.05	100.0%
10/22/2008	NA	NA	NA
Average	0.045	0.042	95.2%
Standard Deviation (STDEV)	0.031	0.029	0.117
Median	0.040	0.040	100.0%

Site #2: Road ditch @ 37th St

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	NA	NA	NA
9/11/2008	0.01	0.01	100.0%
9/18/2008	0.07	0.07	100.0%
9/23/2008	0.05	0.05	100.0%
9/29/2008	0.07	0.07	100.0%
10/7/2008	0.09	0.05	55.6%
10/14/2008	0.03	0.03	100.0%
10/22/2008	NA	NA	NA
Average	0.053	0.047	92.6%
Standard Deviation (STDEV)	0.029	0.023	0.181
Median	0.060	0.050	100%

Site #3: Mill Lake Drain @ CR 388

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	NA	NA	NA
9/11/2008	0.07	0.06	85.7%
9/18/2008	0.07	0.07	100.0%
9/23/2008	0.04	0.04	100.0%
9/29/2008	0.15	0.11	73.3%

10/7/2008	0.12	0.09	75.0%
10/14/2008	0.06	0.06	100.0%
10/22/2008	0.07	0.05	71.4%
Average	0.083	0.069	86.5%
Standard Deviation (STDEV)	0.038	0.024	0.134
Median	0.070	0.060	85.7%

Site #4: Munn Lake Drain @ CR 388

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	NA	NA	NA
9/11/2008	1.40	0.43	30.7%
9/18/2008	0.19	0.19	100.0%
9/23/2008	0.19	0.19	100.0%
9/29/2008	0.24	0.19	79.2%
10/7/2008	0.36	0.28	77.8%
10/14/2008	0.25	0.30	120.0%
10/22/2008	0.18	0.14	77.8%
Average	0.401	0.246	83.6%
Standard Deviation (STDEV)	0.445	0.099	0.281
Median	0.240	0.190	79.2%

This site had the highest average of both total and ortho phosphorus. One sampling event, on 9/11/08, had a very high result. Field notes indicate that there was low water at this site at that time. Thus, the high result could be a due to the release of phosphorus from the stream sediments, triggered by the likely low dissolved oxygen content of stagnant water. When dissolved oxygen levels are less than 1mg/L, iron and manganese hydroxides that bind phosphorus to sediments are reduced (Joe Rathbun, personal communication, 4/17/09). However, even if that sampling event is discounted, the average total phosphorus concentration of the remaining sampling events is 0.235 mg/L, still the highest of all ten sites.

Site #5: Mill Lake Drain (just upstream of Remington & Powers Drain)

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.28	0.25	89.3%
9/11/2008	0.11	0.10	90.9%
9/18/2008	0.16	0.14	87.5%
9/23/2008	0.10	0.10	100.0%
9/29/2008	0.21	0.07	33.3%
10/7/2008	0.18	0.14	77.8%
10/14/2008	0.15	0.13	86.7%
10/22/2008	0.29	0.28	96.6%
Average	0.185	0.151	82.8%
Standard Deviation (STDEV)	0.071	0.075	0.211
Median	0.170	0.135	88.4%

Site #6: Remington & Powers Drain @ CR 388

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.14	0.10	71.4%
9/11/2008	0.03	0.01	33.3%
9/18/2008	0.20	0.19	95.0%
9/23/2008	0.13	0.13	100.0%
9/29/2008	0.18	0.07	38.9%
10/7/2008	0.12	0.10	83.3%
10/14/2008	0.04	0.08	200.0%
10/22/2008	0.05	0.05	100.0%
Average	0.111	0.091	90.2%
Standard Deviation (STDEV)	0.065	0.054	0.515
Median	0.125	0.090	89.2%

Site #7: Haven Drain @ 41st St.

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.13	0.08	61.5%
9/11/2008	0.04	0.03	75.0%
9/18/2008	0.14	0.12	85.7%
9/23/2008	0.08	0.08	100.0%
9/29/2008	0.10	0.06	60.0%
10/7/2008	0.14	0.12	85.7%
10/14/2008	0.06	0.05	83.3%
10/22/2008	0.05	0.05	100.0%
Average	0.093	0.074	81.4%
Standard Deviation (STDEV)	0.041	0.033	0.152
Median	0.090	0.070	84.5%

Site #8: Haven Drain @ Bloomingdale sewage lagoons

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.09	0.07	77.8%
9/11/2008	0.04	0.03	75.0%
9/18/2008	0.15	0.13	86.7%
9/23/2008	0.12	0.09	75.0%
9/29/2008	0.07	0.05	71.4%
10/7/2008	0.11	0.10	90.9%
10/14/2008	0.06	0.05	83.3%
10/22/2008	0.04	0.03	75.0%

Average	0.085	0.069	79.4%
Standard Deviation (STDEV)	0.040	0.036	0.068
Median	0.080	0.060	76.4%

Site #9: Haven Drain @ 45th St.

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.11	0.07	63.6%
9/11/2008	0.08	0.06	75.0%
9/18/2008	0.16	0.14	87.5%
9/23/2008	0.10	0.09	90.0%
9/29/2008	0.08	0.06	75.0%
10/7/2008	0.11	0.10	90.9%
10/14/2008	0.09	0.06	66.7%
10/22/2008	0.05	0.05	100.0%
Average	0.098	0.079	81.1%
Standard Deviation (STDEV)	0.032	0.030	0.129
Median	0.095	0.065	81.3%

Site #10: Great Bear Lake Drain @ 46 ½ St.

Date	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	% Ortho Phosphorus
9/2/2008	0.04	0.04	100.0%
9/11/2008	0.02	0.01	50.0%
9/18/2008	0.09	0.08	88.9%
9/23/2008	0.04	0.03	75.0%
9/29/2008	0.04	0.01	25.0%
10/7/2008	0.05	0.05	100.0%
10/14/2008	0.04	0.00	0.0%
10/22/2008	0.02	0.02	100.0%
Average	0.043	0.030	67.4%
Standard Deviation (STDEV)	0.022	0.026	0.385
Median	0.040	0.025	81.9%

Precision

Field duplicate samples (1 per survey) were collected to assess sample collection consistency and data precision, and the results demonstrated that the results are acceptable precise. All of the samples with a relative percent difference (RPD) of over 20% were samples with very low concentrations (less than 0.05 mg/L, with the exception of the 9/2/08 sampling date which had concentrations of 0.14 mg/L total phosphorus and 0.10 mg/L ortho phosphorus in the investigative sample). Samples that are closer to the detection limit of 0.01 mg/L are more likely to have less precision.

Relative percent difference between investigative sample and duplicate sample:

	9/2/08	9/11/08	9/18/08	9/23/08	9/29/08	10/7/08	10/14/08	10/22/08
Total Phosphorus	24.00%	22.22%	0.00%	0.00%	200.00%	22.22%	0.00%	7.14%
Ortho Phosphorus	35.29%	50.00%	0.00%	0.00%	200.00%	22.22%	100.00%	0.00%

Discussion

As shown above, several of the sampling events were beyond the precision level outlined in the QAPP. However, because phosphorus concentrations were so low and close to the detection limit, it was decided that all samples would be included in the final analysis.

A significant rain event occurred before the 9/18 sampling event. Approximately 7.12 inches fell in the area on September 12, 13, 14 and 15. This may account for some sites having higher phosphorus readings on the 9/18 sampling events.

Seven of the ten sites that were sampled had a total phosphorus amount that is higher than the reference stream number for total phosphorus for streams in the Southern Michigan/ Northern Indiana Till Plain Ecoregion (0.058 mg/L) (MDNR 1994). Reference streams are considered to be minimally affected by human-induced impacts. The seven sites with total phosphorus amounts higher than the reference stream number were 3, 4, 5, 6, 7, 8, and 9. Two sites, 4 and 5, had average total phosphorus numbers of more than twice the reference stream number. Appendix B contains maps that display the sampling results. These results appear to indicate that the primary source of phosphorus in this watershed may be coming from the Munn Lake Drain. Great Bear Lake appears to be a sink for phosphorus, removing an average of 56% of the total phosphorus and 66% of the ortho phosphorus in this study.

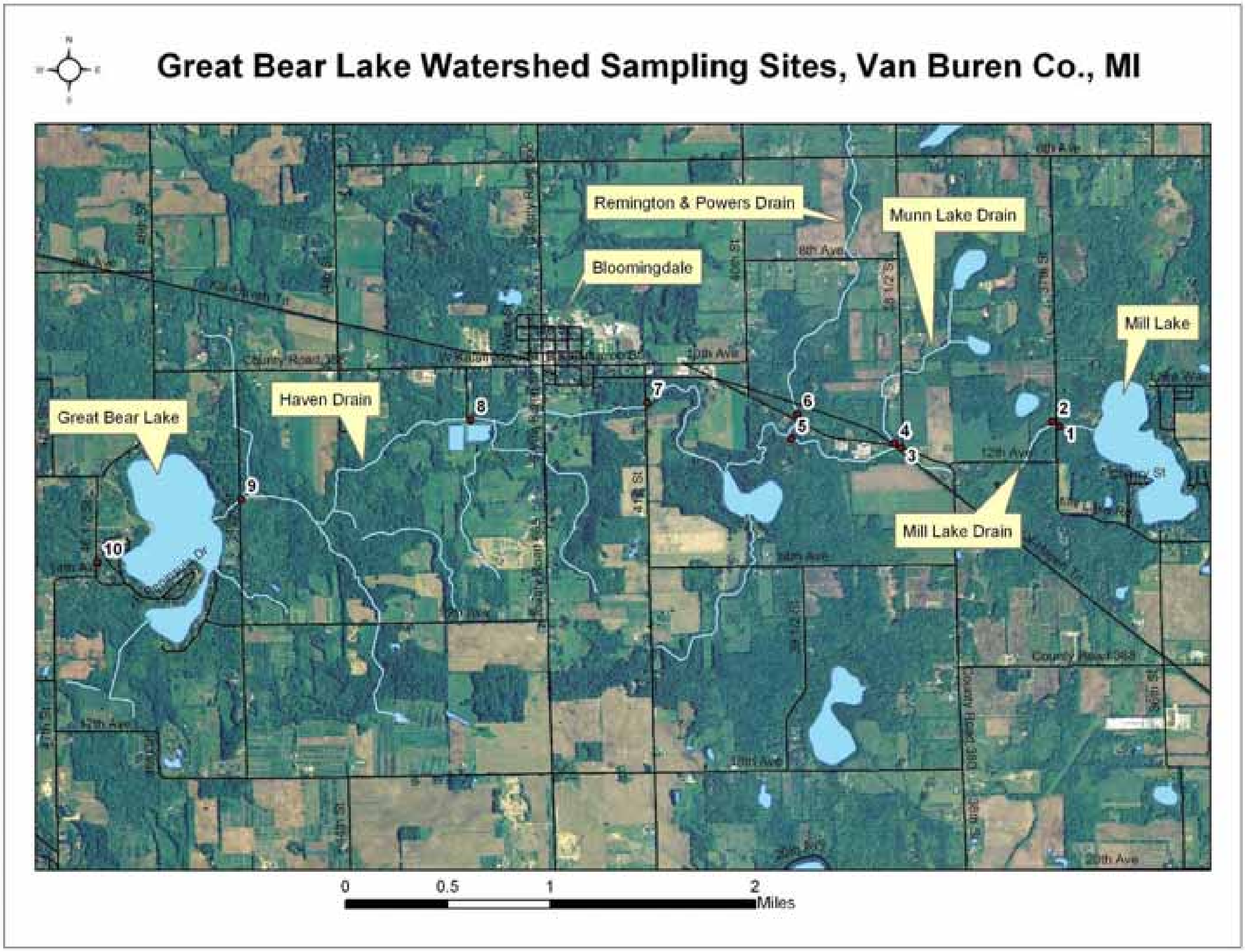
In all sites, the majority of phosphorus appears to be in the form of ortho phosphorus, or dissolved phosphorus (values of ortho phosphorus as a percentage of total phosphorus ranged from an average of 67.4% to 95.2%). This indicates that the source of phosphorus is primarily fertilizers, detergents, septic systems or liquid animal waste as opposed to applied manure or sediment particles from erosion. Dissolved phosphorus is readily available for biological uptake, and can cause an overgrowth of aquatic plants and algae.

Joe Rathbun (MDEQ) applied power analysis statistics to the data to determine the number of samples needed to detect a 50% change in phosphorus concentration with a 95% confidence interval. The predicted sample size (n) ranged from 2 to 19, and was generally less than 10. When the high value at station 4 on 9/11/08 is eliminated, the sample size needed ranged from 2 to 13. See Appendix C for the full results of this analysis.

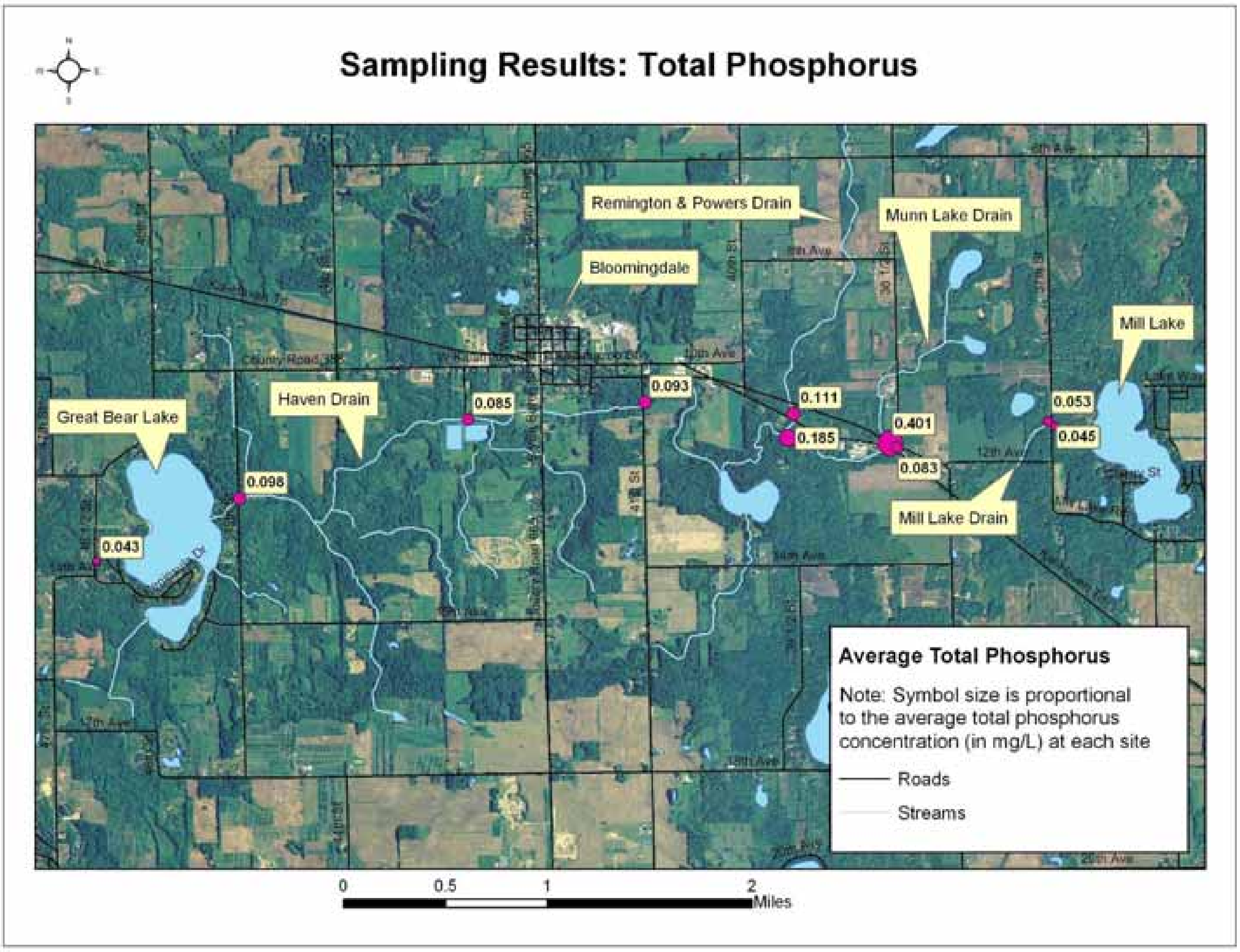
References

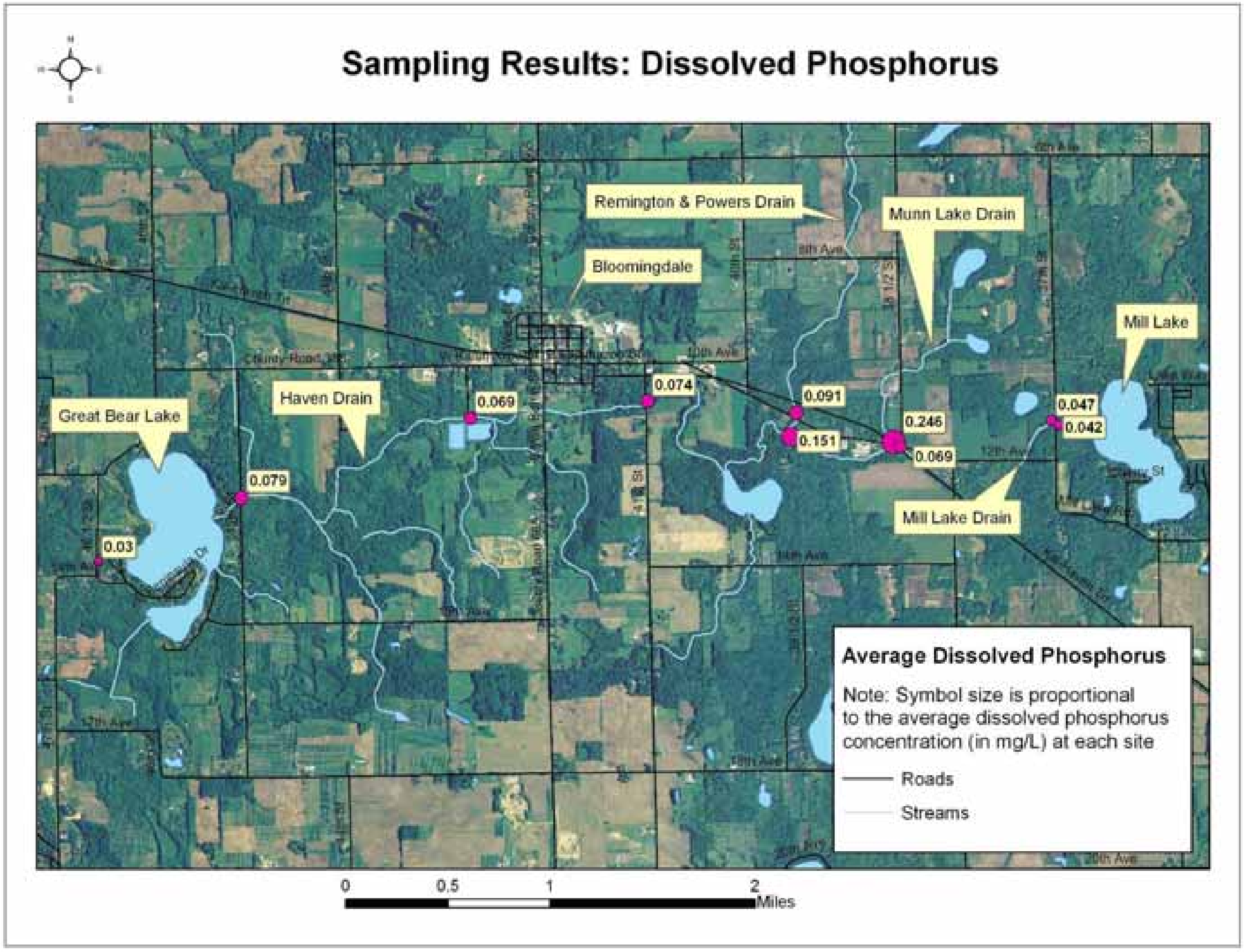
Michigan Department of Natural Resources (MDNR) 1994. Reference Site Monitoring Report (1992-1993). MDNR Surface Water Quality Division. Report # MI/DNR/SWQ-94/048

Appendix A: Site Map



Appendix B: Map of Results




Sampling Results: Dissolved Phosphorus
Remington & Powers Drain
Munn Lake Drain
Bloomingdale
Mill Lake
Great Bear Lake
Haven Drain
Mill Lake Drain
0.03
0.079
0.069
0.074
0.091
0.151
0.246
0.069
0.047
0.042
Average Dissolved Phosphorus
Note: Symbol size is proportional to the average dissolved phosphorus concentration (in mg/L) at each site
Roads
Streams
0
0.5
1
2
Miles

Appendix C: Phosphorus Data Power Analysis

2008 Great Bear Lake Phosphorus Data Power Analysis

(Predicted n = the number of samples to collect in the future to be 95% confident of detecting a 50% change in P concentration)

Total Phosphorus

Station	1	2	3	4	4 (-9/11)	5	6	7	8	9	10
n	6	6	7	7	6	8	8	8	8	8	8
t	2.571	2.571	2.447	2.447	2.571	2.365	2.365	2.365	2.365	2.365	2.365
Std dev	31	29	38	401	68	71	65	41	40	32	22
d	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mean (µg/L)	45	53	83	445	235	185	111	93	85	98	43
Predicted n	13	8	5	19	2	3	8	4	5	2	6

Ortho Phosphorus

Station	1	2	3	4	4 (-9/11)	5	6	7	8	9	10
n	6	6	7	7	6	8	8	8	8	8	8
t	2.571	2.571	2.447	2.447	2.571	2.365	2.365	2.365	2.365	2.365	2.365
Std dev	29	23	24	99	62	75	54	33	36	30	26
d	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mean (µg/L)	42	47	69	246	215	151	91	74	69	79	30
Predicted n	13	6	3	4	2	6	8	4	6	3	17

n(est)	=	estimated sample size
	=	-
	=	
	=	
x	=	sample average