THE BRIDAL VEIL CREEK SUBWATERSHED DESK STUDY: A MISSISSIPPI WATERSHED MANAGEMENT ORGANIZATION WATERSHED ASSESSMENT

A Collaborative Effort between the St Anthony Park Community Council Environmental Committee and the Mississippi Watershed Management Organization

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May 2006

Bridal Veil Creek

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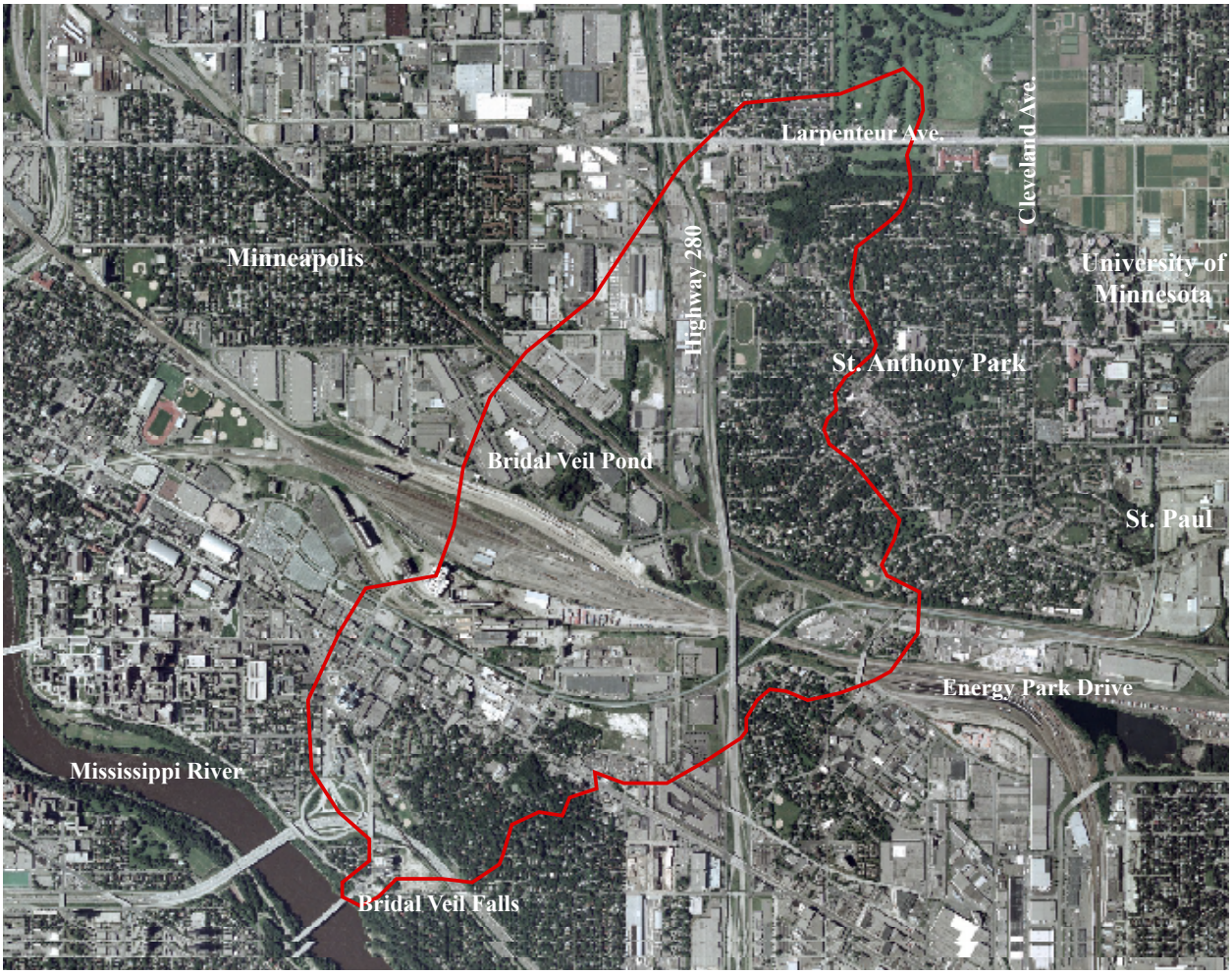

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Bridal Veil Creek

The following report was funded by a grant from the Mississippi Watershed Management Organization to the Saint Anthony Park Community Council to conduct a comprehensive review of information available on the Bridal Veil Creek (BVC) Watershed. The purpose of the study was to undertake a desk review and analysis of all known, prior hydrologic and drainage studies; environmental and biological inventories, histories, pollution and ecosystem studies and reports; and other relevant materials and information on the BVC watershed to be summarized in a narrative report.

Information Reviewed and Methodology

Historic maps were reviewed dating back to the 1850's including city plat maps, railroad maps, USGS topographic maps, river surveys and others (See Appendix A). Aerial photos dating back to 1938 were reviewed to identify alterations to landscape and drainage features. Other historic documents reviewed included Public Land Survey notes, vegetation maps, and soil surveys. Existing land cover, topography, wetlands, public waters, soils and other natural features were reviewed using GIS.

Geological investigations, planning documents, watershed management plans, local histories, and biological investigations were all reviewed in detail. Some of the more important recent studies include the following:

- Mississippi Watershed Management Organization Watershed Management Plan (MWMO, 2000)
- What we have lost and what remains: Options for managing and connecting habitat in St. Anthony Park with surrounding communities (Eckman et al., 2001)
- AUAR for Southeast Minneapolis Industrial (SEMI)/Bridal Veil Area (MCDA and SEED, 2001)
- Bridal Veil Creek & Site Analysis (KDG Inc., 2004)
- Bridal Veil Falls Area Study Feasibility Report (URS, Inc. 2004)
- Daylighting Creeks in Hennepin County (Cornejo, 2005)
- Hydrogeology of the St. Paul Campus (Alexander et al., 2005)

Findings

A historic study of a highly urbanized watershed is like solving a puzzle with many missing parts. No one map or study can provide a comprehensive overview of the watershed boundaries, hydrologic or biological processes. Only by extracting small bits of information from hundreds of sources, were we able to obtain an understanding of the watershed's pre-settlement characteristics.

Landscape Change and Historic Watershed Boundaries

Urbanization of Minneapolis and St. Paul brought wholesale change to the Bridal Veil watershed starting in the mid-1800s. One thing that remains unchanged in the watershed is the general direction of surface and groundwater flow towards the southwest, ending with Bridal Veil Falls plunging into the Mississippi River.

Executive Summary

Watershed land cover is primarily urban and residential with small pockets of highly altered natural areas. Impervious surfaces cover most of the watershed, particularly in the industrial region known as the Southeast Minneapolis Industrial (SEMI)/Bridal Veil Area. St. Anthony Park, a glacial kame that supported oak savanna with several wetlands and lakes prior to European settlement is now primarily residential.

The drainage system was converted from a sinuous stream meandering through a wetland complex in the Bridal Veil valley to the current underground storm sewer network. The only remaining open stream sections are north of the Bridal Veil Pond and a small tributary in the Lauderdale city park. Watershed boundaries have changed as well. Historically the watershed was about 1,177 acres. Topographically the drainage basin was extended north to the City of Lauderdale and east to the State Fairgrounds, via drainage alterations. The current watershed boundary follows the routing of water in the stormsewer system and is 740 acres, about 62% of the original area. The current "sewershed" lies entirely west of Highway 280 with the St. Paul and Minneapolis pipe systems now entirely separated. The cities of Lauderdale and Falcon Heights, formerly connected to the Bridal Veil sewer system, now both drain to the Eustis tunnel (part of the St. Paul pipe system) as of the mid 1990s. Groundwater connections may still exist east of State Highway 280 despite the surface water drainage divide.

Issues Identified in Recent Hydrologic, Geologic and Urban Planning Investigations
One dominant theme in the watershed is the interest by local community groups to clean up the watershed, establish greenways, reduce water pollution, restore natural areas and improve quality of life by enhancing recreational opportunities. In order to achieve this goal, watershed management, landscape-level planning and ecological restoration at ecosystem and site scales will be necessary.

Major watershed management issues facing the BVC watershed include a high percentage of impervious area for stormwater management, the presence of contaminated soils at several Minnesota Pollution Control Agency (MPCA) listed sites and political division of the watershed into multiple jurisdictions. Issues involving natural area management and restoration include habitat fragmentation, loss of natural plant communities and open space areas, spread of invasive species, and degradation of water quality from stormwater runoff. Water quality in BVC is important to downstream areas because it is a tributary of the Mississippi River. Water quality concerns in this segment of the Mississippi River, as identified by the MPCA include high levels of fecal coliform bacteria, ammonia and nitrogen compounds, pH, concentrations of nutrients, biological oxygen demand (BOD), and total suspended solids (TSS).

Looking to the Future: Analysis and Recommendations
Analysis of opportunities and constraints reveals numerous obstacles to ecological restoration and watershed management. The primary constraints are the limited area of natural cover, fragmentation of remaining habitats, a high percentage of impervious surface area, reduction of baseflow, elimination of surface streams, wetlands and ponds, presence of contaminated soils along Bridal Veil Creek, and fragmentation of the watershed into two political units by routing

of storm water along city boundaries. Given these limitations, the ecological integrity of stream, pond and wetland communities will always be limited. As with many urban watersheds opportunities primarily lie in the areas of stormwater management, aesthetics, historical interpretation, recreation, pedestrian accessibility and greenway development. Despite these limitations, opportunities exist for improved management of water quality and natural areas, especially in the areas of storm water BMPs, native plant community restoration, establishment of greenways and corridors to connect parks and natural areas. For an urban area the BVC watershed has a number of natural areas and open spaces that could be connected by improved pedestrian access and native landscaping. Major potential corridors lie north-south from Kasota Ponds to the Luther Seminary area and east-west from Kasota/Bridal Veil Pond along Energy Park Drive to the University of Minnesota, St. Paul campus. A greenway plan is proposed that would encircle St. Anthony Park following these corridors (Figure 39). Within Bridal Veil Creek itself there are opportunities for natural channel design to re-create a surface stream where pipes or concrete-lined channels currently exist. Site selection will be critical due to the many constraints imposed by existing infrastructure and contaminated soils.

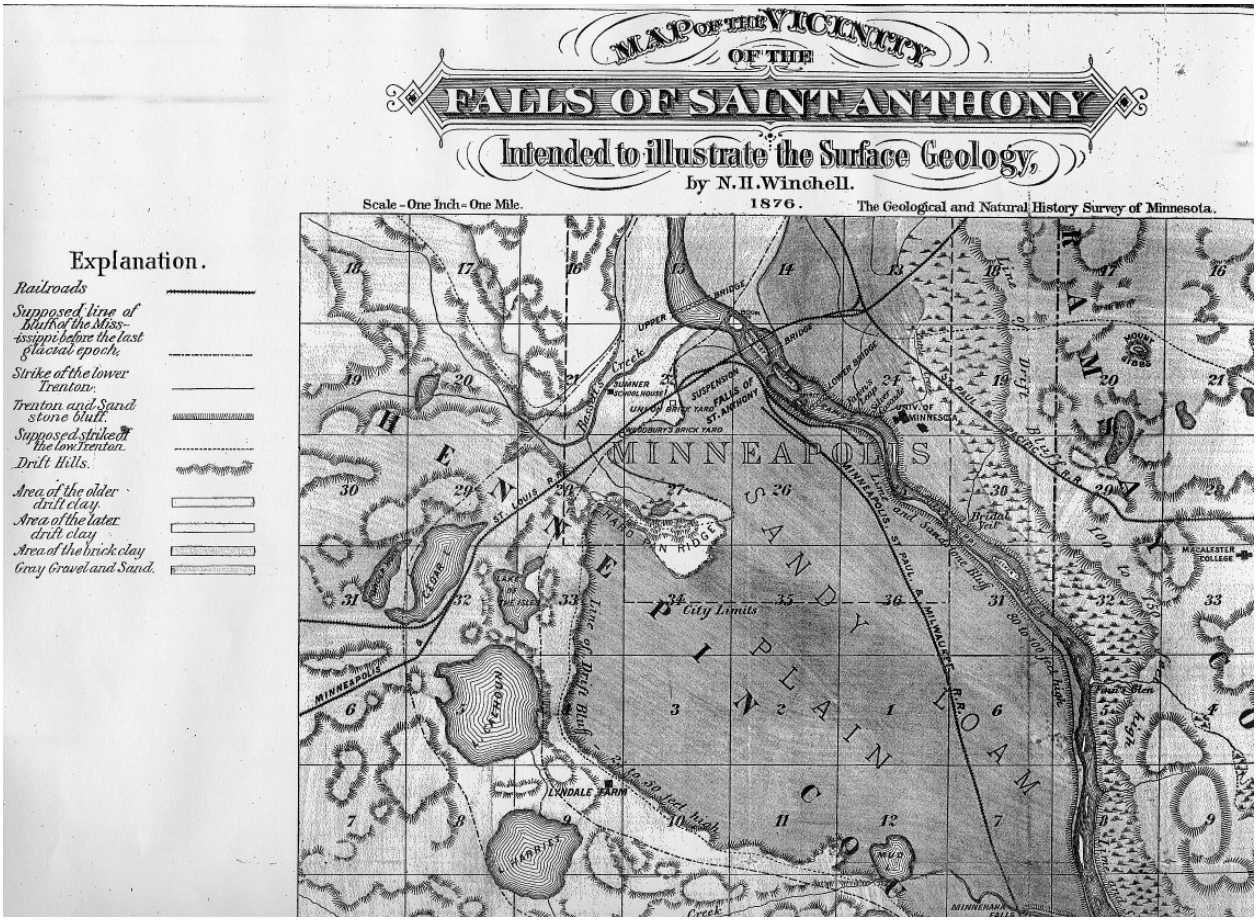


Figure 1: Winchell Map of the Vicinity of the Falls of Saint Anthony 1876

Historic Landscape Characteristics

PART 1: HISTORICAL MAP and DOCUMENT REVIEW

HISTORIC SOIL AND GEOLOGY MAPS

An extensive survey of historic and contemporary maps of the bedrock geology, surficial geology and soils mapping was conducted to create a picture of the formative processes that make up the Bridal Veil Creek watershed. The following section describes characteristics of the pre-urbanized landscape and landscape change over time as found in a review of historic map resources.

Winchell Map of 1876

The N.H. Winchell Map provides a general overview of the relationship between the topographic and surficial geology of the Twin Cities area in concise legible fashion (Figure 1). The Winchell map also locates both Bridal Veil Creek and Mount Gibbs in St. Anthony Park. On the east bank of the Mississippi River, Winchell identifies three predominant features, the Sandy Loam Alluvial Plain of the Mississippi River, a "Line of Glacial Drift" indicated as a hummocky bluff, and a band of wetlands located at the base of the Glacial Drift line. The Line of Drift lies almost directly beneath the current Hwy. 280, separating the sandy glacial deposits of St. Anthony Park from the organic soil deposits in the wetlands of Bridal Veil Valley.

This map provides a graphic picture of the extent to which the Mississippi River Valley bisects the mobile material of the glacial landscape and created a series of river terraces at its ancient, much larger banks. Likewise, Winchell shows the various small streams that drain the bluff-line wetlands. This is the only map located that provides names for the various watercourses and features along the Mississippi River bluff-line. These features include Silver Cascade, a waterfall fed by Tuttle Creek, Fawn's Leap nearby, and Finn's Glen to the south of Bridal Veil Falls.

USGS Geology Map of 1916

The Areal Geology map of 1916 provides additional detail of the Quaternary Geology of the Bridal Veil Region (Figure 2). This map provides insight into the general topographic and vegetative makeup of the presettlement landscape. The surficial geological landscape of the Bridal Veil watershed is highly variable with a composition based both on changing Mississippi River configurations and glacial depositional patterns. The Areal Geology Map of 1916 maps the surficial geology of the region, and as a graphic representation, provides a clear image of glacial deposition in the form of mounds of till represented by the St. Anthony Park and Newell Park neighborhoods of St. Paul, and Prospect Park in Minneapolis.

Three glacial and post-glacial periods dominate the formative history of the Bridal Veil Watershed. The first major deposition of the existing surface till material was brought in with the Superior Lobe of glaciation. This period ended some 15,000 years ago depositing a generally red rock material of sandstone and slate from an area between Hinckley, Minnesota and the Lake Superior Basin. Material of the second major deposition came from the west with the Des Moines Lobe. The deposits of this period consist of bedrock material derived from Manitoba, Canada and western Minnesota. This gray bedrock material was oxidized in surficial areas to a yellow. color The movement of the Des Moines Lobe created some mixing of materials, but gen-

Bridal Veil Creek

erally, the three neighborhoods of Prospect Park, St. Anthony Park and Newell Park are distinct glacial depositional mounds. The red till of the Superior lobe dominates the surficial geology of Newell and Prospect Parks with the younger, gray till comprising the St. Anthony Park area.

To the west of these communities lies the flatter basin of Bridal Veil watershed. This area, dominated by industry and railroads lies at the base of the glacial moraines of St. Anthony and Prospect Parks. This area became an elevated river terrace of the glacial melt-waters that ran through the Mississippi River gorge. The Glacial Mississippi River formed a massive valley as it drained Lake Upham, located in the present Superior Highlands region of the state. The river valley formed by the Glacial River is clearly seen in the areal map running southeast through present day southeast and northeast Minneapolis.

This flattened river terrace contains three landform types created during the post glacial period. The area labeled in green on the map represents locations where water collected at the bases of the glacial mounds to the east, forming wetland depressions. In these depressions, permanentaly saturated conditions provided favorable conditions for peat growth. These large peat formations indicated by green on the areal Geology map are bisected in a few locations by former Mississippi River sandbars, notably the elevated sandy area of the Great Northern Railway yards (indicated in yellow on the Areal Geology Map).

A valuable, concise description of the formative geology of the St. Anthony Park area is provided in the 1969 Community Study for St. Anthony Park by Frederic Steinhauser and the St. Anthony Park Association (pgs II:10 – II:12)

The Areal Geology Map (Figure 2) provides insight into the existing character of the Bridal Veil Watershed in valuable ways. The landform character of the Bridal Veil watershed is clearly expressed in the map units of the Areal Geology map:

- **OD (Decorah Shale) and OP (Platteville Limestone)** – These Ordovician bedrock deposits are exposed along the Mississippi River bluff where the current river channel has created cuts into and below the glacial deposits. The pre-settlement plant community would have been comprised primarily of forested bluffs.
- **Qal (Alluvium and Lacustrine Deposits)** – Located in the lowest portions of the Mississippi River gorge, these riverine and lake deposits were confined to the former Meeker Island. Pre-settlement vegetation would have been a combination of floodplain forest and early successional river species.
- **Qet (Terrace Gravels)** – These formations are associated with terraces of a formerly wider Mississippi River Channel on the West Bank of the river and the East Bank of the river primarily north of Bridal Veil Creek. Bridal Veil Creek is bounded by this area of deposition on the western side of the creek. These Terrace Gravels form much of the

Historic Landscape Characteristics

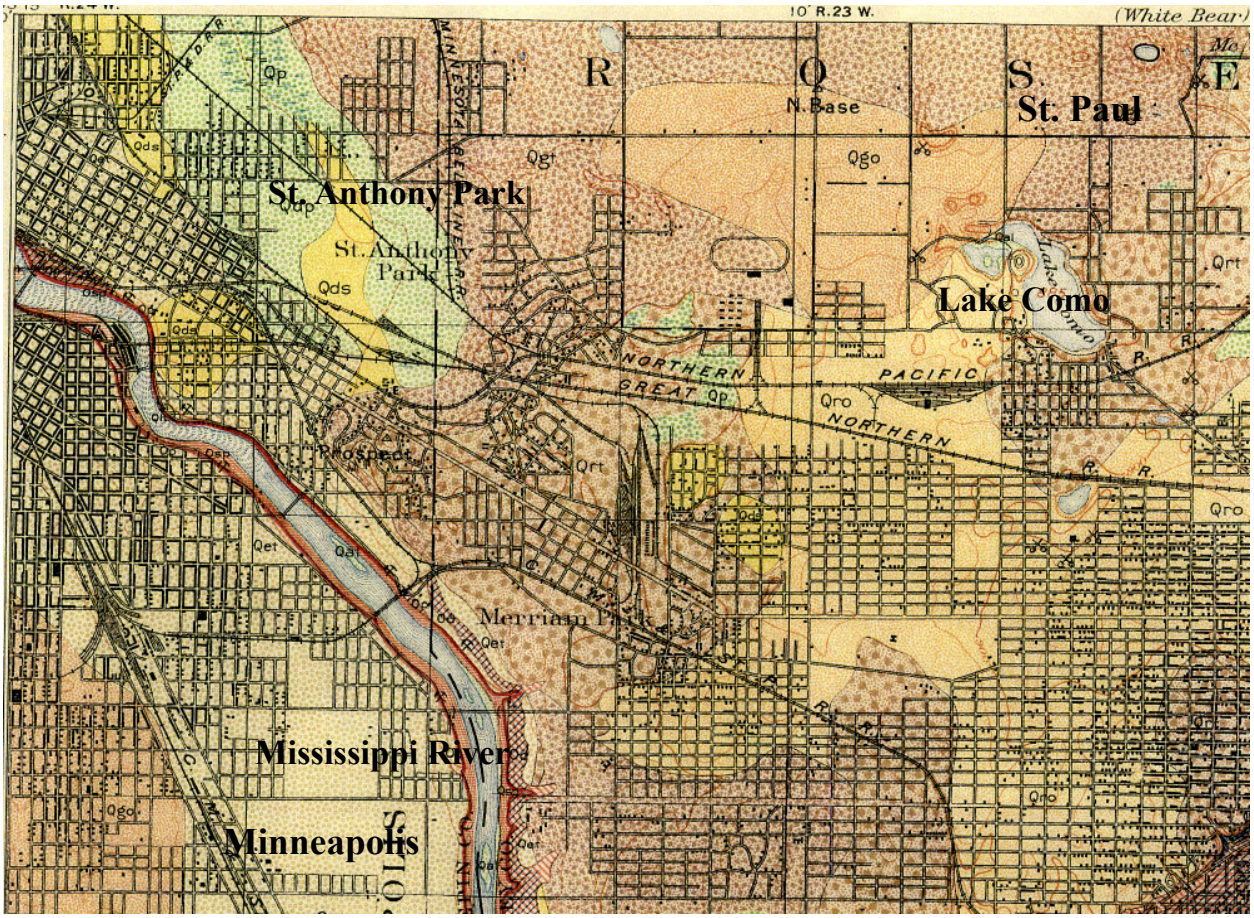


Figure 2: USGS Areal Geology Map 1916 (Hennepin County Historical Society)

USGS Areal Geology Map Key

Code	Description	Notes
Od	Decorah Shale	Green shale exposed at Mississippi River Bluff Line
Op	Platteville Limestone	Blue gray limestone exposed at Mississippir River Bluff Line
Qal	Alluvium and Lacustrine Deposits	Chiefly Sand and Fine Silt
Qdp	Peat and Muck in Marsh Land	Dry Peat in Drained Marshes
Qds	Dune Sand	Glacial river gravels and outwash from young gray drift
Qet	Earlier Terrace Gravels of Glacial Minnesota and Mississippi River	Young gray drift with bare till and some wash on terrace slopes
Qgt	Young Gray Till	Thin sheet, mostly ground morraine
Qp	Peat and Muck on Marsh Land	Marsh
Qro	Red Outwash Gravel	Red sand and Gravel
Qrt	Red Till	Red boulder clay containing few limestone pebbles: chiefly terminal morraine

surficial geology of the University of Minnesota Minneapolis campus areas. Pre-settlement vegetation would have been a transition mix of upland and floodplain forest species. Floodplain species would have been present in drainage channels, creeks, wetland margins and in areas nearest to the river. Upland forest was comprised of Oak Forest and Savanna (based on Marschner's interpretation and PLS notes).

- **Qds (Dune Sands)** – The dune sands located in the Great Northern Railyards and in the center of the University East Bank were likely deposited at the edge of the glacial meltwater channel of the larger and wider Mississippi River during glacial melting. These ancient dunes were a well drained material, and based on PLS notes and the Marschner map interpretation (MRC, 1895), were dominated by Oak forest and Oak Savanna.
- **Qrt (Red Till)** – Red boulder clay containing few limestone pebbles, this is primarily terminal morraine. This is the primary material underlying the Prospect Park and South St. Anthony Park portion of the watershed providing the undulating, and somewhat unpredicable quality of the landscape in the area. Dominated by oak forest and savanna, many of the pre-settlement trees still exist throughout the neighborhoods today.
- **Qgt (Gray Till)** – Gray Till of Ground Moraine origin, this glacial debris also provides the area with undulating hills, including the kettle basin of Langford Lake. Mostly upland, these areas would have been dominated by Hardwood Forest and Oak Savanna.
- **Qdp and Qp (Peat and Muck in Marsh Land)** – Peat and Muck are located where wetland plant detritus and root matter collect in nearly permanently wet conditions. The underwater (anaerobic) setting inhibits the breakdown of dead plant matter, creating a soil of nearly pure organic matter. The areas of Sarita Pond, Newell Lake and the Great Northern Railyards were all underlain with this material. Much of the Bridal Veil Creek watershed drains from the railyards underlain with this organic soil. Based on the PLS notes and other historical documents, this area was likely open marshland, with a mixture of cattail marsh, sedge meadow and wet prairie.

Ramsey County Geologic Atlas

The Ramsey County Geologic Atlas, published in 1992 offers an in depth analysis of Ramsey County Bedrock Geology (Figures 3 & 4). Maps provided by the atlas include:

- Data-base Map by Emily J. Bauer, Jane M. Cleland and Timothy E Wahl
- Bedrock Geology / by John H. Mossler and Bruce A. Bloomgren
- Surficial Geology / by Carrie J. Patterson
- Bedrock Topography Map / by John H. Mossler
- Depth to Bedrock Map / by John H. Mossler and Jane M. Cleland
- Surficial Hydrogeology / by Roman Kanivetsky and Jane M. Cleland
- Bedrock Hydrogeology / by Roman Kanivetsky and Jane M. Cleland
- Sensitivity of Water-Table System to Pollution / by W. Patrick Twiss
- Sensitivity of the Prairie du Chien-Jordan Aquifer to Pollution / by W. Patrick Twiss
- Wells and Well Construction / by Douglas S. Edson and Bruce M. Olsen

At its surface, the geological history of the Twin Cities region is generally dominated by the

advances and retreats of glaciers beginning two million years ago and ending with the last retreat of glaciers from this region some 12,000 years ago. Bedrock formations in the Twin Cities are generally located deep beneath glacial till with the exception of the major river valleys of the Mississippi, Minnesota and St. Croix. Each of these valleys formed as the result of glacial meltwaters associated with glacial Lake Upham II, Lake Agassiz and Lake Superior respectively and melting of their associated glaciers. Beyond the river valleys, the Twin Cities region is dominated by recent geological deposition of glacial debris. Within the Bridal Veil watershed, the depth to bedrock ranges from greater than 150 feet thick in the northern portion of St. Anthony Park to less than 50 feet thick in the SE Como neighborhood. A graphic image of the depth to bedrock beneath glacial till is provided in the Bedrock Geology Section Drawing (Figure 4). St. Anthony Park is located immediately south of point GR2 on this section.

The underlying bedrock of Bridal Veil watershed is entirely comprised of Decorah Shale and the Platteville/Glenwood dolostone and limestone formations. Within the watershed, a thin band of St. Peter Sandstone is located along the Mississippi River bluffs where the river has cut a deep channel through glacial till and bedrock. All of these bedrock types are sedimentary formations of the Ordovician period of roughly 450 million years before the present. These rock formations are considered hydrological confining units promoting develpment of shallow glacial aquifers above the impervious layers. but are non-aquifer bedrock types. A brief description of the bedrock units of the Bridal Veil watershed is provided in the maps below:

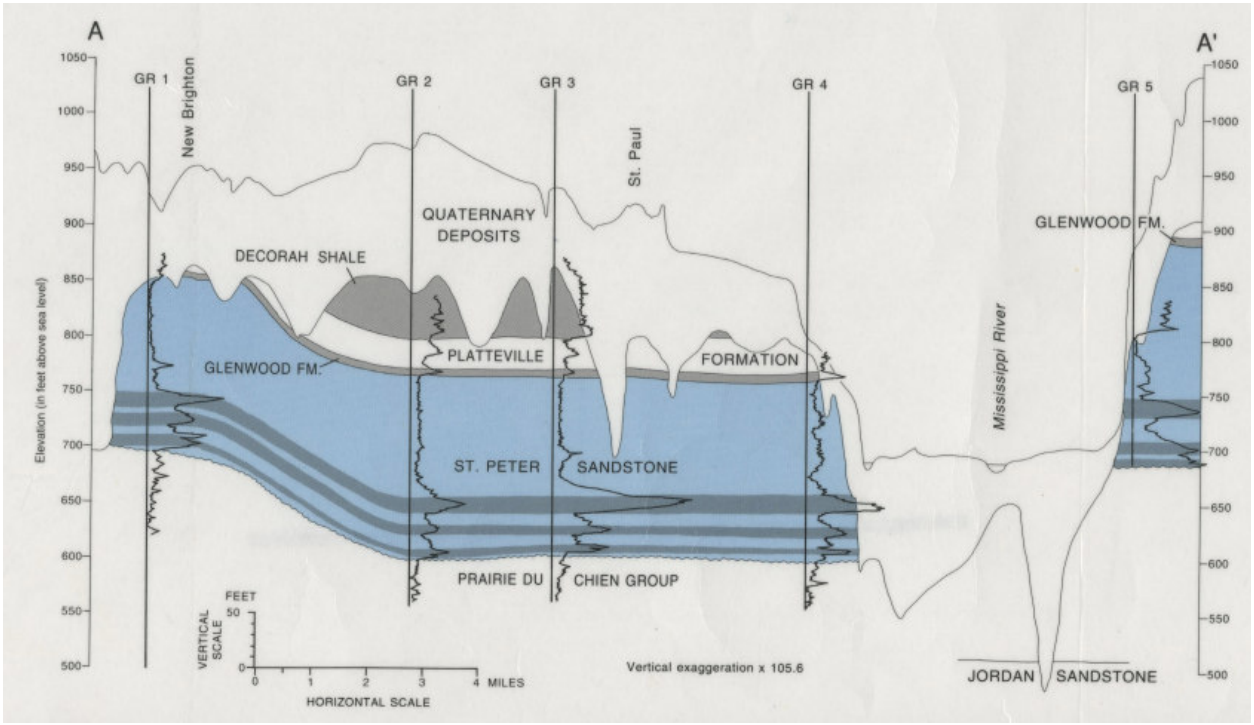
Bridal Veil Creek

Figure 3: Ramsey County Geologic Atlas, Bedrock Geology 1992
(University of Minnesota, Borchert Map Library)

Ramsey County Geologic Atlas Key

- **Decorah Shale (green)** – Located under the highest portions of St. Anthony Park, Prospect Park and the Merriam Park portion of St. Paul, this formation is a green calcareous shale with thin limestone interbedded. This is a formation formed by sediments deposited in shallow seas with water no deeper than 150 feet.
- **Platteville and Glenwood Formations (blue)** – It underlies much of the historic Bridal Veil Creek watershed and is found under the railroad yards between North and South St. Anthony Park and into SE Minneapolis. This is a fine-grained dolostone and limestone. It was used as a building stone in the past, and is quarried in South St. Paul.
- **St. Peter Sandstone (ivory)** - Located as the upper layer of bedrock only near the Falls within the current Mississippi River Valley. This is a fine to medium grained quartz sandstone with interbedded mudstone, siltstone and shale.

Historic Landscape Characteristics



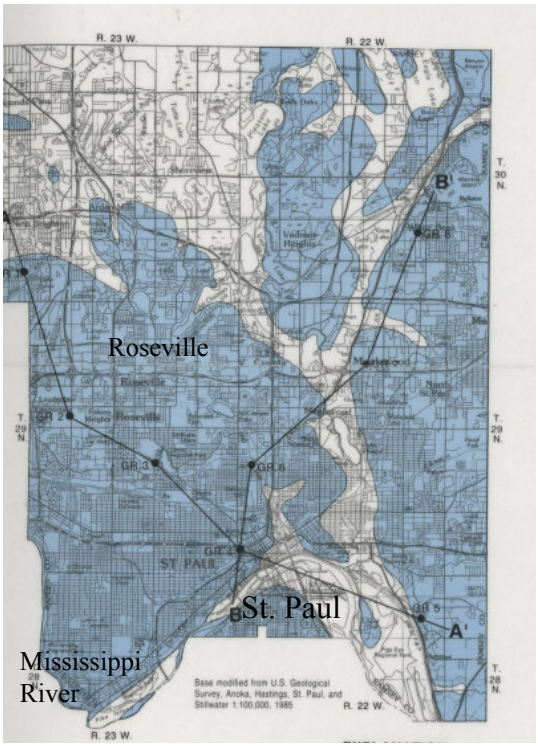


Figure 4: Ramsey County Geologic Atlas, Bedrock Topography Section and Location Map 1992 (University of Minnesota, Borchert Map Library)

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NRCS Soil Survey 1916
Hennepin and Ramsey County soils were mapped in 1914 by the United States Department of Agriculture Bureau of Chemistry and Soil (Figure 5). Soil surveys were created primarily in order to identify productive land for agriculture, and have been expanded for the purpose of natural resource protection (wetlands), development potential and land planning. Due to urbanization, urban soils have not often been mapped since the original surveys, or are mapped as disturbed. The 1916 Soil Survey of Hennepin County very little of the industrial land in southeast Minneapolis, whereas the map for Ramsey County provides detailed soils mapping, possibly due to the presence of the agricultural college at the University of Minnesota.

Recent NRCS Soil Survey Updates
Soils in the urban areas of Hennepin County were not mapped since the area was mostly paved and are therefore labeled "urban lands" in the NRCS Soil Survey. The Hennepin County survey was updated in 2003 (USDA, 2003). Soils in Ramsey County (including St. Anthony Park, Falcon Heights and Lauderdale) were mapped to the extent possible given urbanization. The St. Anthony Park hill consists of sandy loam and silt loam in the uplands, including Kingsley sandy loam, Chetek sandy loam, Freer silt loam, Santiago silt loam and Waukegan silt loam. In low-lying wetland areas, organic soils such as Markey muck are common. In the low-lying areas along the historic location of Bridal Veil Creek, larger peat deposits were mapped which would have had a higher percentage of organic material, due to their landscape position and poor drainage.

Summary of Geology/Soil Information
The BVC watershed has been shaped both by glacial activity and the Mississippi River. St. Anthony and Prospect Parks are both glacial kames and consist of sandy soil deposited on top of the bedrock. The BVC Valley consists of a mixture of sand and organic deposits where wetlands existed historically. The three bedrock types nearest to the surface are Decorah Shale, Platteville and Glenwood Limestone/dolostone, and St. Peter Sandstone. The highly permeable sandy soils combined with impermeable bedrock and steep topography create complex hydrogeologic dynamics in the BVC valley, though generally the flow of water is to the southwest.

Historic Landscape Characteristics

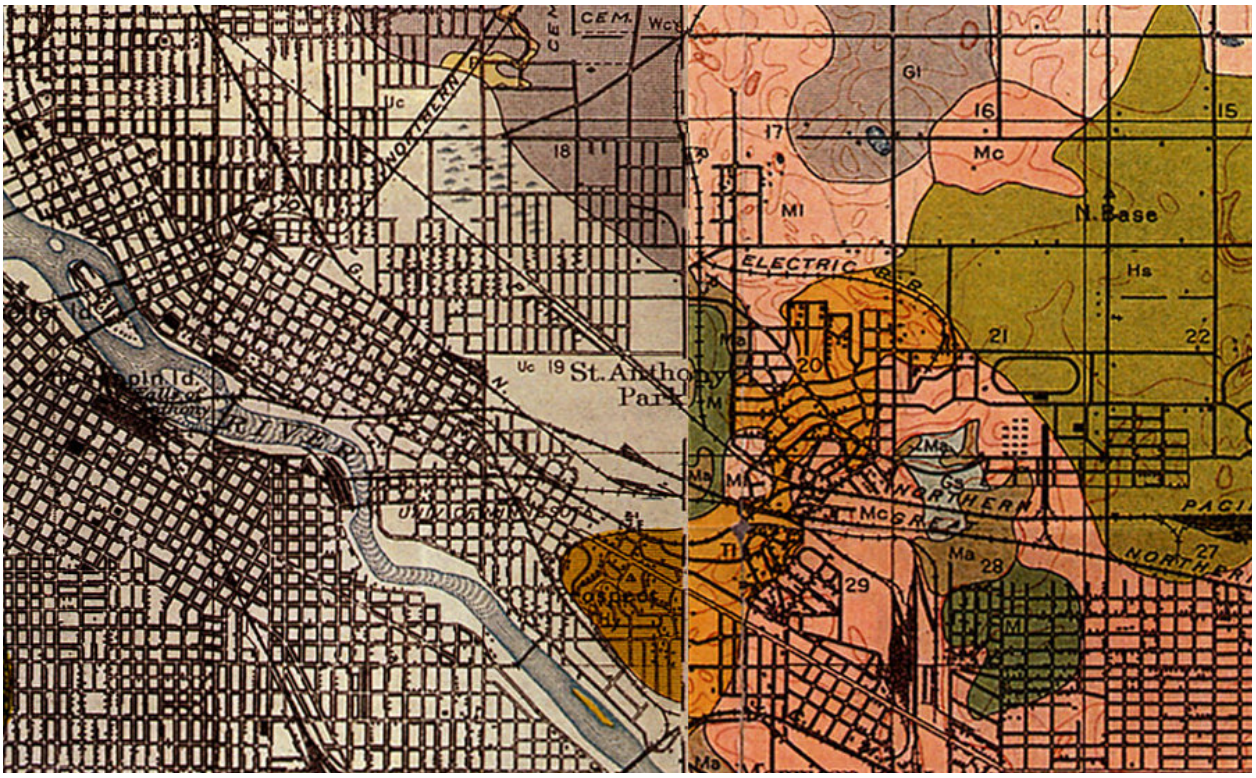


Figure 5: NRCS Soil Survey 1916 (University of MInnesota, McGrath Library)

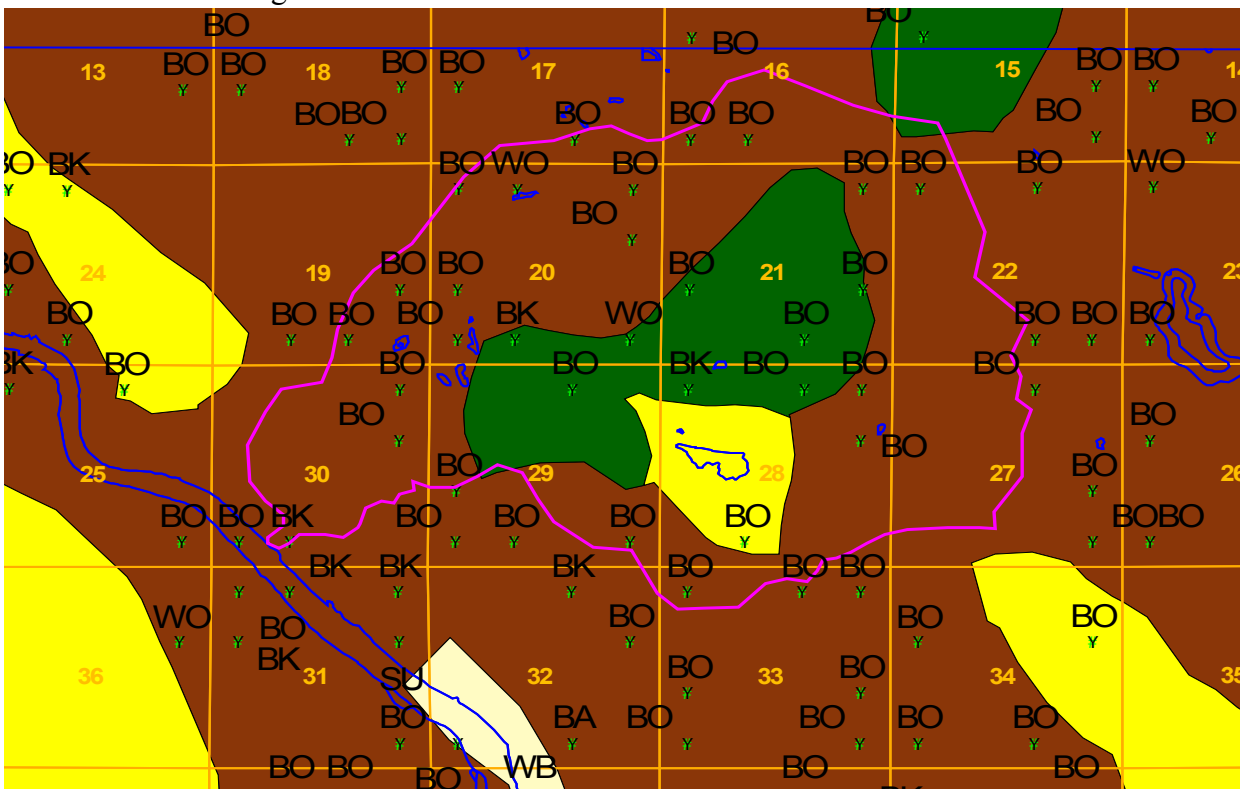
NRCS Soil Survey Key

Code	Description	Notes
Gl	Gloucester loam	8-16 inches of loam underlain by clay loam subsoil often with boulders and cobbles present over red clay of considerable thickness. This is hilly and bumpy land.
Gs	Gloucester fine sandy loam	8-16 inches of sandy to loam soils underlain by a loam to clay loam subsoil over red clay. This is rolling to hilly land.
Hy	Hayden sandy loam	Fine sandy loam to loam over sandy clay loam or clay loam. The surface tends to be well drained.
M	Merrimac loamy fine sand	8-12 inches of loamy fine sand over fine sand to loamy fine sand to 3 feet over coarse soils. This is well drained, level land.
Ma	Marsh	Marsh soils are usually not described in soil surveys.
Mc	Merrimac loam	8-16 inches of loam, underlain by silty clay loam subsoil over clean gravel and sand. This is drought resistant and well-drained undulating upland.
Ml	Miami loam	n/a
Tl	Thurston loam	8-14 inches of brown loam underlain by silty loam subsoil extending to a depth of 3 feet over gravel and sand.
Uc	Unclassified city land	Unclassified.

HISTORIC VEGETATION MAPS

Pre-Settlement Vegetation in BVC Watershed Area

The Public Land Survey for the Minnesota region (T29N, R23W, 4th Principle Meridian, Sections 19 and surrounding areas) was performed in 1845 by J. Marsh (Figures 6 & 7). As part of the public land survey, large bearing trees were identified along all transects. This information provides insight into the types of plant communities that existed in the area at that time. Marsh's notes taken along the interior section lines indicate the area was primarily oak savanna or thin oak forest, with "wet prairie" or marsh in the low spots. Some of the phrases Marsh used in describing the area include: "Wet prairie bottom with sparse timber," and "Hilly, 2nd rate land with scattering of bur, white oak timber." The most numerous trees listed in Marsh's notes were bur oak (BO in Figure 6) and white oak (WO) with occasional elms in depressions and wet areas. The PLS notes were mapped statewide by James Marshner in the 1970s as shown in Figure 6.

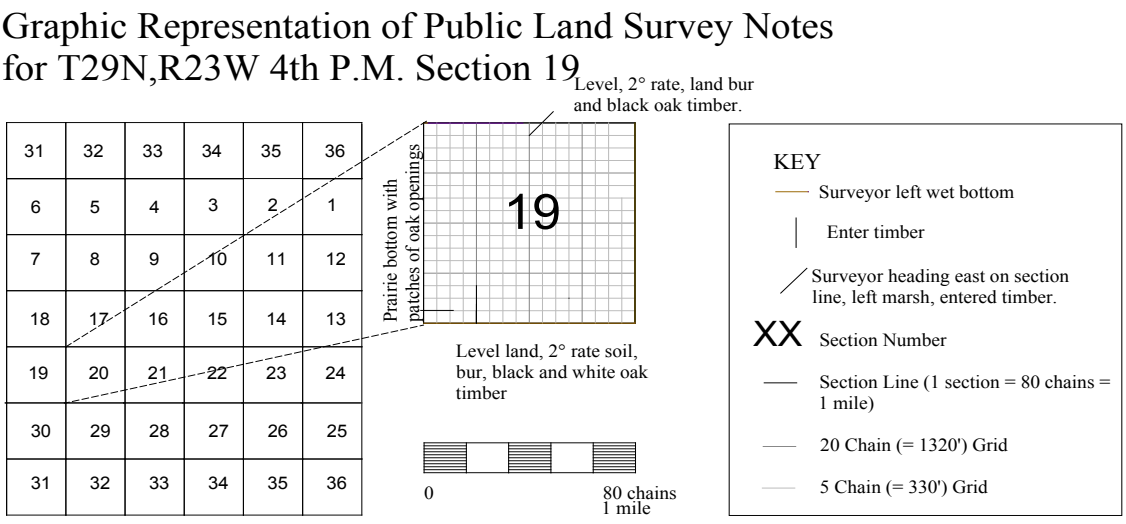


Bearing Trees, Section Lines and Marschner's Original Vegetation

Big Woods - Hardwoods (Oak, Maple, Basswood, Hickory)
Conifer Bogs and Swamps
Oak Openings and Barrens
Prairie
Possible Watershed Area (Current Project Boundary)
Bearing trees
PLS Section Lines

Figure 6: Pre-Settlement Vegetation in Vicinity of Bridal Veil Watershed

Historic Landscape Characteristics



Sources:
1. Map based on public land survey notes by James Marsh, May 1847.
2. Text above section lines represents surveyor's notes along section line.
3. Text under section lines represents surveyor's summary of soil, topography and plant community at section line.
4. Heavy colored lines along section lines represent vegetation recorded by surveyor along section line.
5. See report text for township general description.

Figure 7: Illustration of Public Land Survey Notes for the Bridal Veil Pond Vicinity

Summary of Historic Vegetation Data

There is much less information on historic vegetation characteristics than on the physical parameters such as geology and soils. Urban development occurred so quickly after European settlement in this area, that plant communities were quickly altered or eliminated without any notes taken on their characteristics. The PLS notes are one of the few remaining sources of information concerning plant community characteristics. It is clear from these notes that uplands were dominated by oak savanna communities with some oak forest and maple/basswood forest in moister, shadier areas. Wetland communities were not described in detail by the PLS surveyors so the nature of these communities is speculative. However, given the large number of historic springs and seeps in the BVC valley it is likely that wetland types characteristic of ground-water discharge, such as sedge meadows and/or fens existed in the area. The presence of bogs was noted east of Cleveland Avenue near Como by Steinhauser (1970). Further downstream it is possible that floodplain forest was found along the BVC ravine.

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LANDSCAPE GENESIS and CHANGES TO WATERSHED BOUNDARIES

Review of Maps 1853 - 1896

One of the primary purposes of this desktop study was to identify the current stormwater runoff drainage area (sewershed) and historic topographic boundaries of Bridal Veil Creek watershed. This task should have provided the geographic parameters for the remainder of the study. Watershed boundaries are determined by examining topographic maps to determine the flow of water over the earth's surface. Unfortunately, large-scale development began prior to detailed mapping of the Bridal Veil Creek watershed. Large-scale development in this case was the construction of the St. Paul and Pacific Railroad through the existing corridor between North and South St. Anthony Park under what is now State Highway 280.

A review of the historic maps provides insight into watershed boundaries, but no clear, definitive answers. This investigation into the historic watershed boundary is an iterative process, using multiple sources. No one source provides all of the answers to the watershed boundary, nor does any one source provide detailed information on the characteristics of the stream itself. Thus, the determination of the historic watershed is based on the combination of clues provided in the various historic sources. The following is a review of the maps that provided the most information on the watershed boundaries.

1853 Public Land Survey Map

The map produced by the Public Land Survey system shows the Bridal Veil Falls area as a shaded box at the edge of Section 30 (Figure 8). Neither this map, nor the PLS notes for the Bridal Veil Creek area provide any mapped creek. The PLS map does, however, show Lake Sarita, Langford Pond and Lake Newell. Red River Road is the current University Avenue.

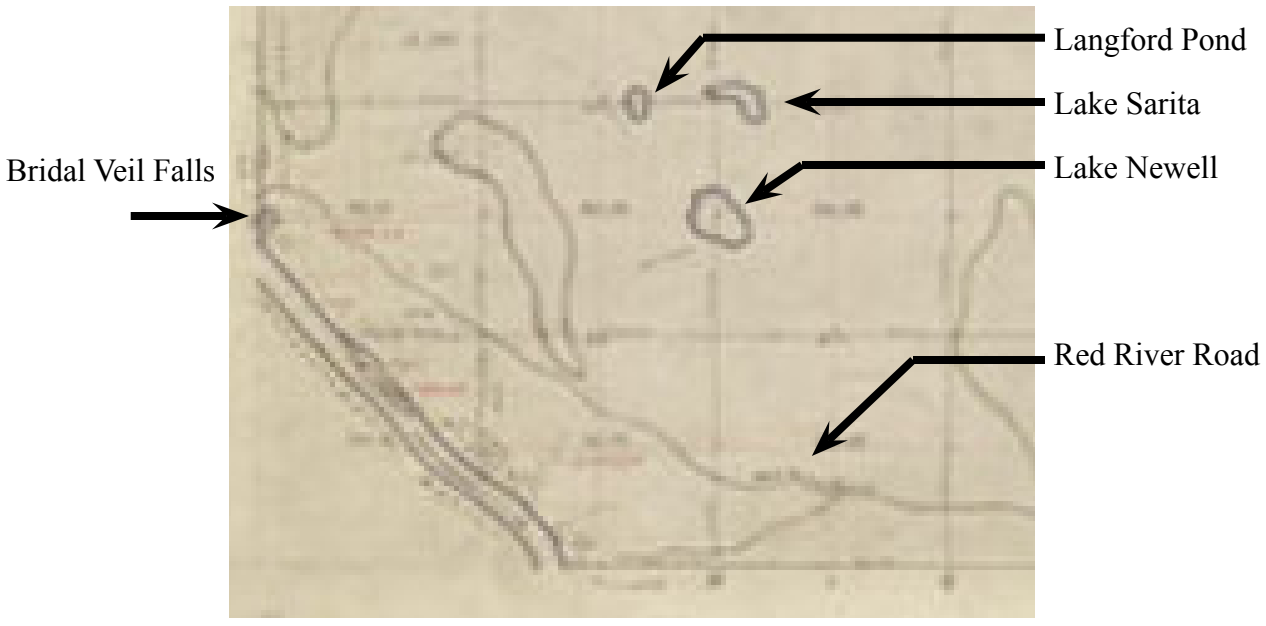


Figure 8: Public Land Survey Map (Minnesota Land Management Information Center)

Historic Landscape Characteristics

1867 Ramsey County Plat Map

The 1867 Plat Map of Ramsey County provides the most detail of all early maps regarding Bridal Veil Creek and the potential watershed (Figure 9). (Water bodies have been highliged in blue). This map shows a stream channel near the Mississippi River outfall, meandering through a series of interconnected wetlands from the north. Within the central portion of the large wetland located in the current railyard area of the watershed this map indicates that an upland wooded area was present. This information concurs with geologic and soils maps indicating that a high sand deposit was located within this portion of the Mississippi River terrace as discussed in the vegetation and geology sections of this document. This map shows a hydrologic connection of Bridal Veil Creek with weltands to the east and through the rail corridor under the current State Highway 280.

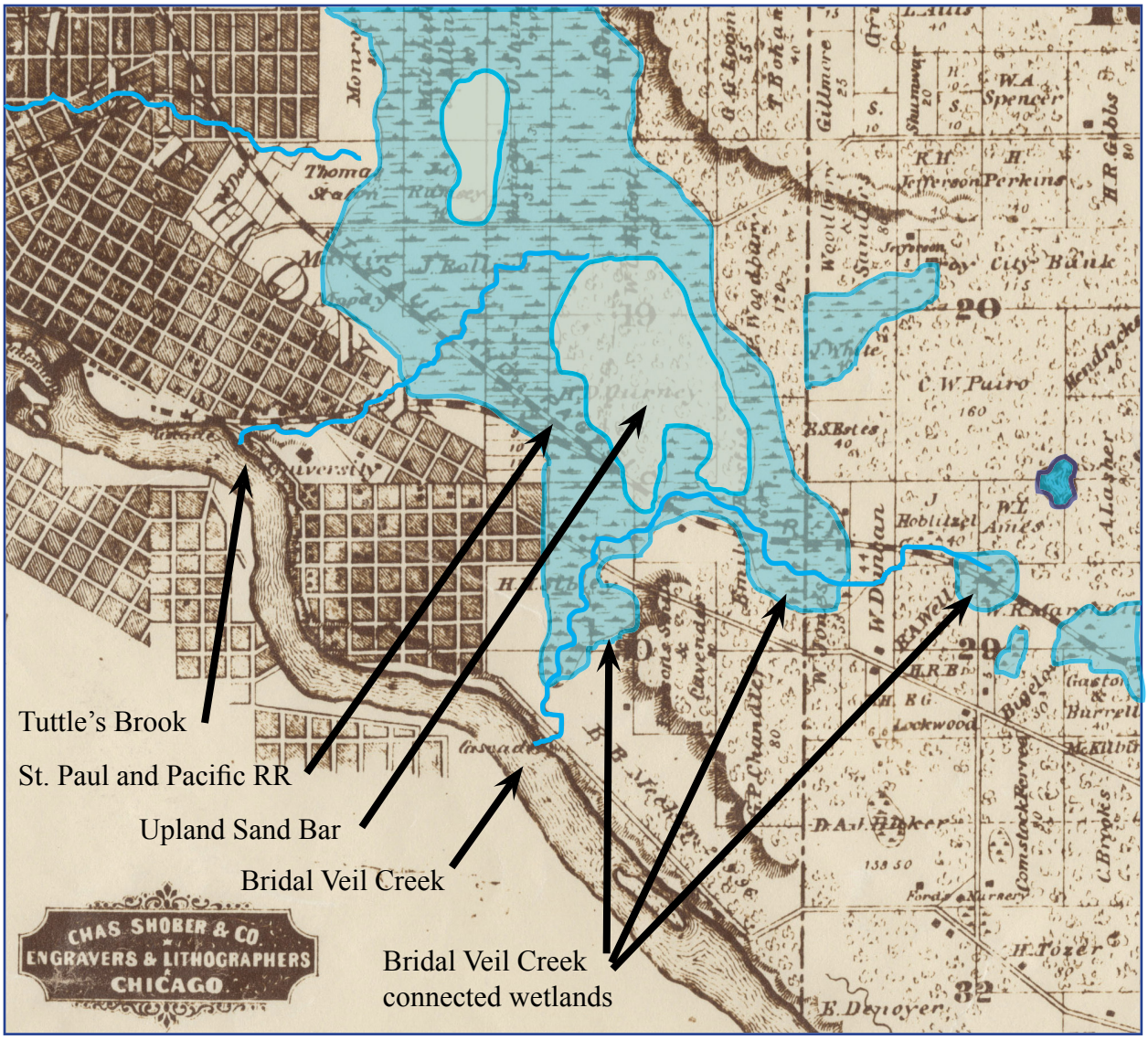


Figure 9: 1867 Ramsey County Plat Map (University of Minnesota, Borchert Map Library)

Bridal Veil Creek

It is very likely that the railroad was built on a streambed, as railroads were often built along the path of least resistance, choosing the lowest point between North and South St. Anthony Park. It may also be the case that the drainage patterns represented on this map were a result of drainage ditches created by the railroad to remove excess water and keep the rail grade stable.

Other features mapped in Figure 10 are the alignment of Tuttle's Brook and wetland extent in the area. Tuttle's Brook was a natural drainage that emptied into the Mississippi River near the current University of Minnesota power plant. Given the topographic signature of the valley and the extent to which this stream was mapped more often and in greater detail than Bridal Veil, it can be assumed that this was perhaps a more significant water course. Tuttle's Brook has long been buried in storm sewer pipes, and because no visible features exist today (waterfall), the brook has been largely forgotten. For the purposes of delineation, this presence of Tuttle's Brook along with the central upland area in the rail yards provides an approximate indication of the western boundary of the Bridal Veil Watershed.

It is an important consideration that this map was created to provide plat information and indicate development potential. As a result this map may be less accurate than scientific maps. as indicated by the straigh wetland boundary in Figure 10. The straight boundary along the section/county line would suggest that the map was either created at disjunct times or by different individuals.

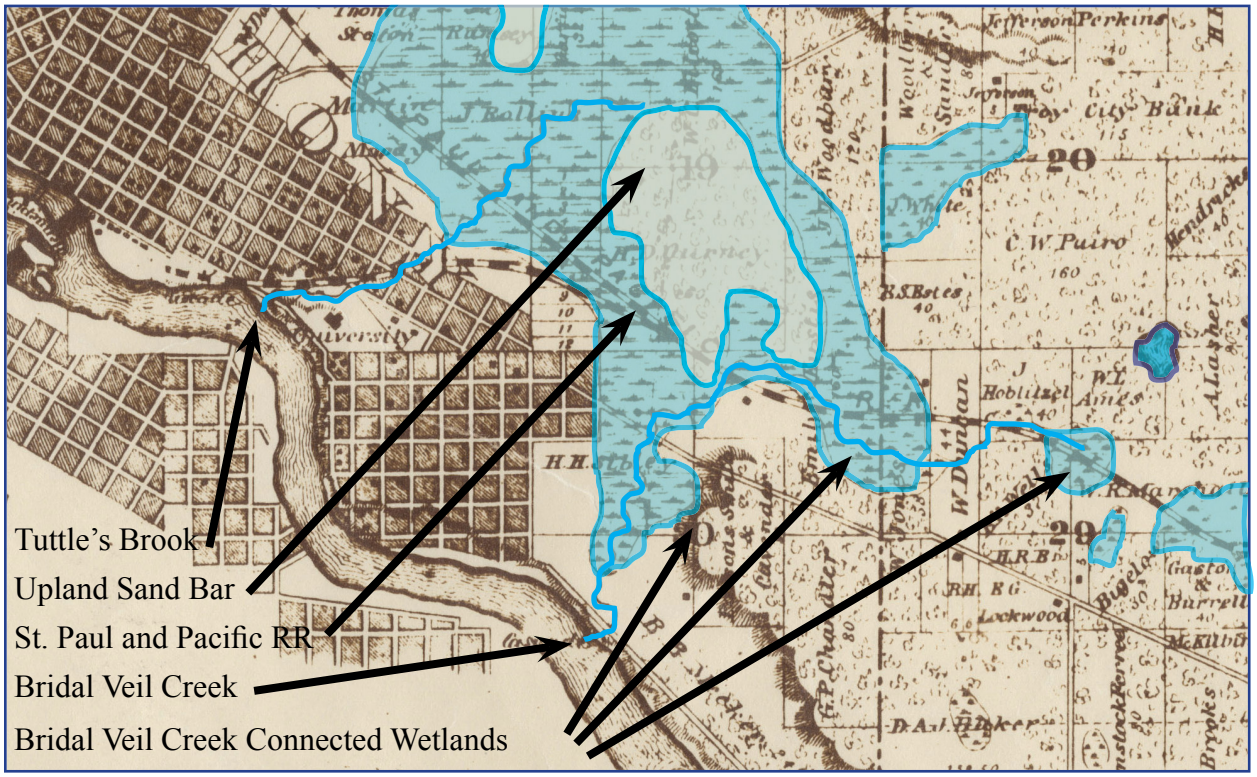


Figure 10: 1867 Ramsey County Plat Map Geo-Referenced with Streams and Wetlands (University of Minnesota, Borchert Map Library)

Historic Landscape Characteristics

1873 Cleveland and French Plan of St. Anthony Park

The plan for St. Anthony Park produced by the landscape architects Cleveland and French provides an indication of the extent to which St. Anthony Park is comprised of the erratic remnants of glacial debris (Figure 11). The glacial landscape is expressed as mounds and depressions scattered throughout the region. Unfortunately, the landscape is represented with little accuracy, created as a document for the sale of lots rather than a clear representation of actual landscape conditions. At the time that this map was created, the St. Paul and Pacific railway was already in place, and the mounds of both North and South St. Anthony Park are expressed as distinct features on both sides of the tracks. The hydrological features of Lake Sarita, Langford Lake, Newell Lake and an additional pond located on the South Side of the tracks, east of the current Raymond Avenue are all clearly shown, but no indication of hydrologic connections is expressed.

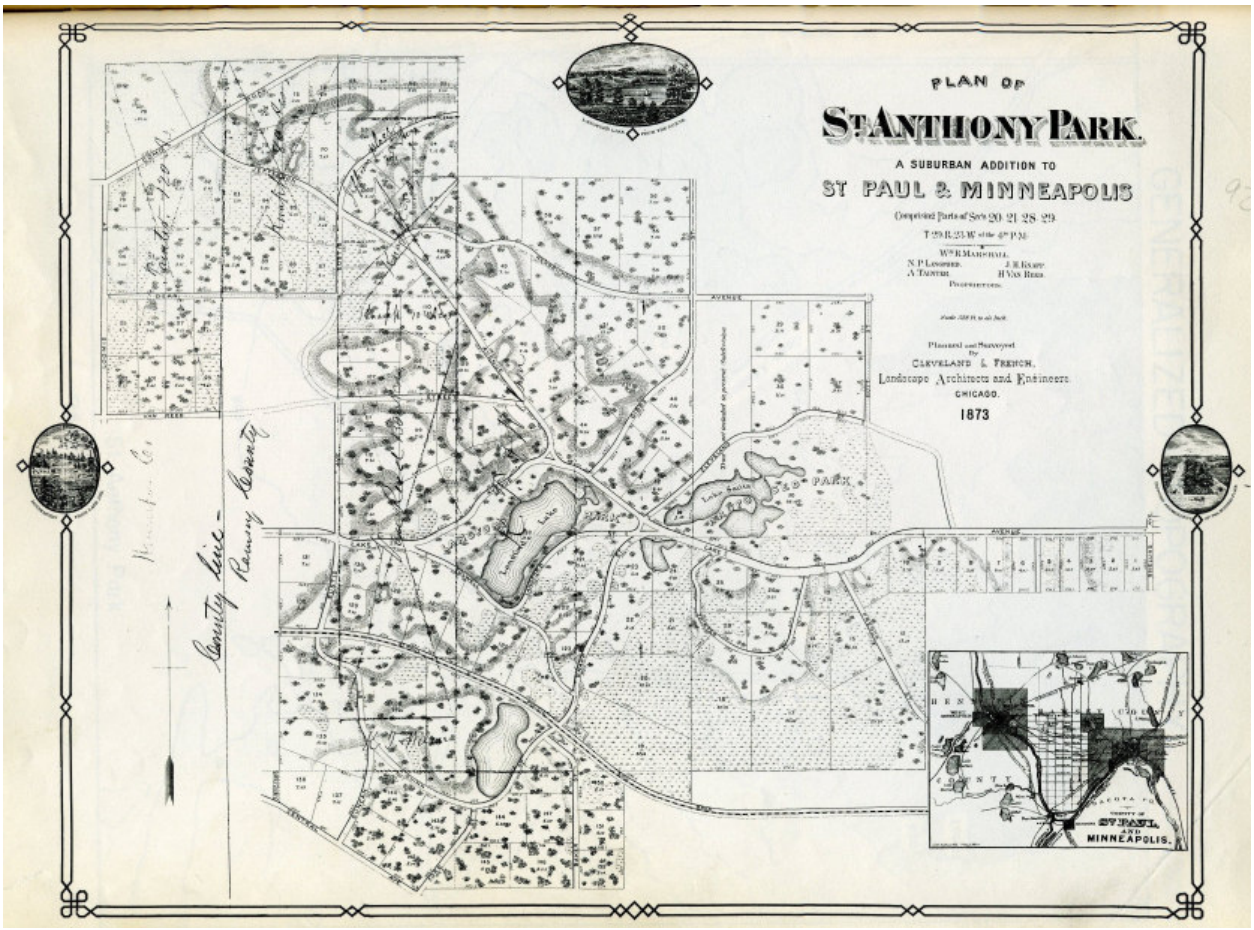


Figure 11: Cleveland and French Landscape Plan for St. Anthony Park (Ramsey County Historical Society)

Bridal Veil Creek

Plat and City Engineers Maps 1860-1896
Additional plat maps and Minneapolis City Engineer's maps (Figure 12) were examined in detail to determine the extent of the mapped Bridal Veil Creek. These maps, as expected, show a diminished open creek as development expanded. An examination of the successive plat and City Engineer's maps indicates that Bridal Veil Creek was placed into pipes, and disappears as a surface stream. Bridal Veil Creek does not appear in the 1890 Minneapolis map. Only the 1879 Plat Map shows the creek extending beyond the Hennepin/Ramsey County Line along the St. Paul and Pacific Rail Corridor (Figures 13 & 14).

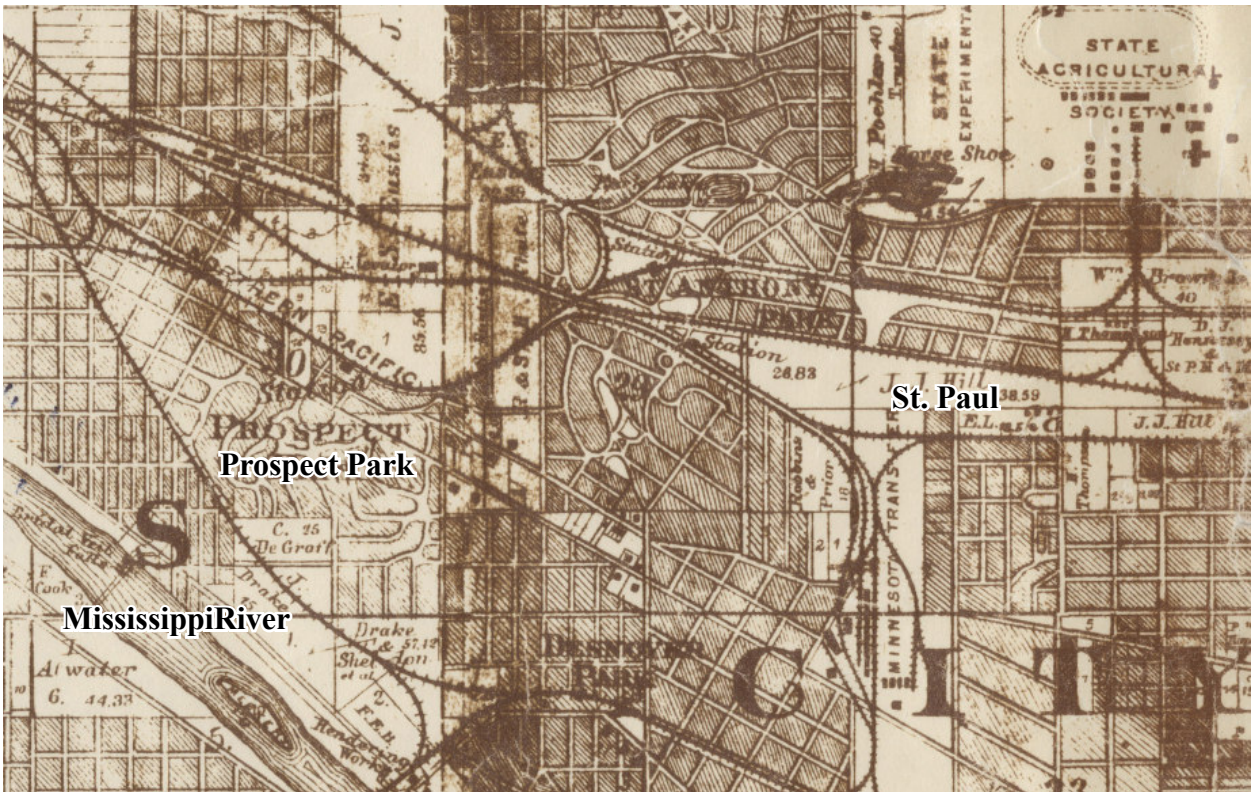


Figure 12: 1890 City of Minneapolis City Engineer Map
(Hennepin County Historical Society)

Historic Landscape Characteristics

Figure 13: 1879 Plat Map (Hennepin County Historical Society)

Bridal Veil Creek

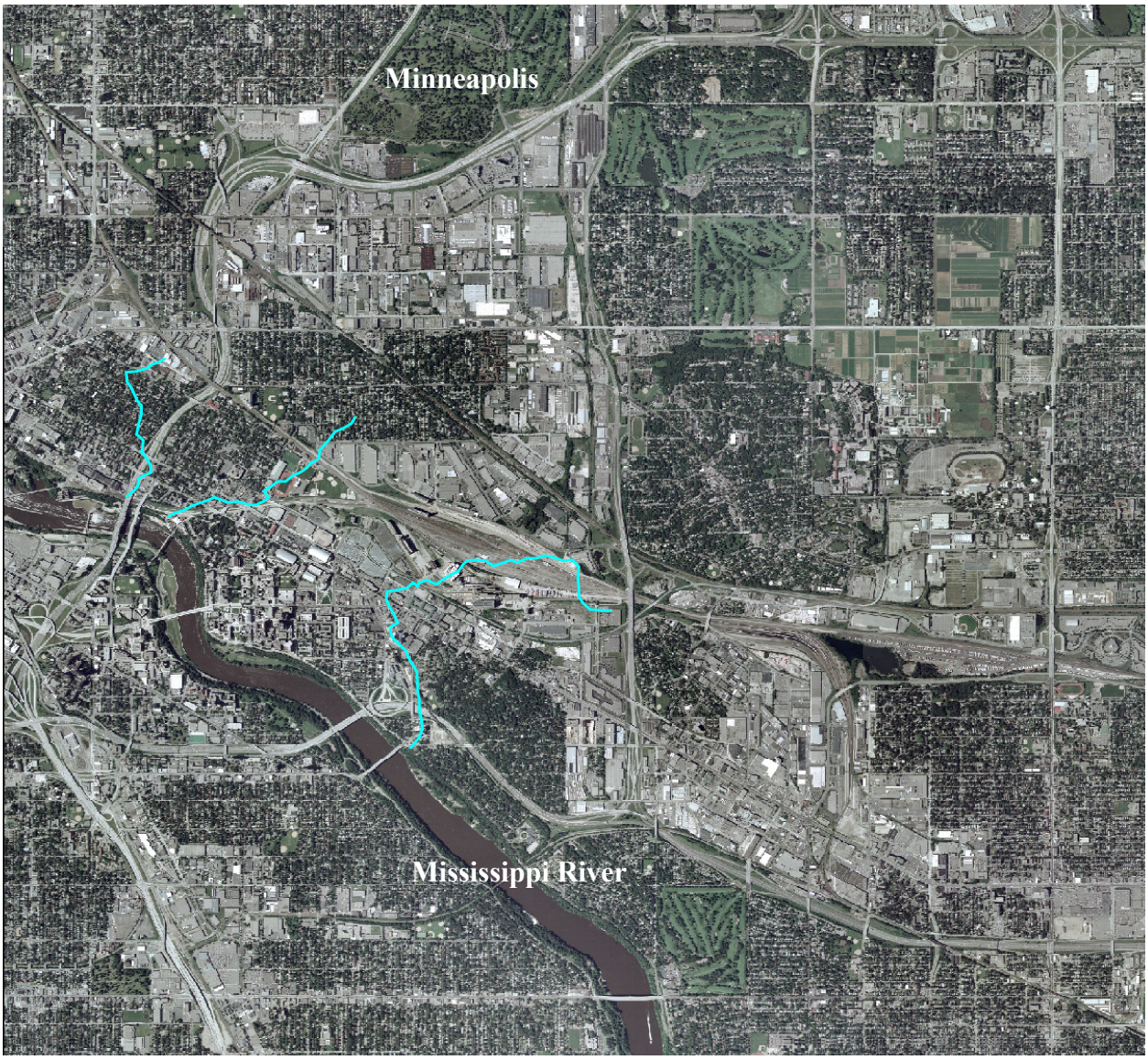


Figure 14: 1879 Streams Placed Over 2003 Aerial Photo

Historic Landscape Characteristics

1890s Detailed Plat and Fire Insurance Maps

Fire Insurance Maps often provide the greatest detailed maps of urban areas in the United States. These maps recorded building types, locations, lots and sometimes major natural features including streams. Since urban streams are often shifted, usually straightened for development of streets and lots, fire insurance maps often recorded in great detail stream configurations prior to build-out.

Bridal Veil Creek was only recorded in the area near the falls. In the 1892 C.M. Foote plat map (Figure 15) and the 1895 Rascher Fire Insurance Map (Figure 16) the streambed is mapped through the existing neighborhood and in the case of the Foote Map, it is mapped directly through two existing buildings. By 1895, the mapping of the stream in the Rascher Map only extends as far as Yale Avenue. Examination of the areas within the Great Northern Railyards was undertaken, but provided very little evidence of stream or wetland characteristics within that area.

Figure 15: C.M. Foote City of Minneapolis Plat Map 1892 (University of Minnesota, Borchert Map Library)

Figure 16: Rascher Fire Insurance Map 1895 (Minnesota Historical Society)

Bridal Veil Creek

Mississippi River Commission Chart No. 189 of 1895
In 1894, the Mississippi River Commission (MRC) mapped the entire Mississippi River and adjacent lands from the headwaters to the Gulf Coast (Figure 17). These maps were created to assess the potential for river navigation, and provide detailed map depths of the Mississippi River along its entire stretch. Chart No. 189 mapped the Minneapolis portion of the river, and mapped in detail, the entire developed city of Minneapolis, including 20' contours, all buildings, roads and rough vegetation types.

The lowest portion of the creek is mapped as an incised channel between Superior and Lenox Streets and connected to a pond at the intersection of Dartmouth and Huron Streets (1). This map shows Bridal Veil Creek crossing University Avenue just east of the Washington Avenue intersection and extending just into the rail yards (2). The drainage patterns through the rail yards indicate a drainage along the 900' contour that leads directly into the valley between North and South St. Anthony Park. The shape and steepness of these contours appear to be created for the purposes of the rail corridor (3). If this is the case, then the historic watershed boundary would be located along the western edge of St. Anthony Park. It is important to keep in mind that the railroad would have logically taken the path of least resistance to create the rail grade, likely seeking a saddle between high points.

The MRC map is the most detailed of all of the 19th century maps available for topographic, land cover, and development information. It verifies watershed boundaries determined from previous map and written sources. The elevated area in the railyards is identified as an ancient Mississippi River sand deposit in the 1916 USGS Aerial Geology Map and is clearly indicated on the MRC Map by differences in topography and vegetation (4). This rise provides a clear drainage boundary between the Bridal Veil and Tuttle's Brook Watersheds in an area of relatively flat topography.

Another valuable distinction that the Armstrong map provides is the indication that in 1895, the Bridal Veil Creek watershed appears to be located primarily within the current channel along the western edge of North St. Anthony Park in the current State Highway 280 corridor (5). One additional feature that the MRC map indicates is a clear drainage on the north edge of the St. Paul City line (6). This drainage lies in the area that would become the Falcon Heights Trolley and Creek Corridor. It is unclear whether this feature is a natural drainage or a gravel borrow pit. Given the nature of the glacial till material and expanding development, a gravel pit in this location would have been logical. However, the MRC map generally indicates large land uses (including gravel pits). If this is a natural drainage, it is likely the headwaters of Bridal Veil Creek, potentially a much older drainageway from the Gibbs Farm and University Golf Course areas.

Historic Landscape Characteristics

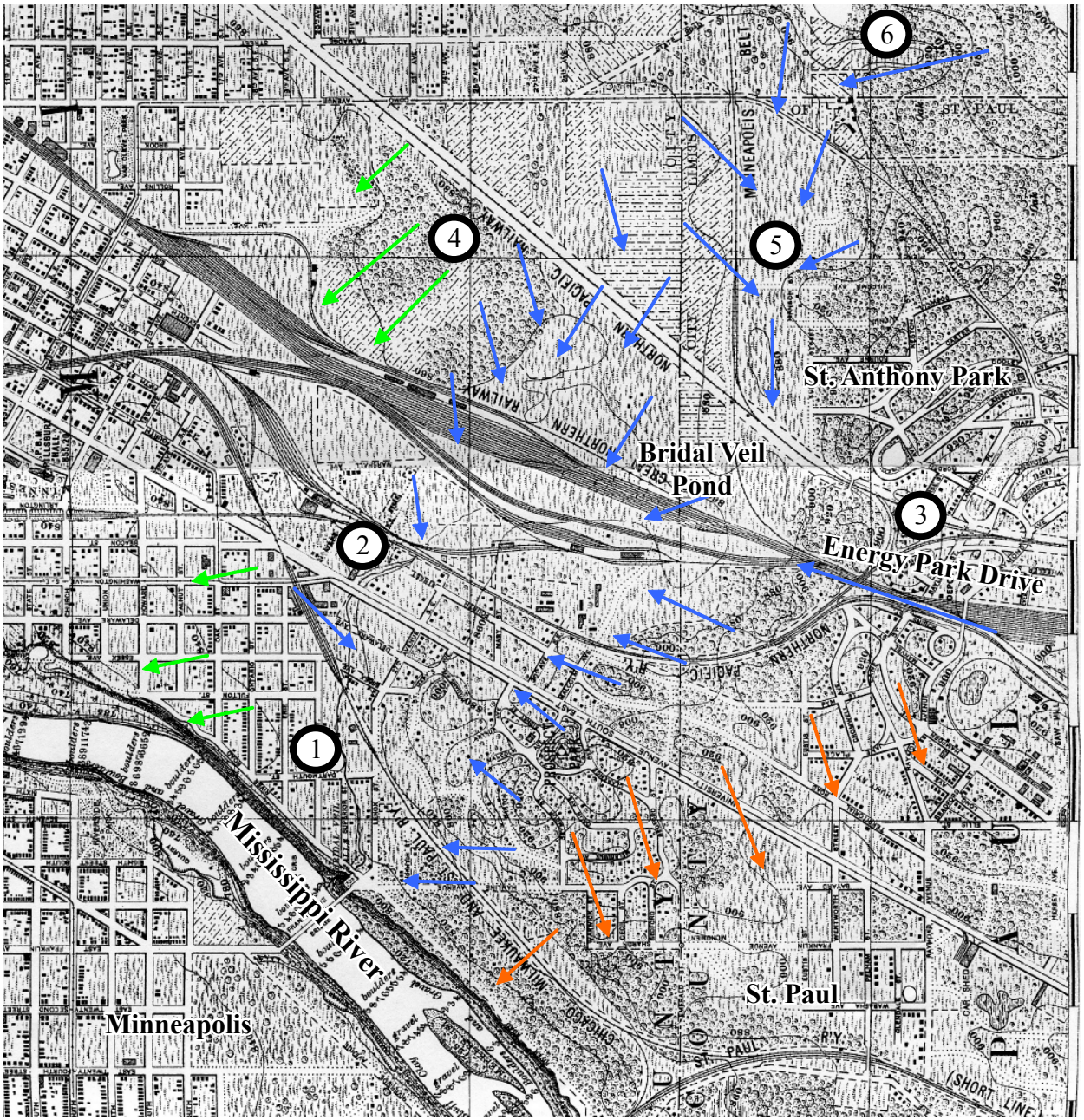


Figure 17: 1895 Mississippi River Commission Chart No. 189
(Hennepin County Historical Society)

Mississippi River Commission Chart No. 189 Key
Drainage flowpaths indicated by arrows. Blue arrows are drainage into Bridal Veil watershed.

Bridal Veil Creek

1896 USGS Map

The United States Geologic Survey was the first Quadrangle Map of the western portions of St. Paul in 1896 (Figure 18). The 20' contours are similar to previous maps, showing a drainage divide between North and South St. Anthony Park. This map, at a larger scale, provides insight into the adjacent watershed to the east. By examining the 900' contour in detail, it appears as though the natural drainage for the eastern side of St. Anthony Park would have likely been to the south and east. The 1896 Quad Map indicates Newell Lake and Lake Sarita as part of a large wetland complex on both sides of the St. Paul and Pacific Railway. The topographic features indicated by the 900' contour would appear to support the theory that Sarita and Newell Lake drained to the south. This map shows two distinct drainage features along the Mississippi River south of Prospect Park, both connected to the Newell/Sarita area through the existing Transfer Railway/Interstate 94 Corridor.

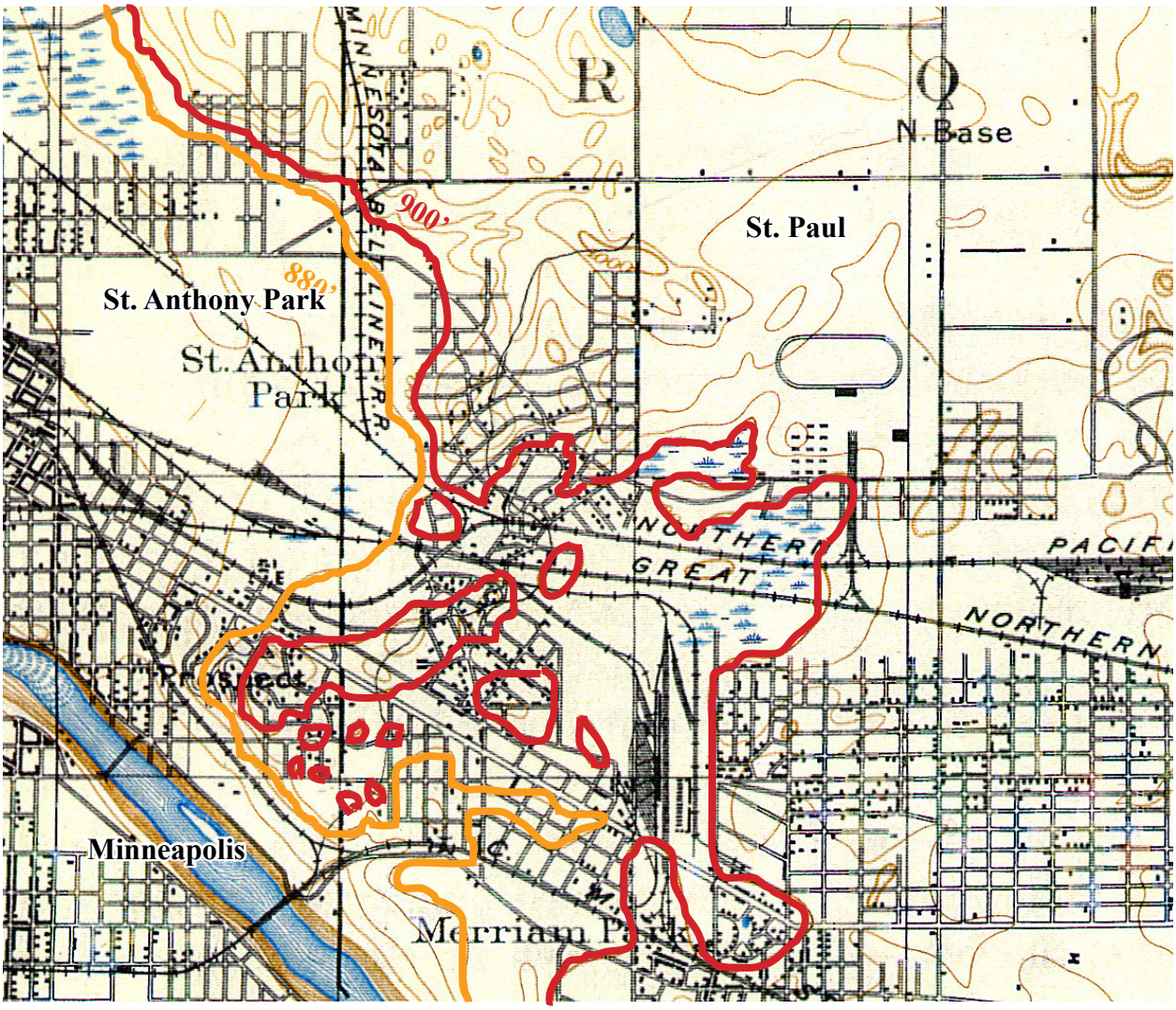


Figure 18: 1896 USGS Topography Near the BVC Watershed Drainage Divide (Hennepin County Historical Society)

Historic Landscape Characteristics

Review of Landscape Change in Watershed from Aerial Photos 1937 - 1957

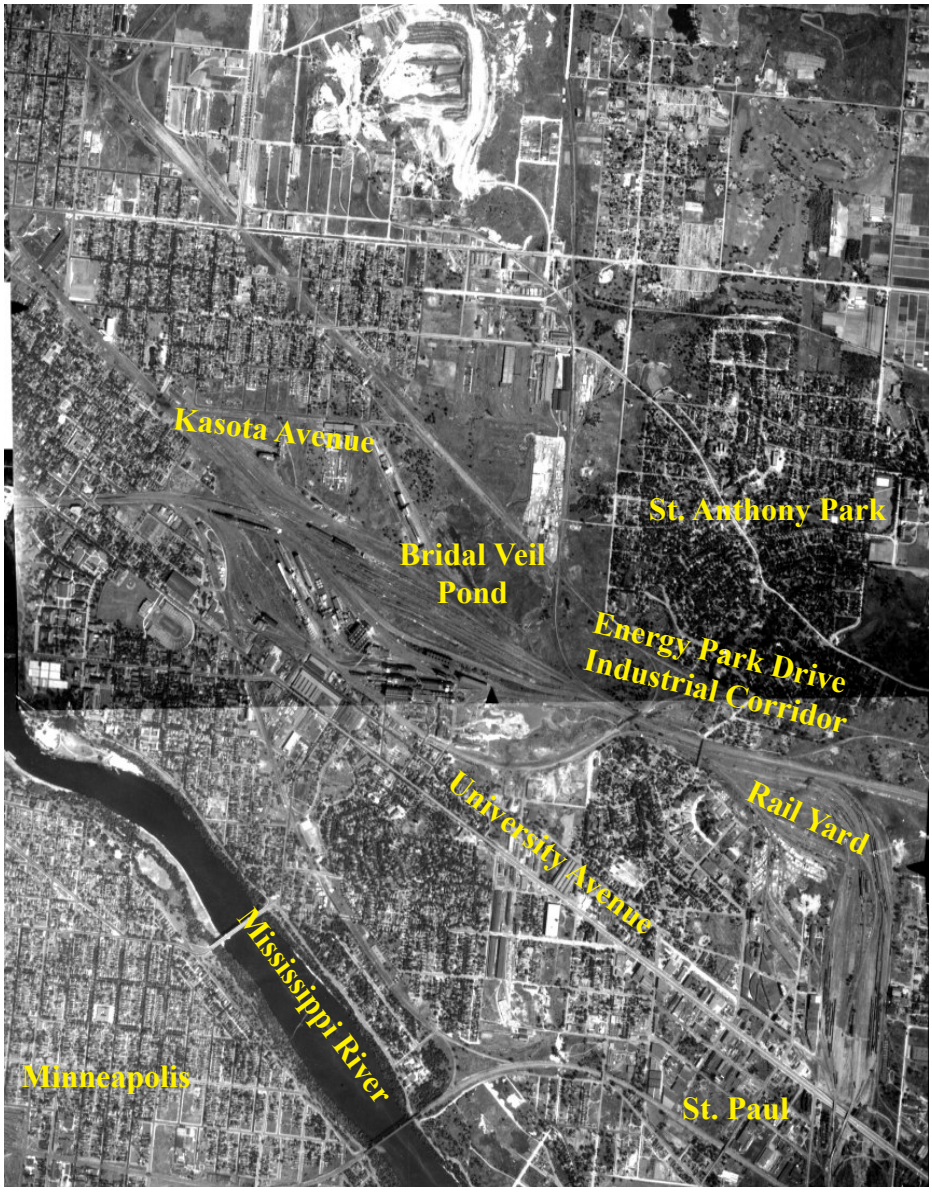


Figure 19: 1937 Aerial Photograph (University of Minnesota, Borchert Map Library)

Notes on the 1937 Air Photo

The earliest aerial photographs available for the Twin Cities Metro area were performed in 1937-1938. The 1937 aerial photograph of the Bridal Veil area shows the fully developed residential communities of St. Anthony Park in St. Paul, and Southeast Como and Prospect Parks in Minneapolis. The central portion of the watershed is dominated by the railyards and associated grain elevators immediately north of University Avenue, and the large Valentine-Clark site adjacent to the St. Paul Transfer Railway. This photo clearly shows wet areas north of the rail yards, as well as the ditch directly west of the Valentine-Clark property. Also of note is the large gravel excavation pit north of Hennepin Avenue in SE Minneapolis. This map also illustrates the extent of tree clearing in the Falcon Heights natural area north of St. Paul Seminary.

Bridal Veil Creek

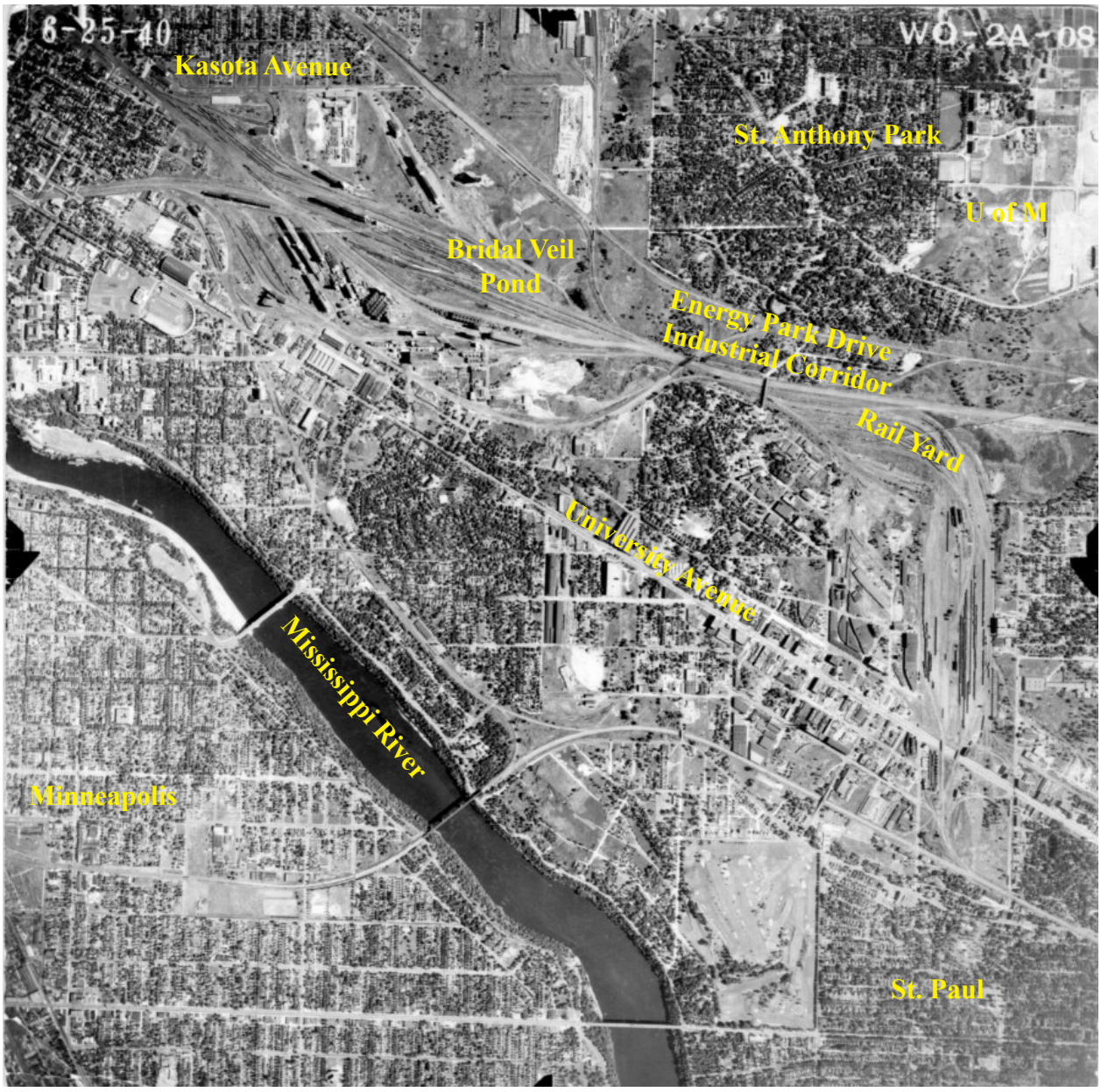


Figure 20: 1940 Aerial Photograph (University of Minnesota, Borchert Map Library)

Notes on the 1940 Air Photo

The 1940 air photograph shows little additional development in the Bridal Veil Watershed. This map is valuable in indicating the hydrological features in the watershed in 1940. The Bridal Veil Ponds were newly excavated in the 1940 photo with bare soils surrounding open water. Open water is present on the west end of St. Anthony Park between Eustis Street, Como Avenue, and the Transfer Railway. Conversely, Newell Lake has open water as two ponds surrounded by shallow wetland, much smaller than the present open body of water that exists today.

Historic Landscape Characteristics

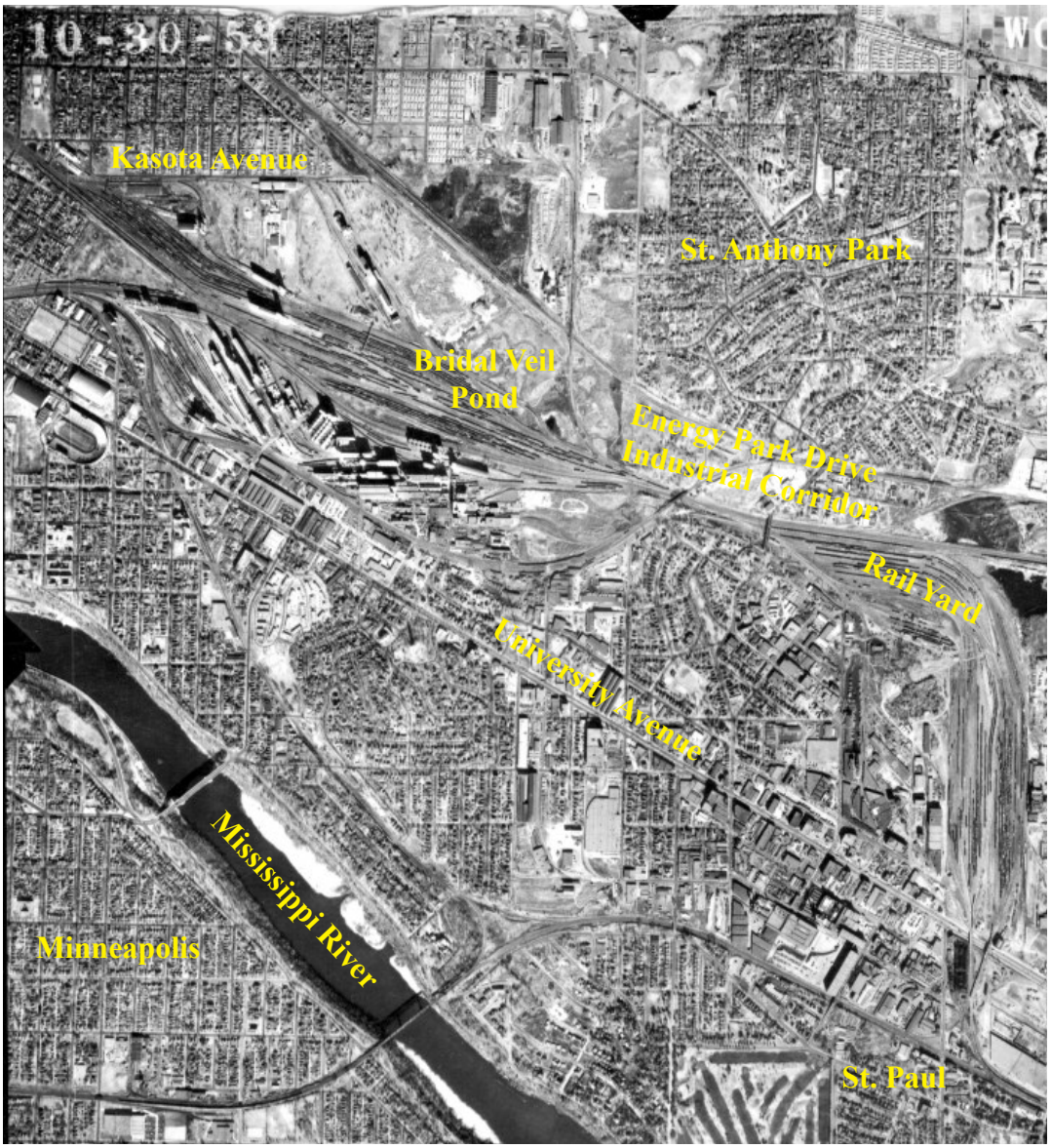


Figure 21: 1953 Aerial Photograph (University of Minnesota, Borchert Map Library)

Notes on the 1953 Air Photo

In 1953, work on State Trunk Highway 280 had begun, filling and eliminating wetlands on the western border of St. Anthony Park and St. Paul. Associated with the development of Trunk Highway 280, large areas of excavation occurred at the confluence of the Great Northern transfer railways at the city and county lines. The photo shows the continued operations of Valentine-Clark as well as what appear to be Quonset style huts south of Como Avenue and east of 29th Avenue SE. With the huts and continued expansion of industrial buildings along Como, an area that appeared as a small wooded area along the Northern Pacific tracks in the earlier photographs appears here as open water. Newell Lake remains as two open water bodies but have grown larger since 1940. Falcon Heights expands to the west along the new Highway 280 construction.

Bridal Veil Creek

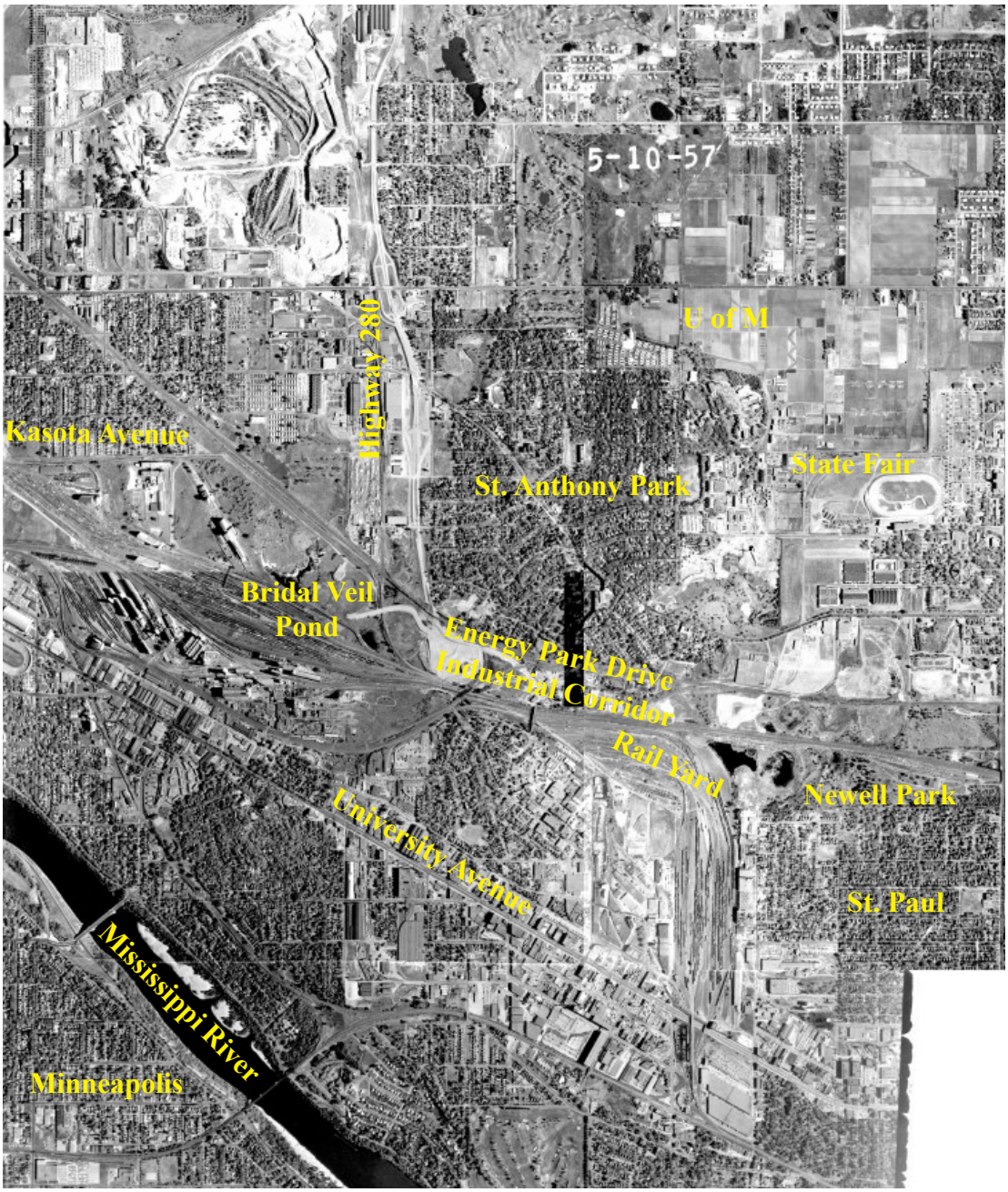


Figure 22: 1957 Aerial Photograph (University of Minnesota, Borchert Map Library)

Notes on the 1957 Air Photo

Bridal Veil watershed was a well developed watershed at the beginning of the 1937 aerial photo record. However, from 1937 to 1957 much of the landscape was still undeveloped. Notable changes during these two decades was the addition of Highway 280, the full development of Falcon Heights and the construction of Bridal Veil Ponds. In the 1957 aerial photo, note that the Falcon Heights natural area is still open.

Historic Landscape Characteristics

Highway 280 Construction Documentation 1954-1956

As part of the documentation of Trunk Highway 280, the Minneapolis Star-Journal-Tribune performed a series of fly-over photography sessions between 1954 and 1956 (Figures 23-25). Three of these photographs are shown below with major points of identification. These photos provide a visual record of the scale of Highway 280 through the Bridal Veil drainage area showing standing water during construction, the scale of industry, particularly the Valentine-Clark Wood Treatment Facility, and the apparent hydrologic connections through the Bridal Veil Creek drainage area. Highway 280, built between 1954 and 1957 is located directly over the lowest portions of the Bridal Veil stream valley. Note the presence of water ponded within construction areas, as well as remnant wetlands at the margins.

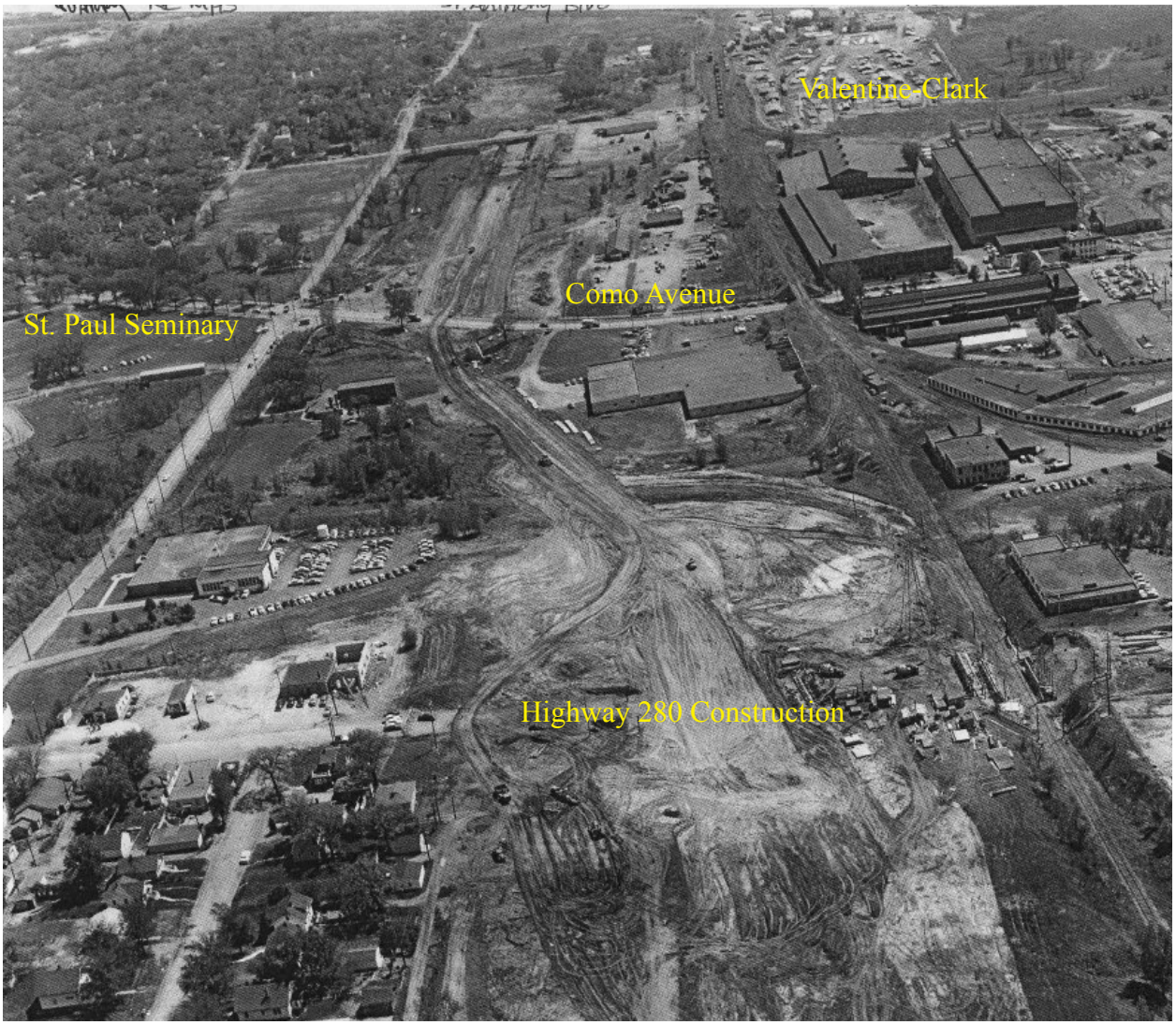


Figure 23: Minneapolis-Star-Journal-Tribune, May 26, 1954 Photograph of State Highway 280 Construction View is to the South (Minnesota Historical Society)

Bridal Veil Creek

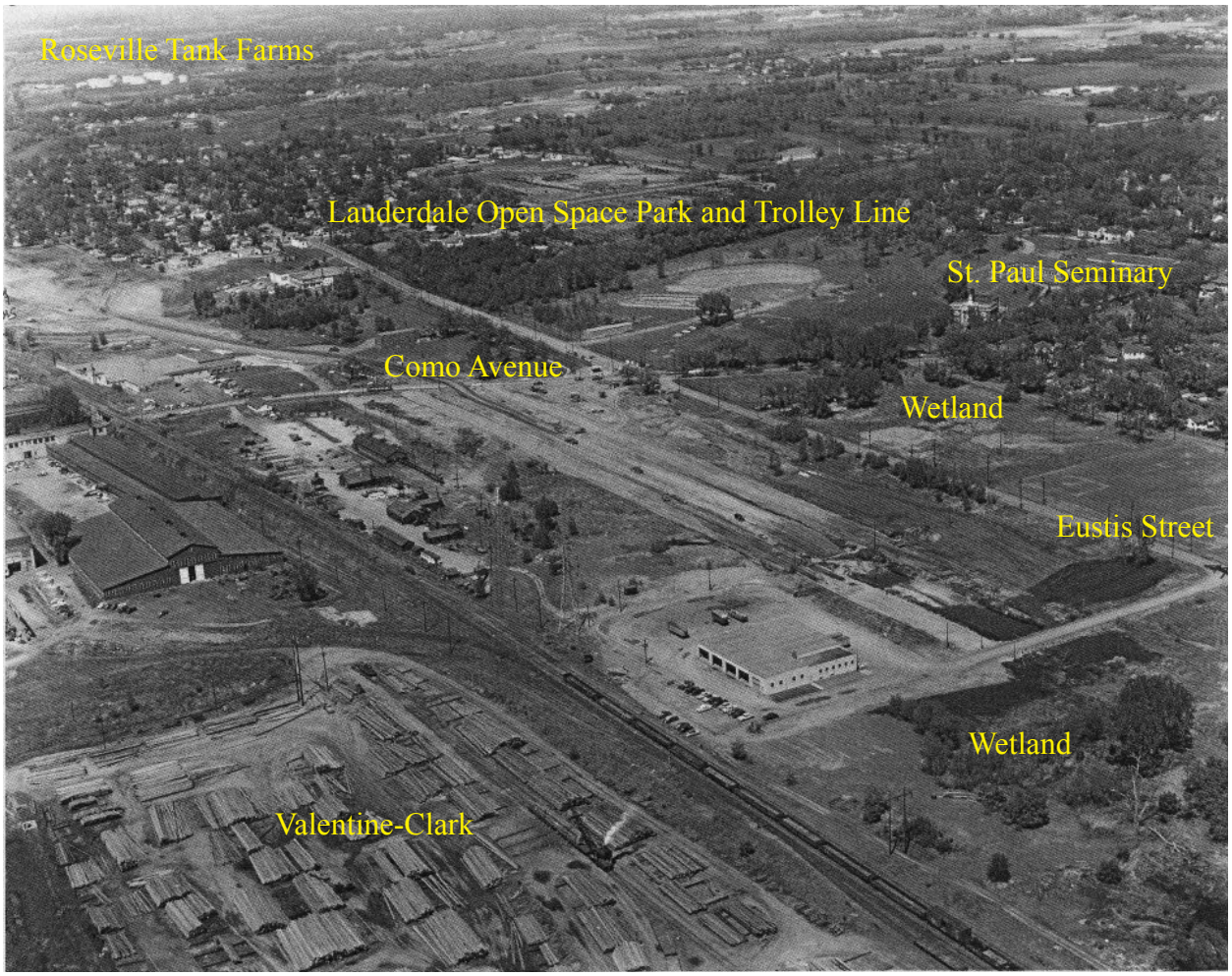


Figure 24: Minneapolis-Star-Journal-Tribune, May 26, 1954 Photograph of State Highway 280 Construction View is to the Northeast (Minnesota Historical Society)

Historic Landscape Characteristics

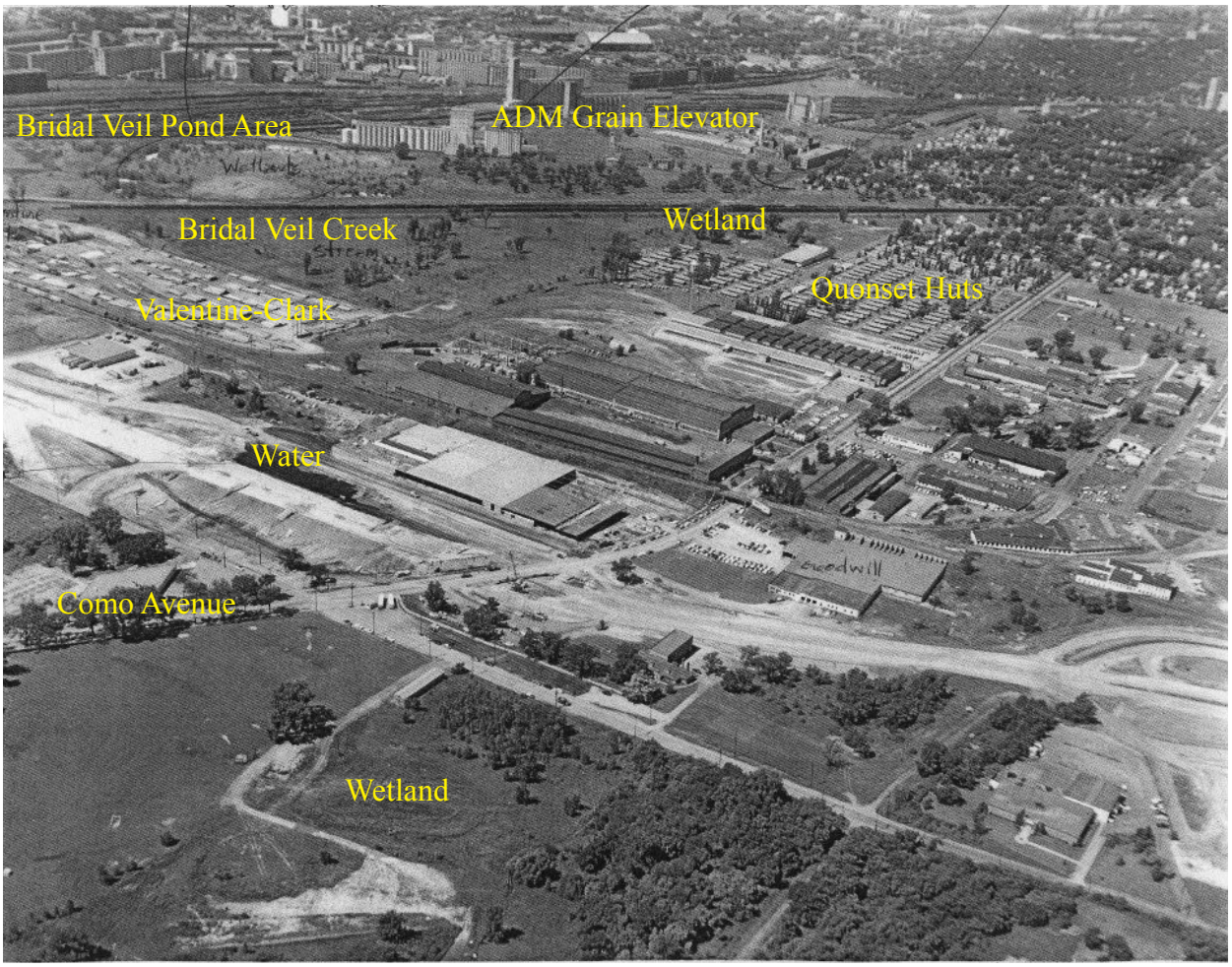


Figure 25: Minneapolis-Star-Journal-Tribune, June 30, 1956 Photograph of State Highway 280 Construction View is to the Southwest (Minnesota Historical Society)

Bridal Veil Creek

SYNTHESIS OF HISTORIC WATERSHED RESEARCH

Composite Maps

Using GIS technology, The Kestrel Design Group overlayed historic maps, historic map features and existing land feature coverages to create composite maps of historic waterbodies, watercourses and watersheds. The following two maps provide composite images of the most reliable maps and evidence found to support our current and past watershed boundary delineations.

Composite Drainages

The composite drainages map provides the combined historic mapped streams and wetlands used to determine the historic watershed boundaries (Figure 26). Notable features supporting the final determination of the watershed include:

- **Location of Historic Streams** – Mapped in light blue, the historic streams are the locations of Bridal Veil Creek indicated on the 1867 and 1879 Ramsey and Hennepin County Plat Maps and the 1895 Mississippi River Commission Chart.
- **USGS Topographic Survey** – The 900' and 880' contours are represented on this map to indicate the likely drainage patterns, particularly in the area east of the 280 divide. Note that a significant drainage appears to exist south of Newell Lake, but this area had been filled for University Avenue by this time.
- **Mapped Hydric Soils** – The hydric soils map provides evidence that indicates the headwaters of BVC were located in North St. Anthony Park. Generally, soils within the Bridal Veil Watershed are mapped by the NRCS as urban, disturbed soils, however, Markey Muck was mapped in a few locations. Presence of Markey Soil Type in these small depressions suggests undisturbed soils as organic soils require thousands of years for formation. The presence of this soil type in the location indicated by the * is supporting evidence that this is a pre-settlement drainage feature. The combination of this fact with the topographic signature provided by the 1895 MRC map indicates that this is a natural feature, not created. The small tributary flowing out of this area was likely one of the headwater streams feeding Bridal Veil Creek.
- **1944 St. Paul Public Works Wetlands** – These wetlands were indicated on St. Paul Public Work Sewer Maps. These wetlands are located in the areas indicated on earlier maps, and strongly suggest a natural drainage pattern in a southerly direction through the current State Highway 280 corridor.

Historic Landscape Characteristics

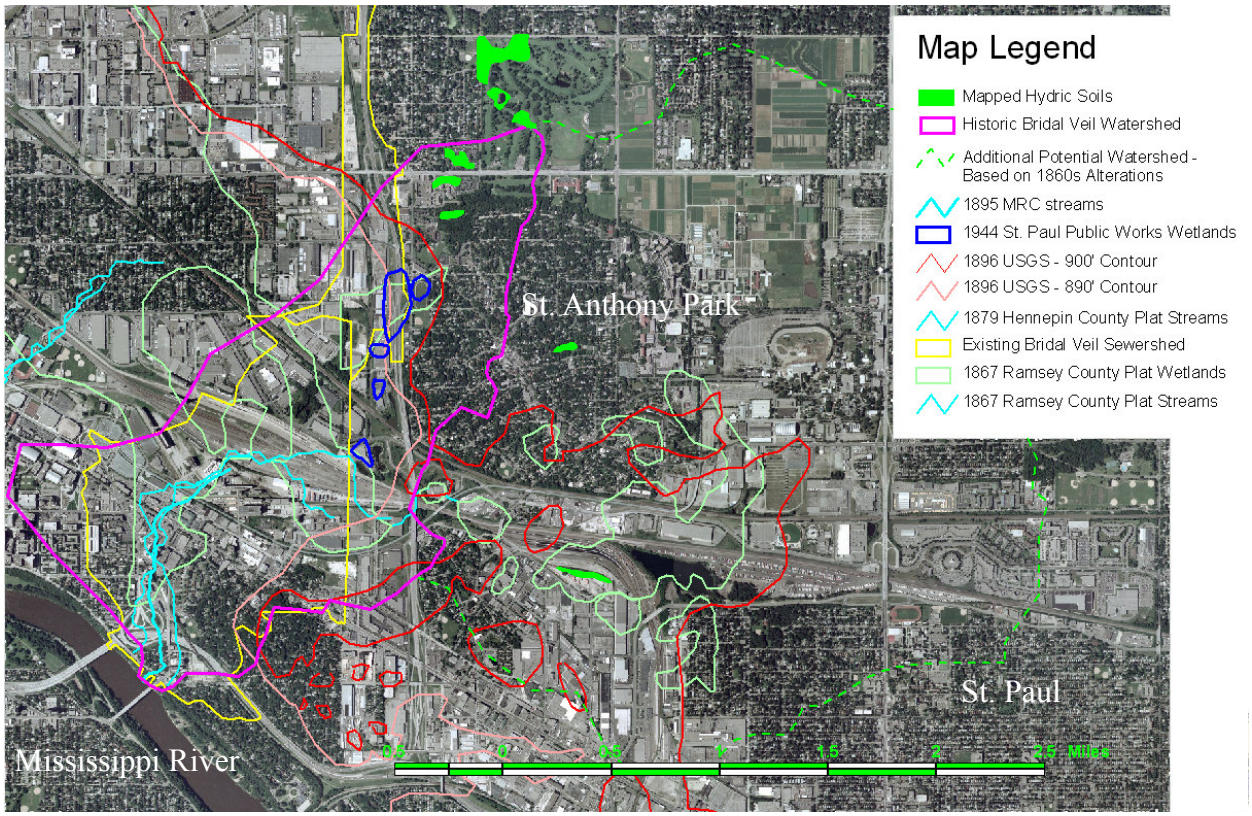


Figure 26: Composite wetland and stream map of BVC watershed on 2003 Aerial Photo

Bridal Veil Creek

Composite Watershed Map
The composite watershed map represents three distinct time periods in the watershed history of Bridal Veil Creek. These periods are presented below:

- **Pre-Settlement Period** – No maps were found to definitively show the pre-construction topography along the Great Northern Rail Corridor. The western boundaries of the watershed were determined using both historic evidence of elevated areas (based on geology, soils and vegetation maps) within the rail yards and university areas. The Prospect Park boundary was located through conventional topographic interpretation. The pre-settlement topography between North and South St. Anthony Park remains an open question and may never be fully answered. Between 1853 and 1867, the St. Paul and Pacific Railroad was built through the passage between North and South St. Anthony Park.

  Using the signatures of the 1895 Mississippi River Commission map, we have determined the watershed boundary in vicinity of Highway 280. The light blue line on the 1895 MRC map to the right is a best estimate of the historic Bridal Veil Creek Watershed just prior to European settlement of the region in the area of the current Highway 280 crossing (Figure 27). Topographic signatures from early maps suggest that the 20' deep depression through the rail corridor was likely created. Note that the four points indicated on the MRC map here are all located more than 20' above the rail grade on either side of the divide and that these four points are on separate knolls divided by additional railroad crossings. This suggests that this drainageway through the glacial kame depost was created for the rail line. Since this deposit was not created by fluvial erosional processes, it is likely that this cut through the glacial deposits was a man-made excavation. If this interpretation is accurate, the pre-settlement watershed was 1177 acres.

- **Potential Additional Watershed Areas** – Following the 1860s construction of the railway through the Highway 280 divide, and the elevation of the road grade along University Avenue, the potential surficial area of the Bridal Veil Watershed was greatly expanded, up to 3690 acres. The altered topographic watershed is due to the gradient of the Great Northern tracks leading from the St. Paul Transfer yards west through the Highway 280 divide. The slope of the railroad tracks is uphill beyond Snelling Avenue in St. Paul, and University Avenue, and topographically is higher than Newell Lake. However, railroad maps indicated drainage ditches and tiles were installed and removed at various points through the period between the 1860s and the mid 1940s, when the St. Paul and Minneapolis sewer systems were greatly expanded into the rail yard areas of the watershed. Although the area of potential watershed was expanded by over 2000 acres during this period, in reality, drainage alterations only marginally expanded the Bridal Veil watershed through the 20th Century as the Newell Lake overflow ran south through St. Paul to the Mississippi River. Perhaps more importantly, it is likely that much of the area east of St. Anthony Park consisted of isolated basins that did not drain directly to Bridal Veil Creek, except perhaps at very high flood stages.

Historic Landscape Characteristics

The Existing Bridal Veil Watershed/Sewershed – The existing Bridal Veil Watershed is vastly altered from historic conditions. The insertion of railroads, neighborhoods, industry and highways has fundamentally altered the way water moves across the landscape. The current watershed is more accurately described as a sewershed, where water flows through a system of pipes. There are only two short reaches of open stream still flowing at the surface.

Beginning in 1995, as a part of street improvement projects, St. Paul removed most of its drainage from the Bridal Veil System through curb and gutter connections to its own Eustis Tunnel. Falcon Heights and Lauderdale, which once relied on the Bridal Veil System for storm overflow have been mostly incorporated into the St. Paul Eustis Tunnel System and are mostly disconnected from the Bridal Veil drainage system by surface water runoff. However, it is possible that subsurface groundwater connections still exist.

The current sewershed is approximately 740 acres and is limited to Minneapolis and a small portion of State Highway 280 within the City of St. Paul. Based on pre-settlement size of 1177 acres, the current watershed is only about 62% of the original drainage area. Roughly one-third of the drainage basin has been cut off from the original area. Figure 28 combines the three watershed periods described above in a graphic format.

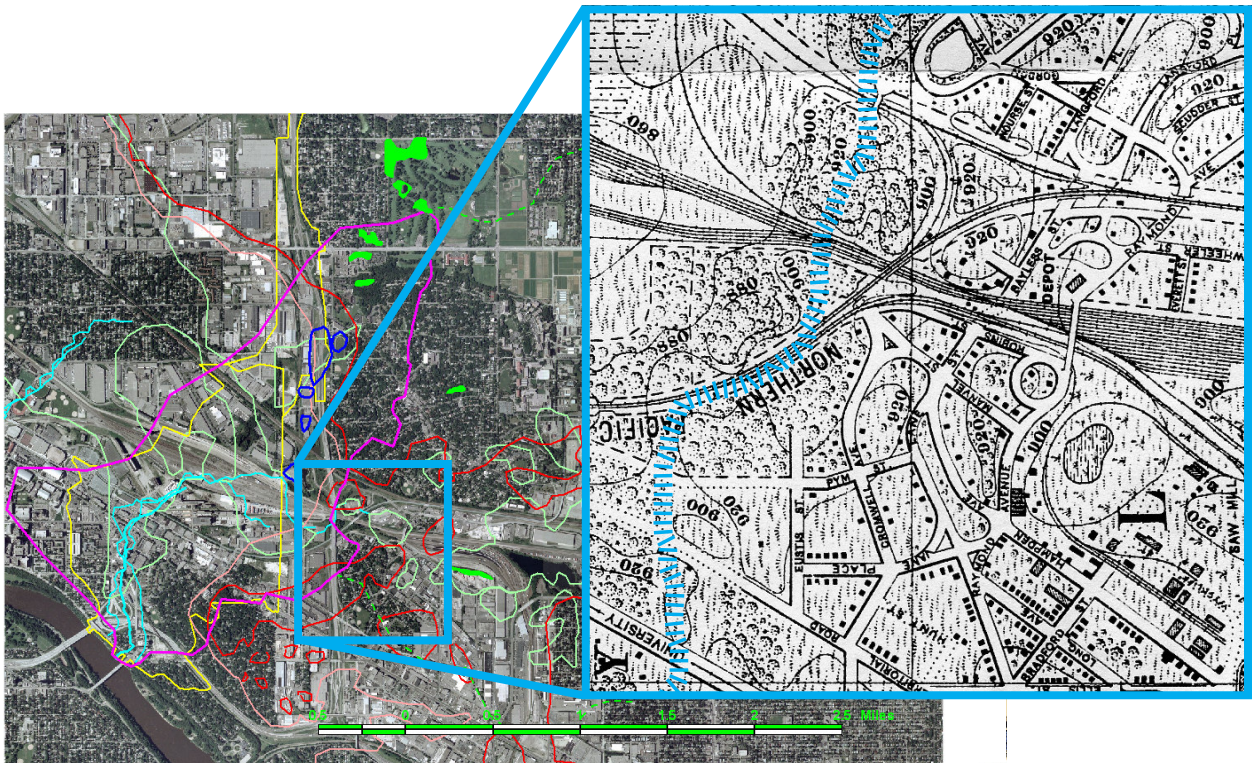


Figure 27: 1895 MRC Map Detail Showing Original Watershed Divide in Blue

Bridal Veil Creek

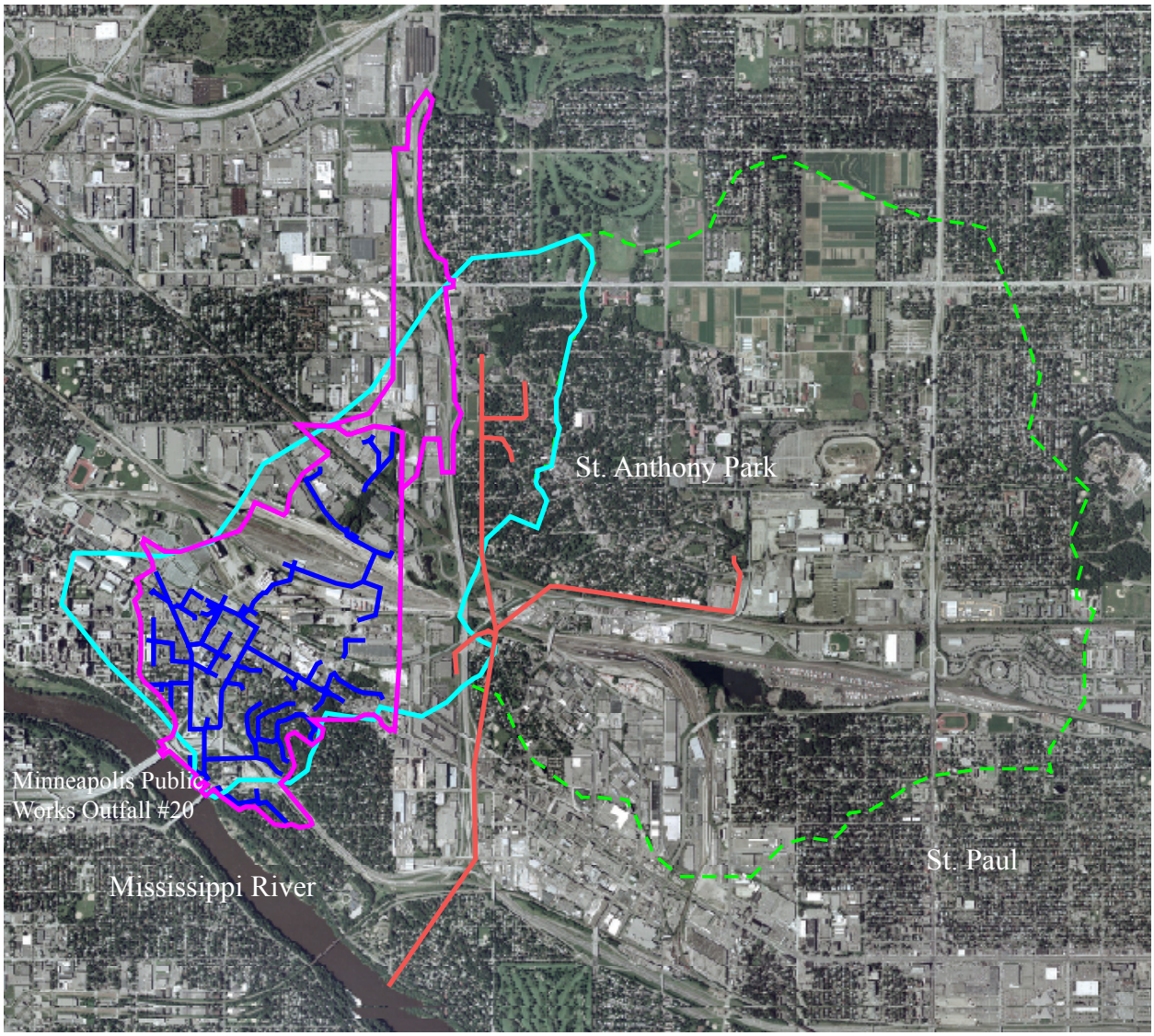


Figure 28: Composite Map of Historic and Existing Bridal Veil Watersheds

Composite Map Key

- Historic Bridal Veil Watershed
- Additional Potential Watershed Areas - based on altered topography after 1860s
- Existing Bridal Veil Storm Sewers
- Existing Eustis Tunnel
- Existing Bridal Veil Sewershed

Historic Landscape Characteristics

Summary of Information on Watershed Boundaries
The historic, pre-European watershed of Bridal Veil Creek was larger than it is today. With urbanization and drainage alterations, the current watershed boundary (sewershed) is now located along Hwy 280, with the eastern part of the watershed disconnected from BVC and routed to the Eustis tunnel in St. Paul.

The far eastern watershed area, in the vicinity of Sarita Wetland and State Fairgrounds, was topographically within the same drainage basin following the construction of the railroad track through St. Anthony Park. However, given high infiltration rates, a lack of any existing connecting channels and no historic mapping of Bridal Veil Creek tributaries in this area, it is probable that the U of M campus and State Fairgrounds area contained isolated basins that were not connected to BVC by perennial streams. Additionally there is no clearly defined watershed immediately east of the BVC watershed. A series of short groundwater discharge seeps form waterfalls going into the Mississippi River but do not extend up to the State Fairground area. Given this secondary evidence, the best conclusion is that these basins (including Lake Sarita and Langford Lake) never drained to Bridal Veil Creek, or only did at large, infrequent flood levels much larger than the bankfull event (1.5 year flood).

While the surface water drainage basin has been reduced to the area mainly west of 280 and the road itself, it is important to recognize that there may still be groundwater connections underneath 280, feeding the wetlands and ponds of Bridal Veil and Kasota Ponds. There are numerous springs (e.g. Skonard Springs) and points of groundwater discharge in the Bridal Veil Creek valley that must have a water source somewhere up-gradient of the springs, most likely the St. Anthony Park hill.

Despite the division of the BVC watershed, historical interest and ecological connectivity of natural areas through patches and corridors are important reasons for considering the historic watershed boundaries. For education and management purposes, particularly greenway development, the historic Bridal Veil watershed provides a defined “management unit” and historic context for education purposes.

SECTION TWO: EXISTING CONDITIONS

HYDROLOGIC CHARACTERISTICS OF THE BVC WATERSHED

Pre-Settlement Water Budget

The Twin Cites region of Minnesota receives approximately 29 inches of rainfall per year, of which approximately six inches is carried off as runoff (Gebert et al., 1985). The hydrologic cycle in the pre-settlement landscape would have had much larger evapotranspiration (ET) and shallow groundwater flow components than the present urban landscape (Brooks et al. 2003). This is because native prairie and savanna plant communities have much higher ET and infiltration rates than urbanized surfaces. Prior to urbanization, the remaining 23 inches of rainfall would have been divided amongst ET (approximately 15 inches), with the remainder going towards groundwater infiltration (roughly 8 inches) (Gebert et al., 1985 and Lorenz et al. 1997). (The actual percentage of ET versus groundwater infiltration may have varied from what is shown in Figure 29a, however the important point is that about 50% of water was used by ET and less than 25% of rainfall became runoff).

Changes to Hydrology with Urbanization

The primary hydrologic changes were changes to watershed area and conversion of a natural surface channel to a sub-surface pipe system. The original BVC watershed (the topographic watershed boundary) was approximately 1177 acres. Following connection of the railroad tracks through St. Anthony Park, the watershed increased in size dramatically to about 3690 acres, although much of the watershed area east of Cleveland Avenue likely consisted of isolated basins that were not directly connected to BVC itself, except at very large floods. The existing sewershed, or surface drainage area of Bridal Veil Creek is 740 acres with mostly urban (>75% impervious surface area) and residential (25-75% impervious area) land cover. Urbanized watersheds tend to have greater runoff and less infiltration than undeveloped and unpaved areas (Figure 29). De-

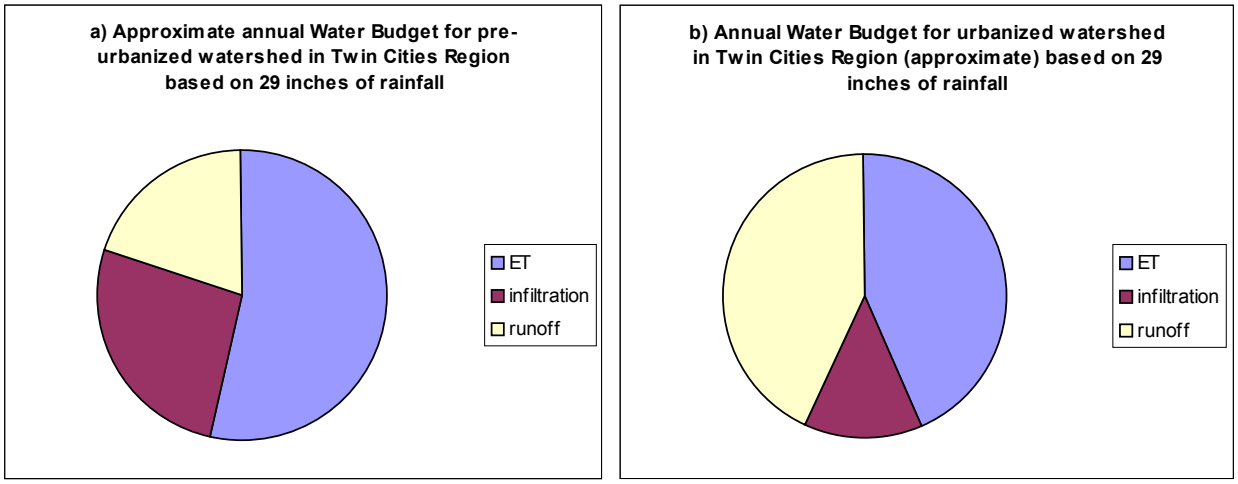


Figure 29: Water Budget for a) Pre-Urbanized Watershed and b) Urbanized

spite these changes, areas of active groundwater discharge still exist in the BVC watershed. For example, in the area north of Kasota Drive and west of Highway 280 an active groundwater discharge area still causes flooding issues for the parking lot and basement in the vicinity of the spring. However, with increased imperviousness and reduced watershed area from the original size, baseflow has been drastically reduced in BVC compared to the pre-development stream. While baseflow has been reduced, following rain events, surface water runoff occurs much more quickly causing faster rises in water level within the creek itself, folllowed by a drop back to very low flow levels. These conditions have led to warming of the stream and drying out with longer periods with little or no flow. While there is little hydrologic data from the stream itself to document changes to the flow regime, field observations of channel downcutting in the open section of BVC and low baseflow levels illustrate the hydrologic impacts of urbanization.

Impervious surfaces lead to greater stormwater peaks which require increasing the size of the pipe system for BVC. Increased peak flows were reflected by the increase in size of the storm-water pipe over time at the Bridal Veil Falls outlet from a 27-inch to a 72-inch pipe following construction of I-94. Later much of the flow was diverted away from the falls, because the aging pipe system could no longer support such large flows (Appendix A, Interview #3).

In addition to land cover, bedrock characteristics strongly influence groundwater hydrology. For example, boundaries between different bedrock layers often mark the location of springs (Brick, 1997). All three of the bedrock types found in the watershed are considered hydrological confining units tending to cause lateral water movement where geological layers meet. In the BVC watershed, the line of contact between surface glacial drift and the Decorah Shale layer marks the location of about 24 springs in St. Paul, mapped by Brick (1997), with one at the SW corner of the U of M golf course. Groundwater discharge was a major source of water to the spring-wetland complex in the Bridal Veil Creek valley.

Storm Water Management History in the Bridal Veil Watershed

- **1860s** - The first set of rail road tracks were laid between St. Paul and Minneapolis through a corridor between North and South St. Anthony Park. A drainage ditch was laid along these tracks carrying stormwater westward through the railyards to the Bridal Veil Creek crossing at the current intersection of 27th Ave. S.E. and University Ave.
- **1860s through 1900** – Bridal Veil Creek was placed into storm sewer pipes successively through the years as land was platted and city blocks were filled in with housing and industry. Plat maps from 1867 through 1895 show the length of the exposed stream becoming successively shorter as development expands. The only map that indicates Bridal Veil Creek extending to the Highway 280 divide is the original 1867 map. Based on Minneapolis Sewer drawings, the major sewer line that connected the bottom portion of the stream from University to the falls was put into place in 1889.
- **1900 through 1940s** – Minneapolis Public Works carried out stormsewer installations throughout the lower watershed from the falls to the entrance into a storm sewer pipe at

26th Avenue SE and 4th Street SE. Upstream of this point, St. Paul and Minneapolis placed the waters of Bridal Veil Creek into controlled ditches, human made depressions, existing wetlands and ponds limiting the use of pipes to roads and railway crossings.

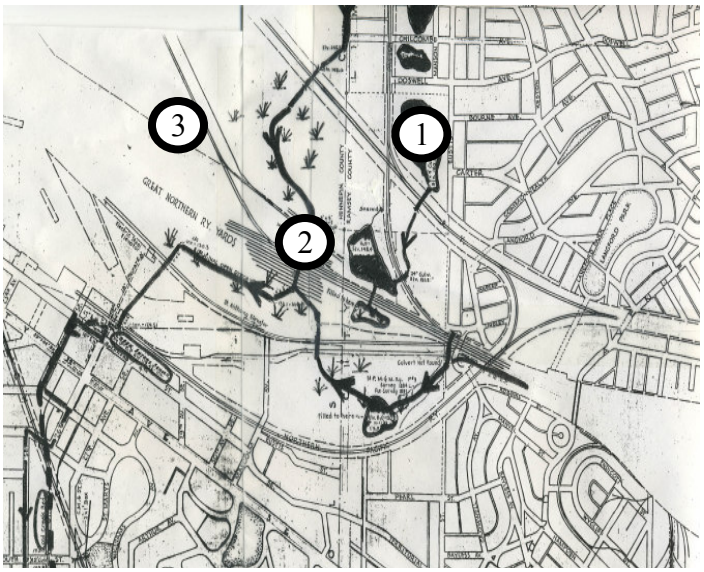


Figure 30: 1944 St. Paul Public Works Drainage Map

This 1944 St. Paul Sewer Map (Figure 30) provides a good picture of the Highway 280 corridor conditions at the time: 1) ponded areas where the current ballfields at Buford and Eustis are located, 2) a spring (Skonard Spring) north of the convergence of the Transfer and Great Northern tracks, and 3) the current Bridal Veil Pond as a marsh with open, straightened ditches connecting each of the water features.

- **1946-1947** – In 1946, business owners, including the United States Air Conditioning Corporation and Oliver Implement Company began to petition the Cities of Minneapolis and St. Paul to construct more efficient drainage networks through the industrial area between Como Avenue, Eustis Street and the Great Northern Railyards. This area, was largely built on top of wetland peat deposits, and had a history of flooding throughout the early part of the 20th Century. The problem was compounded by the fact that the area was shared between two municipalities and a county boundary line. In this case, waters from the Bridal Veil watershed originating in St. Paul were discharged overland into systems managed by the City of Minneapolis.

On August 1, 1946, The Minneapolis Morning Tribune ran a story with a photograph describing the intersection of 29th Avenue SE and Como Avenue as “Lake Como” due to street flooding. City engineers for both cities toured the flooded area and discussions began to move the waters of Bridal Veil Creek into larger conveyance systems. In 1947, a storm sewer plan was developed by the two cities and agreed to by the numerous affected property owners. This plan which included cost sharing by the cities and counties for the improvements formally connected the sewer networks of Minneapolis and St. Paul. The network connections were completed in 1947. As part of this plan, the ponded areas were to be retained as water storage.

Existing Conditions

- **1950s** – Highway 280 is constructed, filling most of the ponds used for water storage and infiltration. MnDOT constructed additional storm sewer systems to handle overflow from their project, but according to Public Works Department of St. Paul notes these systems were inadequate to address the loss of storage in the filled ponds.
- **1970s** – St. Paul begins to advocate for the creation of a separate storm sewer system to remove it from the shared network and potential liabilities that it foresees. This system would tie into a proposed St. Anthony Park Storm Water Tunnel. Bridal Veil Creek is rerouted to accommodate a new industrial building.
- **1986** – The City of Lauderdale establishes a stormwater management plan that provides for ponding to handle internally "historic runoff rate." Lauderdale chooses to remain a part of the Bridal Veil Sewer system with a "clearwater" connection to the Minneapolis system rather than to enter into an agreement with the City of St. Paul.
- **1986-1990** - In October 1986, Bridal Veil Creek becomes clogged due to St. Paul construction activities. Through four years of negotiation between state, cities and private property owners, it is agreed that dredging costs for ditch and pipe cleanout within the City of Minneapolis are to be shared between Minneapolis and St. Paul.

Table 1: Chronological History of Stormwater Management in BVC Watershed

Date	Event	Significance for BVC watershed
1860's	Railroad tracks installed between Twin Cities	Development of area is further promoted by rail corridor. Drainage alterations occur for track construction.
1880s	BVC put in sewer pipes	Loss of BVC as a surface stream over most of its length.
1900 - 1940	Improvements to storm drainage system	Improved drainage and reduced flooding with continued loss of wetlands and degradation of water quality.
1946 - 1947	Drainage improvements in Como area. Storm sewer plan developed by the Twin Cities.	Flooding reduced in Como St. area. In 1947, a storm sewer plan formally connected the sewer networks of the Twin Cities. Ponded areas were to be retained as water storage, but were lost in later drainage projects.
1950s	Highway 280 is constructed and ponds are filled	Highway 280 is constructed, filling most of the ponds used for water storage and infiltration. MnDOT storm sewer systems inadequate to address the loss o**f** storage from the ponds, resulting in flashier flood peaks from the watershed.
1970's	St. Paul builds separate storm sewer system	Separation of the drainage basin by political boundaries. Creek re-routed to accommodate a new industrial building.
1986	The City of Lauderdale establishes a stormwater management plan.	The City of Lauderdale establishes a stormwater management plan that provides for ponding to handle internally "historic runoff rate."
1986 - 1990	Bridal Veil Creek maintenance plan developed	Due to clogging of the creek and related flooding problems, eventually the cities would place remaining open segments into pipes to reduce maintenance costs.
1990 - 1993	Dredging and new channel construction begins. Duck kill occurs at BVC pond	Duck kill spurs contaminant investigations. Dredging ceases while all parties develop clean-up plans. Removal of contaminants becomes major issues. A 1992 plan reroutes the creek again to avoid contaminated soils.
1995	City of St. Paul completes Eustis Tunnel.	Separation of St. Paul runoff from Minneapolis sewer system divides historic watershed into two, avoiding shared management issues. Cities of Lauderdale and Flacon Heights connected to St. Paul via Eustis Tunnel.

Bridal Veil Creek

Groundwater

Several groundwater studies have been done in the BVC watershed vicinity, including the hydrogeologic study done be Alexander et al. (2005) described earlier, the Brick study of Twin Cities springs and the EOR study (CRWD, 2004) of groundwater flow around Sarita wetland. The general flowpath of surface water and shallow groundwater in the watershed moves from the northeast towards the southwest. For example, the area in the southwest corner of the City of Lauderdale historically flowed southwest to Bridal Veil Creek. However, this area has been hydrologically disconnected from Bridal Veil Creek today by Highway 280. Infiltration rates are high in the sandy soils associated with the watershed's uplands. Upland sandy soils have infiltration rates in the range of 2 – 6.2 inches/hour (USDA, 2001). In other areas, infiltration rates are much lower. For example in detention basins within the watershed, modelers estimated infiltration rates at 0.1 in/hr for the permanent pool and 0.6 in/hr for the flood pool (CRWD, 2004).

The movement of shallow groundwater in the watershed was mapped using a variety of sources to identify discharge and recharge locations (Table 2, Figure 31). The red line represents the pre-settlement BVC watershed, while the green line represents the post-railroad construction watershed. Often wetlands and other water receiving areas will vary between recharge and discharge depending on the seasonal variation of water levels. For example, the area near Bridal Veil Creek appears to seasonally switch from discharge in the spring to recharge in late summer/fall, according to the STS (2006) report.

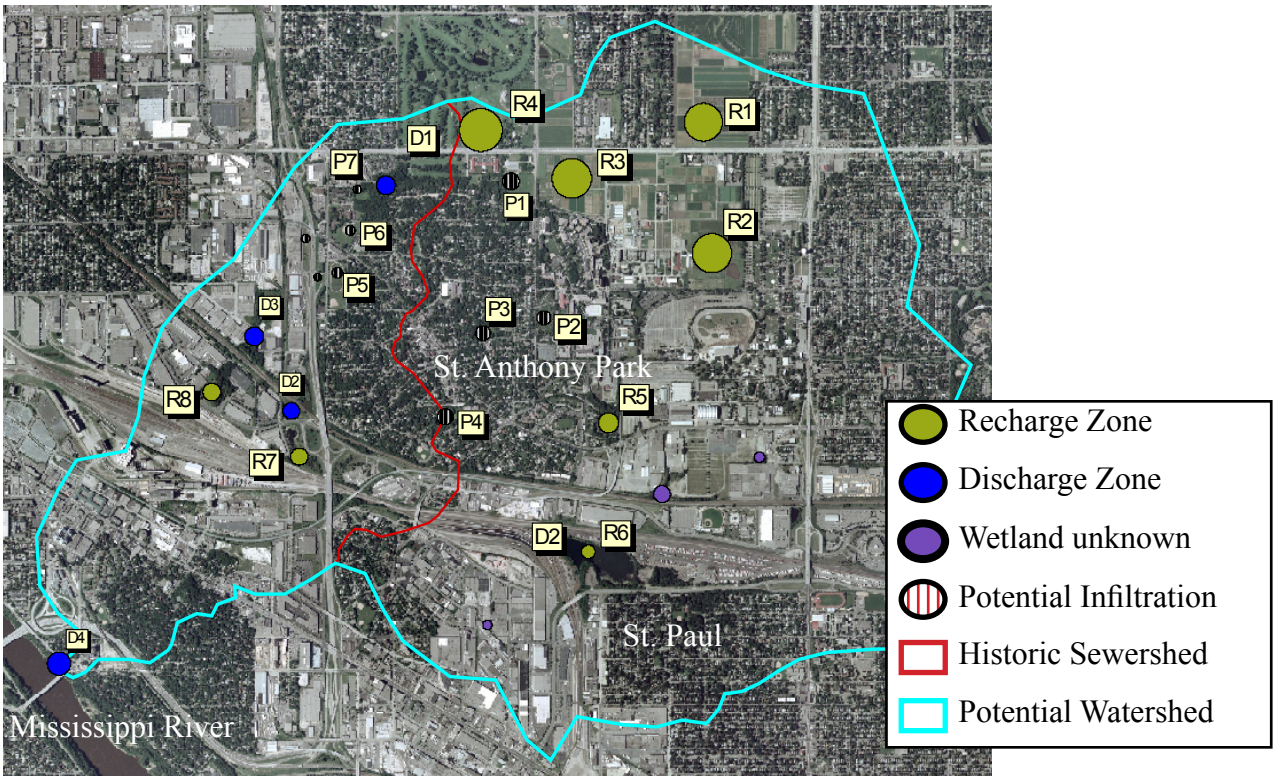


Figure 31: Spatial Distribution of Groundwater Recharge and Discharge in the BVC Watershed

Existing Conditions

Table 2: Documented Groundwater Discharge and Recharge Areas in BVC Watershed Area

Site	Map #	Location	Notes	Reference
Discharge areas				
U of M golf course	D1	Southwest slope of St. Anthony Park hill in Lauderdale	Discharge wetland	Brick, 1987; Kestrel observations
Skonard Spring	D2	Skonard Spring	Artesian spring (GW discharge)	Eckman et al. 2001
BVC at Kasota Dr.	D3	Kasota and RR tracks	Discharge into creek provides baseflow, with seasonal variation (groundwater may shift to recharge seasonally).	Kestrel field observation; STS Inc., 2006.
Bridal Veil Falls outlet	D4	Franklin St. at Mississippi River	Seepage through rock layers by Mississippi River	Brick 1987
Recharge areas				
U of M agricultural fields	R1, R3	South of Larpenteur, west of Gortner and east of Cleveland Avenue	Tile drainage in agricultural fields speeds up the rate of shallow groundwater flowthrough.	Alexander 2005
Sheep pasture	R2	State Fairgrounds near Como	Recharge area near fairgrounds	EOR 2004
U of M golf course	R4	Larpenteur, west of Cleveland Ave	Recharge – water drains south toward Sarita.	Brick 1987, Alexander 2005
Sarita Wetland	R5	Southeast corner of St. Paul wetland	Strong recharge. Diverts flow towards southeast	URS 2004, Alexander 2005
Stormwater ponds and Kasota Ponds	R6, R7, R8	Focused recharge occurs on pond bottom and edges	Recharge (seasonally)	URS 2004

Table 2 was derived using the following methods:

- Existing studies that mapped known groundwater discharge/recharge sites and springs were reviewed (Brick 1987, Eckman et al. 2001, E.O.R. 2004 and Alexander et al. 2005).
- Stormwater ponds were assumed to provide GW recharge at high waters levels, when water infiltrates into pond edges (URS 2004).
- Using topography, landscape position and soil overlays in GIS, probable locations for groundwater recharge were identified. The sandy uplands located in St. Anthony Park were determined to be likely recharge locations, with the low-lying areas in the Bridal Veil Creek valley were more frequent locations of GW discharge.

Bridal Veil Creek

Bridal Veil Creek Characteristics
Little or no information remains regarding the original dimensions of Bridal Veil Creek, however its location is clearly shown on many early maps south of the railroad yards. It is most precisely mapped in the 1892 C.M.Foote & Co. Atlas of the City of Minneapolis, and largely disappears in the 1895 plat map, as discussed previously. Otto Schussler provided a detailed description of the stream and its alteration in his recollections from 1928 (Box 1).

> *"The vigorous, enterprising city which had grown up about the great Falls of St. Anthony two miles farther up the stream, began a rapid march down both sides of the river and in a few short years the territory drained by the little creek underwent incredible change. Broad meadows and quiet woodlands that had lain undisturbed for ages were torn and perplexed by numberless freshly-graded street: ditches and tunnels ran here and there: hundreds of cellars and basements were dug: wells were sunk, water mains and sewers were laid and soon the great watershed to which the little stream had always looked confidently for an unfailing supply of pure sparkling water was so altered that the rains which fell upon it found themselves directed into a thousand unfamiliar channels. The once sizable creek became a modest brook, then dwindled to the dimensions of a tiny rill and finally disappeared from sight altogether save at the very rim of the ledge at the head of the glen where a pitiful trickle (barely enough for comforting tears but not at all for song) may now and then be seen by those whose hearts are touched by the little stream's sad fate."*

Box 1: Early Description of Bridal Veil Creek and its Alteration (Schussler, 1928)

Eventually most of the channel was placed in stormwater pipes. The current existing segment of open stream was placed there in the 1950's during construction of Highway 280. Since the stream was never mapped north of the rail yards, existing evidence suggests that BVC was a diffuse headwaters stream fed by groundwater discharge off the slope of St. Anthony Park. The stream meandered through numerous wetlands and ponds that existed in the Bridal Veil valley until a well-defined channel arose close to the current railyards. The former path of the stream roughly followed current Highway 280, possibly extending to the east along the current railway (See Table 1 for a chronological history of stormwater management in BVC Watershed).
A survey of the stream was conducted in 2004 in connection with the Bridal Veil Creek and Pond restoration project. Survey data showed a moderately entrenched stream with an average

cross-sectional area at the bankfull elevation of 11ft2 (KDG Inc, 2004) (Table 3). Entrenchment is caused by downcutting of the streambed when shear forces exceed the resistance of the bed, leading to lowered bed elevation and consequentially, disconnection of the stream from its floodplain. The open segment of Bridal Veil Creek was probably placed in its current location during construction of Highway 280. Downcutting likely occurred as the channel adjusted to increased runoff from an increasingly impervious drainage basin. At the end of the open segment, a sediment delta has occurred because aggradation is occurring as velocity slows and the channel widens into the Bridal Veil Pond. The channel appears to have nearly year-round baseflow, indicating groundwater discharge feeds the stream, despite the high percentage of impervious surface area in the watershed.

While biological data was not collected on the stream, surprisingly the stream does have some variety of pool / riffle flow conditions and in-stream structure (logs and rocks). If it were not for contamination upstream the stream would support a variety of invertebrate and fish species. Low baseflow in the late summer-fall probably limits potential fish habitat. In addition, the Bridal Veil Falls acts as a barrier to movement from the Mississippi, preventing the wide variety of fishes found there from entering the stream.

Table 3: Bridal Veil Stream Channel Characteristics
Survey Data North of Bridal Veil Pond to Railroad Tracks (KDG Inc. 2004)
Survey date: February 2004.

Sinuosity	1.20
Channel length	582 ft.
Valley length	481 ft.
Slope (water surface)	0.0086 ft/ft
Cross-sectional area at bankfull elevation	11 (8.4-13.6) sq. ft.
Entrenchment ratio	1.6 to 1.8 (moderate)

Water quality data

There have been no published reports concerning water quality data in the BVC. Parameters of concern in the Twin Cities' segment of the Mississippi River include high levels of fecal coliform bacteria, ammonia and nitrogen compounds, pH, nutrients, biological oxygen demand, and suspended solids (MWMO 2000). Water quality data is currently being collected by the Mississippi Watershed Management Organization at the outfall of Bridal Veil Tunnel. Parameters being monitored are listed in Appendix B.

Bridal Veil Creek

Existing Wetlands and Waterbodies

Numerous wetlands and stormwater ponds exist in the extended watershed area. However, only five wetlands or ponds exist in the active BVC sewershed (Figures 32 & 33). They are all located in the Kasota Ponds/Bridal Veil Pond area, along Kasota Avenue. All of these wetlands receive varying amounts of stormwater runoff and have variable levels of ecological functionality and biological diversity.

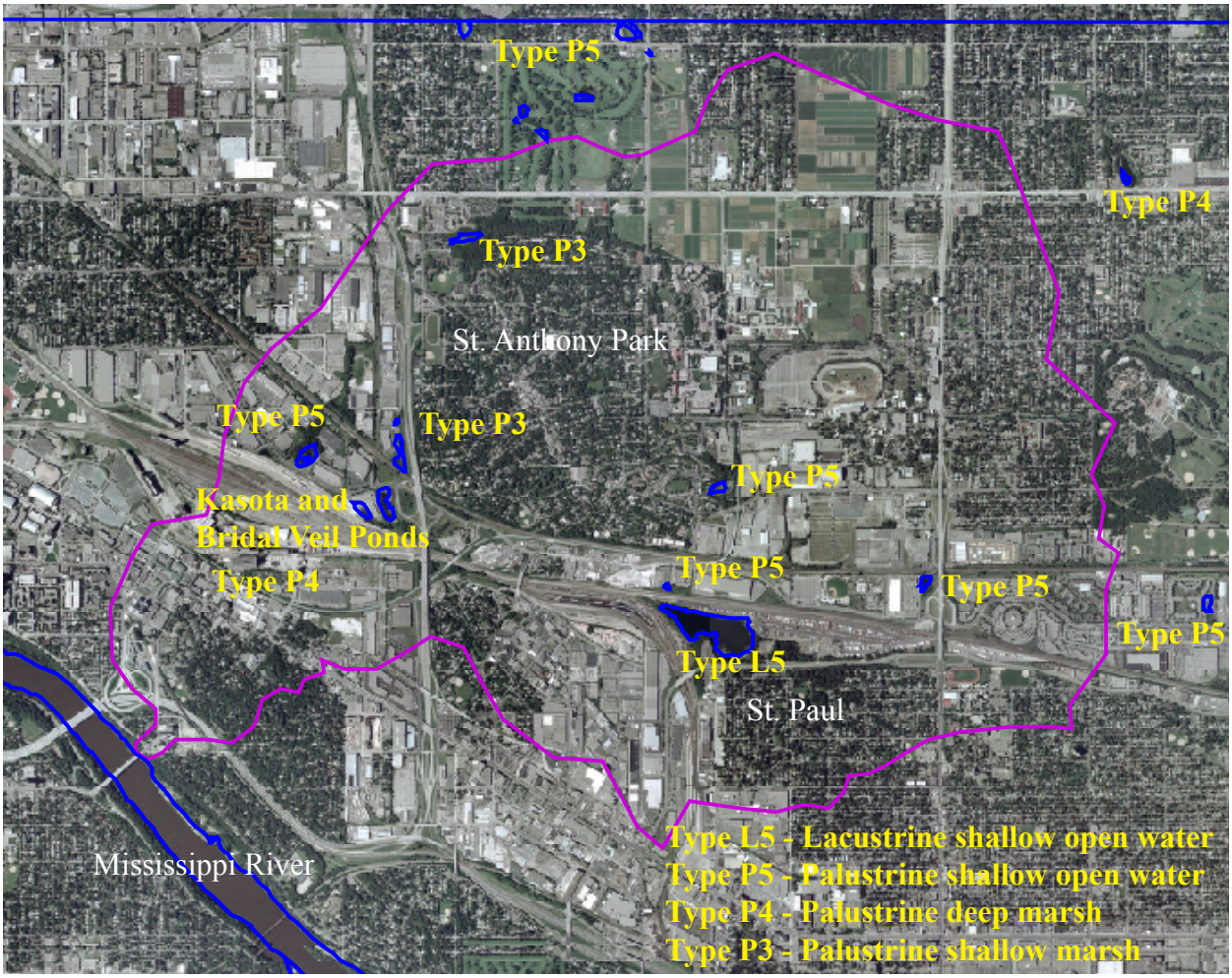


Figure 32: National Wetlands Inventory Map

Modeling Studies

There have been several stormwater modeling projects in the watershed using programs such as XP-SWIMM and HydroCad. Modeling of peak stormflow was done by the City of Minneapolis to size the stormwsewer system, culverts and stormwater ponds in the watershed. These studies provide valuable information on the peak and volume of stormwater discharging from a given watershed area. However as with most modeling exercises there is professional judgement utilized in estimating the parameters going into the model with a lack of field-verified data. Further watershed-specific studies on infiltration and other hydrologic factors would be useful to verify modeled estimates of runoff.

Existing Conditions

Other stormwater studies completed in the watershed in clude the E.O.R. study of the Sarita Wetland watershed and the Lauderdale City Stormwater runoff analysis (CCWD, 2004). The EOR study funded by the Capitol Region Watershed may be relevant to other parts of the University of Minnesota campus, though this area is not representative of most of the BVC watershed. The Sarita watershed has large areas of agricultural fields, while most of the BVC watershed is either residential or industrial.

Public Waters Inventory

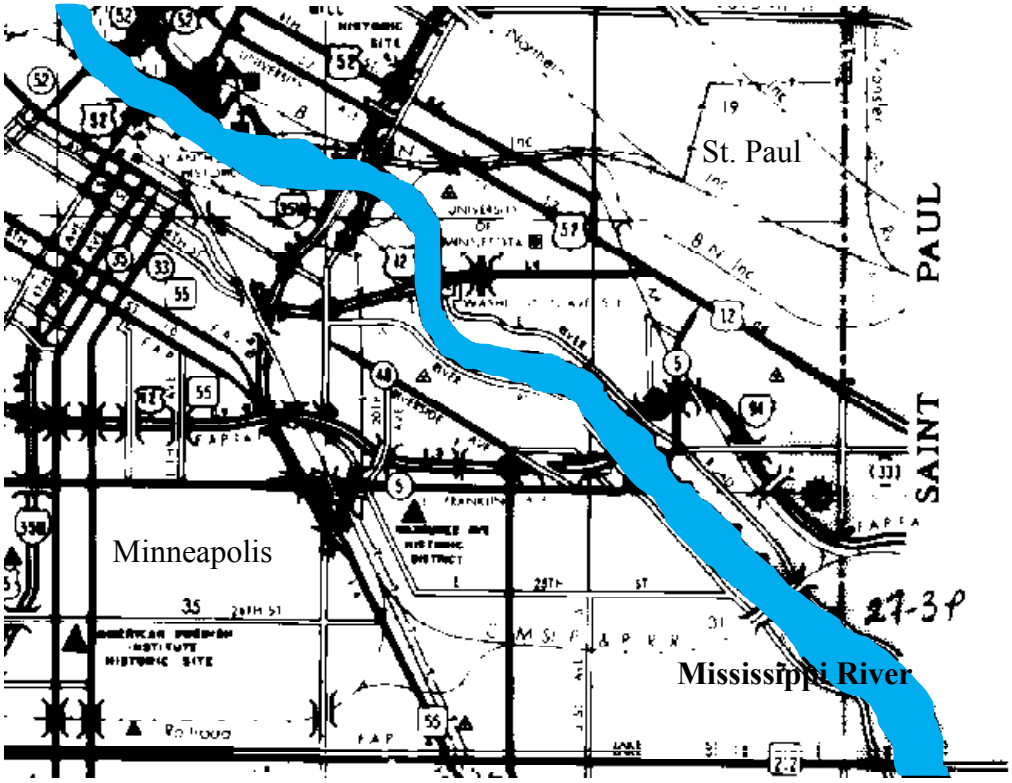


Figure 33: DNR Public Waters Inventory (PWI) Map for Hennepin County 27-3 P, Mississippi River

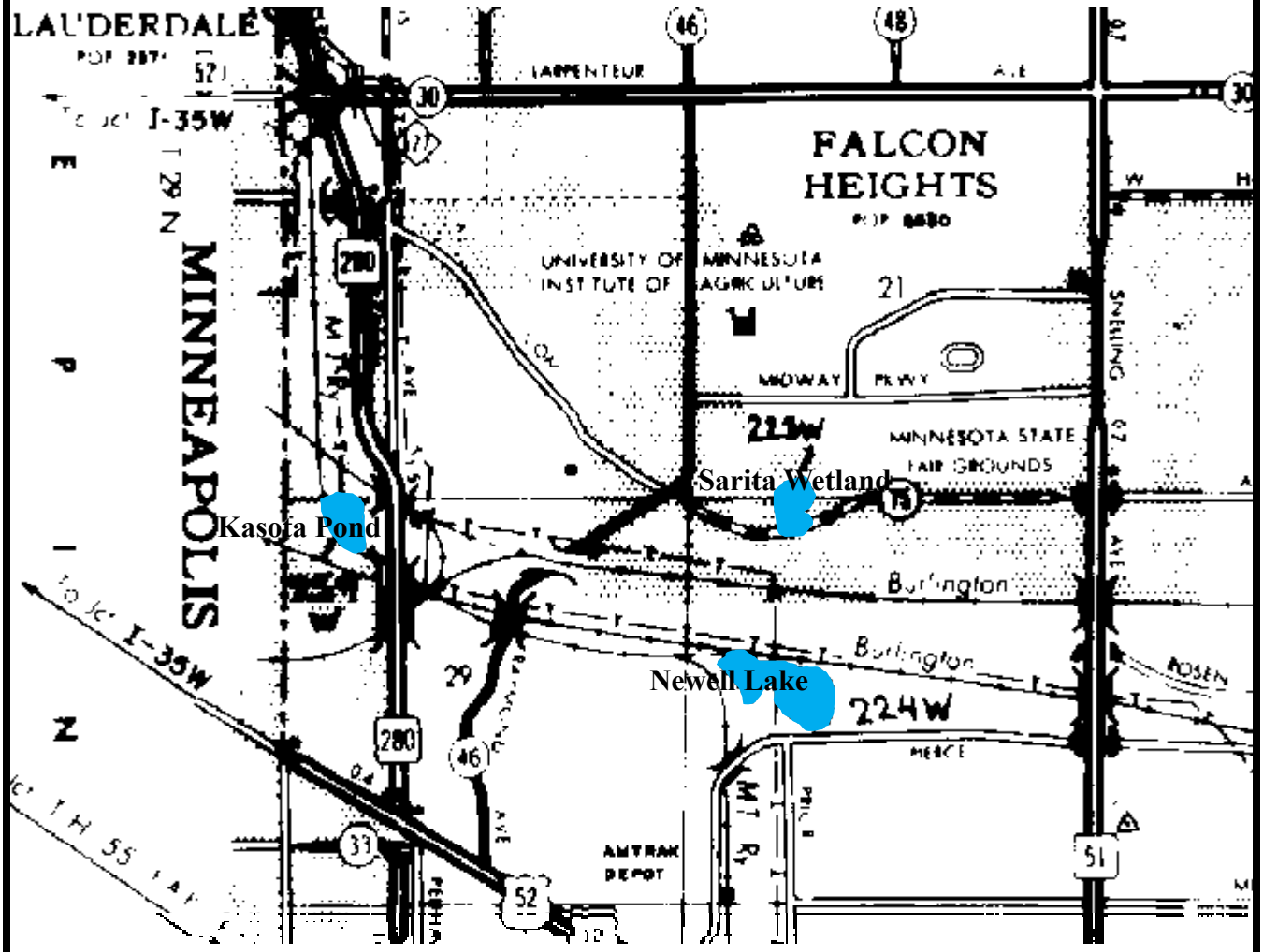


Figure 34: DNR Public Waters Inventory (PWI) Map for Ramsey County: 223W - Sarita Wetland, 259W - Kasota Pond, 224W - Lake Newell

Figures 33 and 34 show the Public Waters and "Public Waters Wetlands" protected by the Minnesota DNR. Public Waters are only those permanent water bodies deep enough to support Type 3, PEMC wetlands or deeper water bodies. There are four Public Waters / Wetlands in the BVC watershed vicinity:

223W - Sarita Wetland,
259W - Kasota Pond,
224W - Lake Newell, and
27-3 P - Mississippi River.

Public waters have additional protection beyond seasonal or shallow wetlands.

Monitoring Data

The University of Minnesota's St. Paul Campus Climatological Observatory collects hourly data on rainfall, soil moisture, temperature and other atmospheric variables such as humidity, evaporation rates, wind speed and radiation. Information is available at http://climate.umn.edu/doc/observatory.htm. There are no other rain monitoring stations in the watershed that provide publicly available data. The Hennepin County SWCD collects rainfall data in nearby northeast Minneapolis, though it is outside of the watershed.

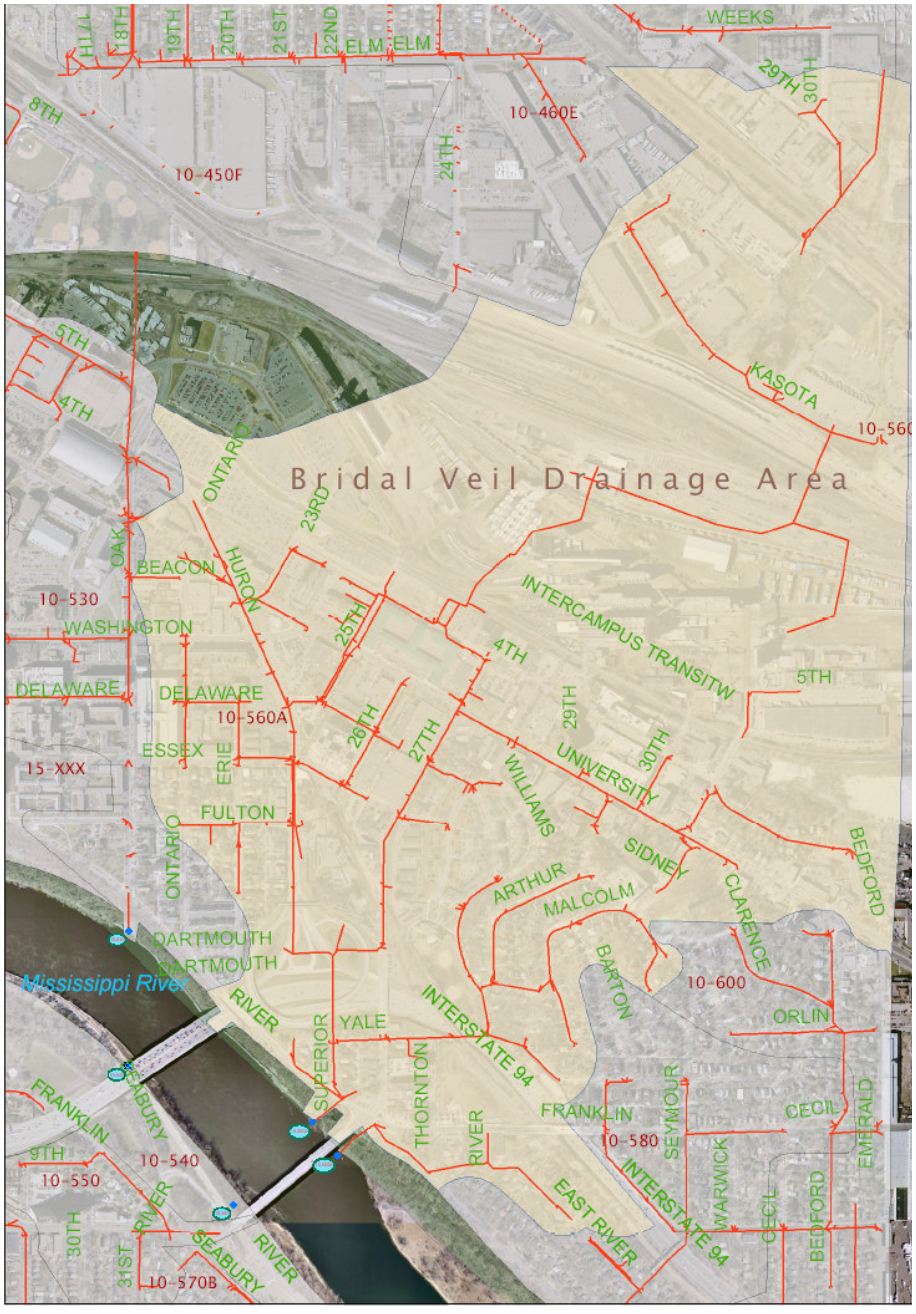


Figure 35: Current Boundaries of the BVC Surface Water Drainage System (Sewershed)

Bridal Veil Creek

SOIL CHARACTERISTICS OF THE BVC WATERSHED

Soils

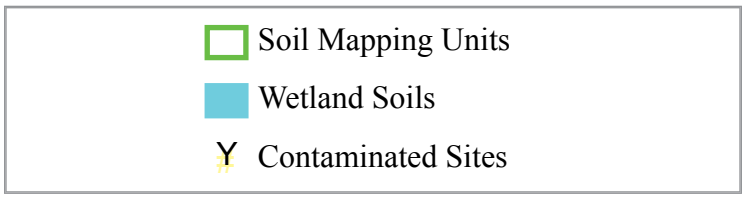
NRCS mapped soils are shown in Figure 36. Much of the area is mapped as Urban Land Kingsley 3-15% slopes, Urban Land Hayden-Kingsley complex 3-15% slopes, and Urban Land Waukegan complex. There are also large areas of Waukegan and Santiago silt loam. Existing soil conditions were described in detail in Part One of this report (See also the MWMO 2000 Watershed Management Plan).

Major changes have occurred to soils since urbanization, primarily through the development process, grading and filling. Numerous areas of hydric soils in wetlands have been filled. Organic soils are disproportionately impacted by development as they are subject to oxidation and subsidence in the drainage and development process. None of the bogs mentioned in the early histories are present anymore Steinhauser (1969). The only significant organic soil deposit remaining appears to be the Markey muck located in a wetland in Lauderdale.

The most critical current soil issue is contamination at the Valentine-Clark site and other industrial brownfields and its impact on downstream waters including: Bridal Veil Creek & Pond and the Mississippi River. The Valentine-Clark site is located to the north of Bridal Veil Pond, just north of the railroad tracks. Contaminants of concern include Poly-aromatic hydrocarbons (PAH), pentachlorophenol (PCP), and dioxins. According to a study done by STS Consultants, these contaminants have been transported downstream to Bridal Veil Creek and Pond area (STS, 2006).

Although Valentine-Clark is the only superfund site in the watershed, many contaminated soils have been found within the watershed. These localized sites are contaminated with a range of toxins, likely ranging from hydrocarbons, to old batteries. Figure 37 illustrates the ubiquitous nature of known or potential groundwater contamination sites in the area. Because of this, it is important to contact the MPCA for information or conduct a Phase I environmental assessment prior to proceeding with any development, grading or construction activities in the watershed.

Other soil issues include salinization of soil near roads and compaction from grading in residential, commercial and industrial areas. Salinization often occurs from salting of roads, limiting the types of plants that may survive in these locations, particularly in areas where snow is shoveled or stockpiled. Soil compaction is very prevalent in urban areas and influences the effectiveness of BMPs such as rain gardens and infiltration basins. Activities that counteract the effects of salinization and compaction include the use of haliophytic (salt tolerant) plant species in landscaping and paraplowing or v-ripping to shatter hard pan soils.



Existing Conditions

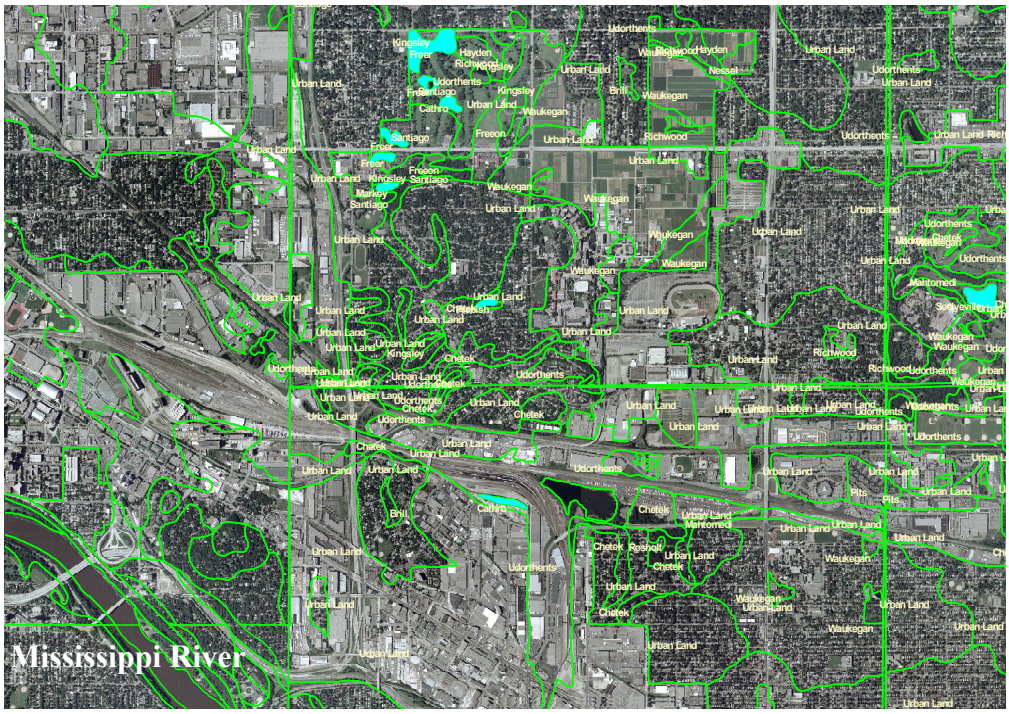


Figure 36: Existing Soils as Mapped in the NRCS Soil Survey.
note: unlabeled areas are classified as urban land

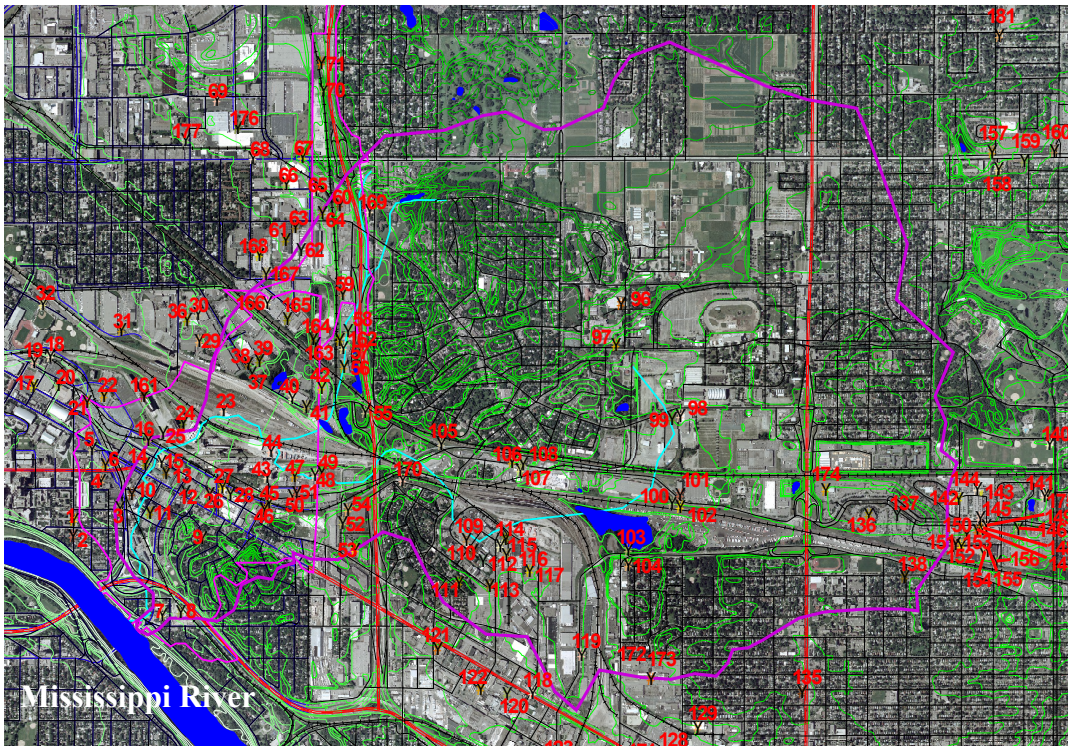


Figure 37 Known and potential sources of groundwater contamination (MPCA)
(See appendix D for list of sites)

VEGETATION CHARACTERISTICS OF THE BVC WATERSHED

Landscape Scale Landcover Using MLCCS

Land cover in the BVC watershed is dominated by impervious area, with large residential sections and few natural areas. This region was mapped using the Minnesota Land Cover Classification System (MLCCS) (Figure 38). Results showed that 84.9% of the mapped area was classified with > 25% impervious coverage (Table 4). Residential and light urban areas (MLCCS # 11000-13000s) with 25-75% impervious area, cover 31.4% of the mapped area, while urban and industrial areas with greater than 75% impervious area (MLCCS # 14000s) comprise 53.5% of the region. Maintained lawns, parks and agricultural areas (MLCCS # 21000-24000) cover 12.2% of the mapped area. Natural areas and open water areas together comprise only 2.9% of the mapped area. In contrast, the original pre-settlement watershed was about 60 % wetland and 40% forest/savanna and prairie.

Table 4a: Landcover in Bridal Veil Watershed Region* **-(all polygons in figure 38)**

Landcover Description	MLCCS Code #	Acres	% watershed area
26-75% Impervious (Residential/Light Urban)	11200-13000	1521	31.4%
>75% Impervious (Urban/Industrial)	14000-14200	2591	53.5%
<25% Impervious (Grass/Lawn/ Agriculture) (non-native herbaceous vegetation dominant)	21000-24000	592	12.2%
Forest	30000-32000	56	1.2%
Wetland	60000-61800	35	0.7%
Open Water, Ponds	92000-93000	48	1.0%
Total Area		4843	100%

*This includes all mapped MLCCS polygons in Figure 36; the area east to Snelling Ave, south to the Mississippi River, north to Larpenteur Ave, and west to approximately the BVC watershed boundary

Table 4b: Landcover in Existing Bridal Veil Surface Drainage System (Sewershed)

Land Cover Description	MLCCS Code #	Acres	% watershed area
26-75% Impervious (Residential/Light Urban)	11200-13000	118	15.9%
>75% Impervious (Urban/Industrial)	14000-14200	543	73.4%
<25% Impervious (Grass/Lawn/ Agriculture) (non-native herbaceous vegetation dominant)	21000-24000	36	4.9%
Forest	30000-32000	12	1.6%
Wetland	60000-61800	21	2.8%
Open Water, Ponds	92000-93000	58	1.4%
Total Area		740	100%

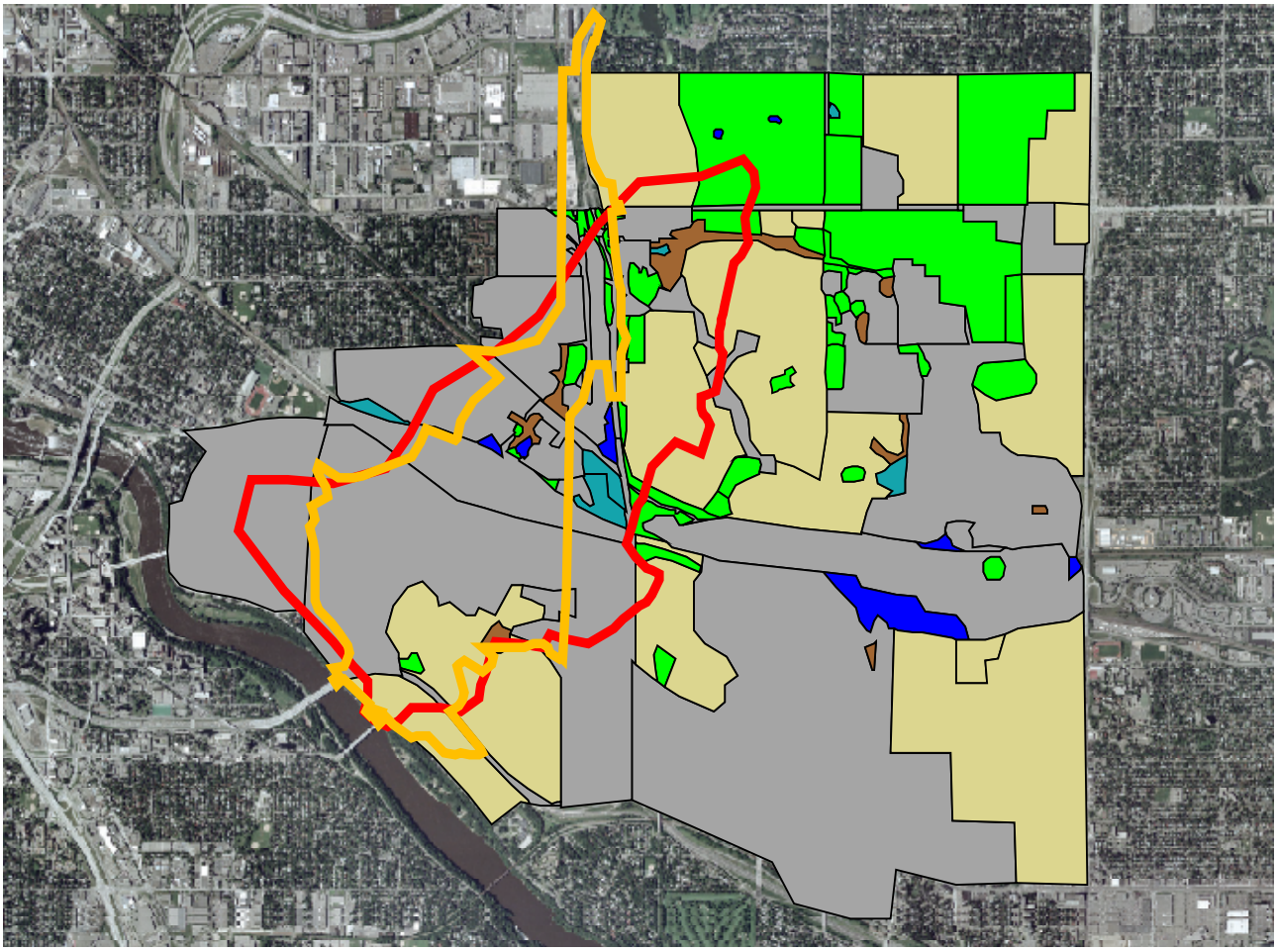


Figure 38: Minnesota Land Cover Classification System Map

Minnesota Land Cover Classification System Key

- Historic Watershed
- Current Sewershed
- <25% Impervious
- 26-75% Impervious
- >75% Impervious
- Forest
- Wetland
- Open Water

Bridal Veil Creek

Site and Community Level Vegetation Assessments

As the wetlands were gradually eliminated, there was a loss of sedge meadow, wet prairie and shallow marsh plant communities. There is very little information regarding the characteristics of historic wetland vegetation prior to urbanization. However, upland plant communities were better mapped (see Cleveland and French, 1873). Much of the upland oak savanna and oak forests were converted to residential neighborhoods in St. Anthony Park. Although most understory vegetation was eliminated, many large bur and white oaks still exist in the neighborhoods, particularly along the north end of St. Anthony Park by the U of M Golf Course and in Lauderdale City Park.

Table 5: Flora and Fauna sources of information

Organism Types	Information Contained	Citation
Vegetation	Pre-European settlement vegetation descriptions	Public Land Survey notes, 1853
Vegetation Communities	Map of plant communities of interest in St. Anthony Park in 1873	Cleveland and French (1873).
Vegetation	Plant inventory of Bridal Veil Pond	Bridal Veil Site Inventory and Analysis (KDG Inc, 2004).
Vegetation	Inventory of city park trees and description of aquatic and wetland vegetation	Eckman et al. 2003
Fish and Invertebrates	Sampling data from Kasota Ponds area	Eckman et al. 2003

Existing Conditions

The Mississippi River Gorge Ecological Inventory and restoration management plan though not located in the BVC watershed contains descriptions of local native plant communities (Shaw and Carr, 2002). Although the gorge is a unique environment with its steep bluff walls, some similarities exist with the bur oak communities on the uplands and the lowland floodplain forest communities. The plan also contains restoration strategies that have applicability to the forest communities of the BVC watershed.

Historic wildlife data is lacking but there are several good anecdotal accounts of wildlife conditions prior1950. One of the best descriptions was from Steinhauser's history of St. Anthony Park (1970) describing the hunting grounds along Eustis and Commonwealth Avenue in St. Anthony Park:

> "*Well into this century the area in the vicinity of Eustis, Commonwealth, Hillside and Gordon provided a hunting ground for men and boys, as ducks and blackbirds were available there. A beautiful spring existed near the corner of Commonwealth and Keston which provided refreshment and relief from a not too trustworthy water supply*."

Overall, there is very little biological data available for this region compared to the physical parameters: geology, hydrology and soils. In general, ecological integrity and diversity are low, but some highlights exist. The stands of bur oaks are clearly one of the outstanding natural features of this area. They represent "old growth" species that should be protected. Due to the age of many of these trees, a long-term planting program should be coordinated with local governments and SAPCC to ensure establishment of younger age-classes to replace the mature trees at some point in the future. This type of long-term (scale of decades) landscape management is frequently overlooked in management plans.

Perhaps the biggest issue confronting existing BVC natural areas is fragmentation and a lack of connectivity which subsequently leads to loss of native seed sources and exotic species invasion. It is unlikely that this watershed will ever be of great ecological value due to the large degree of alteration that has occurred. However vast improvements could be made through improved management of existing natural areas and establishments of corridors linking up the core areas.

SECTION THREE: ANALYSIS and RECOMMENDATIONS

CONSTRAINTS and OPPORTUNITIES ANALYSIS

As a preliminary watershed planning exercise, constraints and opportunities for watershed management and restoration were assessed, using a several techniques. A variety of factors were considered, including; hydrologic, ecological, economic and educational issues. One of the primary considerations in the BVC watershed is the limitation of hydrologic and ecological "integrity" due to the dense urban areas. Ecological integrity of stream, pond and wetland communities will always be limited in the BVC watershed because the relative extent and timing of hydrologic processes has been fundamentally altered by the urbanization process. As with many urban watersheds, opportunities are greatest in the areas of retrofitting for stormwater management, aesthetic improvements, recreation, pedestrian accessibility, greenways/ecological connectivity and the establishment of historical significance.

Opportunities for restoration and improved management are listed in Table 6, while major constraints identified are described in Table 7.

Table 6: Opportunities for Restoration and Management of Bridal Veil Watershed

Opportunity	Description or Purpose
1. Central location in Twin Cities metro region and proximity to universities	Potential research and interest by both students and faculty Ensured long-term existence of parkland and open space
2. Importance to local community groups	SAPCC, Southeast Como Improvement Association (SECIA) are active in management and restoration activities in the area
3. Unique natural features	Bridal Veil Falls, glacial kames of Prospect Park and St. Anthony Parks
4. Daylighting, reconnection and/or restoration of Bridal Veil Creek	The open section of BVC may be restored while piped sections may be day-lighted to establish surface streams as valuable ecological, aesthetic and recreational amenities
5. Natural corridors or greenways	Connection of habitat remnants such as Bridal Veil and Kasota Ponds
6. Native plant restoration and native landscaping	Restoration of existing natural areas to native vegetation with natural landscaping in parks and yards to augment habitat for birds and other wildlife
7. Implementation of stormwater management BMPs	Improved water quality of BVC discharge to Mississippi River

Analysis and Recommendations

Description of Opportunities

1. Central Location
The central location of BVC Watershed makes it invaluable for education, recreation and greenway development. Its location within the Twin Cities metro area makes this watershed a highly valuable piece of real estate. Greenways in the area could link up natural areas such as Bridal Veil and Kasota Ponds with parks in the St. Anthony Park and Lauderdale neighborhoods. It's proximity to the University of Minnesota presents opportunities for research and student involvement, as demonstrated by the Sarita Watershed projects on the St. Paul campus. In that case, student and faculty involvement has spurred on research, restoration and clean-up of Sarita Wetland.

2. Importance to Local Community Groups
Local community groups, such as Southeast Como Improvement Association (SEICA) and the St. Anthony Park Community Council (SAPCC) have made the Bridal Veil Creek Watershed a high priority. This grass-roots interest is critical to the success of urban restoration projects, by generating momentum for the project.

3. Unique Natural Features
The falls that empty into the gorge of the Mississippi River are a unique and valuable natural feature that has suffered from reduced flow, degraded water quality and road construction projects for decades. Routing more flow into the Bridal Veil outlet, along with opening up of the view of the falls via bridge reconstruction could greatly improve the aesthetics of the falls (see URS, 2004). The large glacial kames of St. Anthony Park and Prospect Park are interesting glacial geology features in their own right, providing topographic relief that is unusual in the Metro area. St. Anthony Park and Prospect Parks are the highest spots in this part of NW St. Paul and its first ring suburbs.

4. Daylighting and Restoration of Bridal Veil Creek
There are several possible locations for restoration of the existing stream channel or re-establishing a natural surface channel from pipes or concrete-lined channels (Figure 40). The routes shown in Figure 40 may or may not be politically feasible. The purpose of Figure 40 is to promote discussion on alternatives for re-establishing hydrologic connectivity of the stream and its larger watershed. While it is not possible for complete ecological restoration of this stream, it is possible to restore certain ecological and stormwater functions, aesthetic features, and recreational benefits.

5. Natural Corridors or Greenways
Opportunities exist for the establishment of corridors running east/west along Energy Park Drive and the University Transitway, and running north/south from Bridal Veil Pond to the Lauderdale City Park (Figure 39). Establishment of natural corridors is a high priority for MWMO, SAPCC, SECIA, and the Minnesota DNR. It is likely that this will be a focus area for future management efforts to improve recreational opportunities, quality of life, and ecological integrity.

6. Native Plant Restoration

The Bridal Veil Pond area is undergoing native plant community restoration with oak savanna, mesic and lowland forest being restored in 2005-2006 (See KDG, Inc. 2004 and 2005). The project is funded by Southeast Como Improvement Association (SECIA) with support from the MN DNR. Opportunities for native plant restoration also exist in the Lauderdale City Park, the brownfield areas along Highway 280, the rail yards and adjacent to the University Transitway.

Native landscaping in residential areas and city parks enhances habitat for birds and wildlife and improves "connectivity" to existing natural areas. The Luther Seminary campus as well as College Park and Langford Park have potential for expanding areas of native plant cover.

7. Implementation of Stormwater BMPs

Retrofitting impervious areas to reduce runoff through rain gardens, vegetated swales, pervious pavement, green roofs and other BMPs could be accomplished in many areas, particularly the urbanized SEMI/SEED area and the U of M campus. There are numerous parks, open spaces and pervious surface areas that could be utilized to increase infiltration. Generally the pattern of shallow groundwater flow is towards the southwest, with recharge occurring on the sandy soils atop the St. Anthony Park hill and with discharge occurring on the west side of the hill in the Bridal Veil Valley. Infiltration basins would therefore naturally be positioned in the upland sands of St. Anthony Park. However, infiltration may be accomplished lower down the hill, given appropriate soils and separation from the water table. For example, numerous parks on the east side of Highway 280 may be suitable locations for infiltration. It is likely that groundwater table lowering has occurred over the decades of hydrologic alteration in the watershed, making these areas drier than they were historically.

Table 7: Constraints to Restoration and Management of Existing Bridal Veil Watershed

Constraints	Problem or Issue
1. Limited size and fragmentation of natural areas	Limited options for ecological restoration or habitat enhancement, increased "edge" habitat reduces ecological value of remnants
2. High percentage of impervious area	Stormwater management/water quality improvement
3. Loss of surface waterbodies (streams, wetland, lakes)	Loss of aquatic ecosystems, aesthetic and recreational features
4. Reduction of baseflow due to impervious surfaces	Limits options for stream restoration, impacts quality of stream
5. Presence of contaminated soils at Valentine-Clark Superfund site and others	Remediation of pentachlorophenol (PCP) and polynuclear aromatic hydrocarbons (PAH) may eliminate area from use for decades
6. Political boundaries hinder management of watershed as one unit	Flow has been separated by city boundaries, eastern half of watershed is cut off from Bridal Veil Creek
7. Loss of memory of natural features in the area	Very few people remember the value of the natural areas that existed prior to industrialization and Highway 280 construction

Analysis and Recommendations

Description of Constraints

1. Limited Size and Fragmentation of Natural Areas
There are limited natural areas left in the watershed, and most remaining areas are degraded. The low quality of remaining natural areas limits ecological value and increases time and cost needed for ecological restoration. Fragmentation of the original landscape into habitat "islands" has increased "edge" habitat, which favors invasion of exotic species, while eliminating interior dependent birds and other animals.

2. High Percentage of Impervious Area
Impervious area increases storm runoff peak and volume, increasing sediment and pollutant loading downstream to the Mississippi River. Impervious areas are concentrated in the southern and western parts of the watershed with more mixed land uses in the St. Anthony Park/University of Minnesota area.

3. Loss of Surface Waterbodies
In addition to the creek itself, many lakes and wetlands have been completely eliminated from the Bridal Veil watershed. Bridal Veil Creek is now contained within a pipe over most of its length to its outlet at the Mississippi River. Many lakes and wetlands have been drained. Langford Lake in St. Anthony Park no longer exists and is now a grass field in a park. Many of the wetlands adjacent to Bridal Veil Creek in the current Highway 280 area have been filled, although Kasota Ponds and Bridal Veil Pond still exist.

4. Reduction of Baseflow Due to Impervious Surfaces
One of the greatest challenges for stream restoration in urban areas is lack of baseflow, created by decreased infiltration in highly impervious urban areas. Because of this lack of baseflow, even if surface channels are reestablished, the flashy hydrographs characteristic of urban streams tend not to support perennial streamflow. For example, the open segment of BVC does have some baseflow, but it is only a trickle most of the year, limiting the value of the stream for fish, amphibians and invertebrates. Following storm events, BVC discharge increases dramatically (data on discharge is not available) leaving sediment deposits at the mouth of Bridal Veil Pond.

5. Presence of Contaminated Soils
The Valentine-Clark Superfund site severely limits restoration options for Bridal Veil Creek. On the Valentine-Clark site, upland restoration or management is limited because soil cannot be moved around until the site is cleaned up. Also the site potentially affects downstream areas via seepage through the shallow groundwater into Bridal Veil Creek. Studies concerning contaminant transport from the Valentine-Clark site are currently being conducted by the Minnesota Pollution Control Agency.

6. Political Boundaries
The separation of stormwater sewerpipe systems between Minneapolis and St. Paul divided the watershed in two. Although groundwater connections crossing the Highway 280 divide probably exist, for most practical management purposes (i.e. stormwater management) the eastern portion of the watershed has been cut-off.

7. Loss of Memory of Natural Features
Very few people remember the value of the natural areas that existed prior to industrialization and Highway 280 construction.

RECOMMENDATIONS
Multi-Scale Management Approach
A multi-scale approach to ecological restoration and management is recommended and summarized in Table 8. Landsape level planning is needed for big-picture considerations, such as brownfield restoration and greenway establishment. Issues of connectivity and development planning lend themselves to landscape level analysis. On the other hand, site-specific actions are more readily available. Given that the watershed is fully developed, many of the opportunities for restoration and management are at the site scale or plant community level.

- **Landscape Scale** - At the broadest level, consideration of the whole BVC watershed entails land-use planning to improve connectivity of natural areas and enhance recreational opportunities. Opportunities and issues were discussed earlier, with perhaps the two largest issues being 1) reclamation of brownfields and degraded industrial areas along Highway 280 and, 2) retrofitting impervious areas for improved stormwater management to protect Mississippi River water quality.

- **Community Scale** - Community level restoration involves active management of selected natural areas, such as the Bridal Veil Pond, the U of M campus woods or the woods south of the U of M golf course in Falcon Heights/Lauderdale. There are few intact or undisturbed natural communities in the watershed, and the remaining areas need considerable management to re-establish healthy native plant communities.

- **Site Scale** - At the site scale of individual yards and roadsides, native landscaping and exotic species control as well as stormwater management may be accomplished. In developed urban areas, the site scale tends to have the greatest potential benefits. Native landscaping helps ecologically and aesthetically and may act as buffer zones to natural areas, extending the area of beneficial habitat, particularly for small animals like birds. Removal of exotics in yards near natural areas helps to prevent their spread. This could be achieved by coordination of MWMO working in partnership with SAPCC and SECIA. Many stormwater management techniques that can be implemented on a site level, for example use of permeable pavement, green roofs, rain gardens, vegetated swales, and others to accomplish runoff reductions from industrial sites and large parking lots.

Analysis and Recommendations

Focus on Dense Urban Corridor to Reduce Imperviousness
About 3/4 of the watershed (73%) is classified in the most impervious category (>75% impervious). Reduction of imperviousness on just a few of these large industrial properties and parking areas could have a large impact on stormwater runoff reduction.

Table 8: Hierarchy of Management in BVC Watershed Area (pre-settlement boundary)

Landscape Level	**Groups Involved**
• Land-use planning • Brownfield reclamation • Greenway development • Watershed management	Government agencies (cities, MWMO), (state level: MPCA, MNDOT), industrial and brownfield land-owners
Community Level	
• Native plant restoration • Wetland restoration • Forest management • Stream daylighting/natural channel design	Community organizations (SAPCC, SECIA), Minneapolis Public Works , Minneapolis Parks and Rec. Board, MWMO, MNDNR, MPCA, City of Lauderdale, Capitol Region Watershed District, U. of Minnesota, Luther Seminary
Site Level	
▪ Native landscaping ▪ Stormwater reduction/infiltration ▪ Exotic species control ▪ Buffering of natural areas	Community organizations (SAPCC, SECIA), individual residents, MWMO, industrial land-owners, University of Minnesota

ECOLOGICAL RESTORATION AND MANAGEMENT
Landscape level: Greenways and Corridors
A landscape-level plan for managing existing natural areas and establishing greenways should be developed. The Bridal Veil Creek and Pond Site analysis (Kestrel Inc, 2004) contains a preliminary landscape level analysis of the Bridal Veil Creek watershed area. This report contains a more detailed MLCCS inventory that will support greenway planning efforts (See Figure 38). Improved connectivity is needed for improved ecological integrity as well as pedestrian and bike traffic. Currently there are several natural areas that pedestrians utilize. However, roads in much of the area that serve as potential pedestrian and bicycle routes are not pedestrian friendly, such as Energy Park Drive.

A preliminary greenway development plan is presented in Figure 39. The plan was based on analysis of the MLCCS land cover map developed for this project by Kestrel Design Group Inc. with consideration of recommendations from previous reports (see Table 9). The greenway plan contains seven different categories, with a core area of parks, natural areas and waterbodies all connected by pedestrian walkways, bike paths and pedestrian friendly “parkways” for automobiles. Existing parks and natural areas serve as the core of the trail network. Proposed pedestrian linkages and the existing university bike path provide linkages between core areas.
This plan links the Bridal Veil-Kasota Ponds area to the Luther Seminary-Lauderdale City Park

area to the northeast. Following the old trolley line straight east, it links up with the open areas of the St. Paul campus and the grounds of the future Bell Museum of Natural History to be located at the corner of Cleveland and Larpenteur. Although it has not been constructed yet, the grounds of the new museum will contain native landscapes and pedestrian trails, adding to the existing natural area network in BVC. The Bell Museum native landscape grounds can be a natural "anchor" for future greenway development.

As part of the "greening" of the Bridal Veil watershed, conversion of Highway 280 into a reduced speed, limited access parkway to improve aesthetics and safety would be of tremendous benefit. The cloverleaf access points are highly dangerous along Hwy. 280, particularly the Larpenteur and Como Avenue ramps. Traffic management issues such as speed limits and on-ramp design should be reviewed for safety as well as ecological and aesthetic concerns. Landscaping in the median and along the roadside should support improvements in the area. Minnehaha Parkway and Summit Avenue in the Twin Cities or the George Washington Parkway near Washington D.C. could serve as models for the transformation of this highway.

Table 9: Proposed Greenway System (Explanation of Figure 39)

Map Feature	Explanation	Notes and References
Proposed pedestrian linkages	Sidewalks, trails, bridges and/or underpasses needed to provide pedestrian access between core natural areas	Kestrel recommendation. See Bell Museum Master Plan draft (University of Minnesota 2006)
Proposed reduced speed parkway	Proposal to reduce speed, improve safety and aesthetics and implement native landscaping along Highway 280	Kestrel and Bridal Veil public workshop recommendation
Proposed parkways	Improved pedestrian and bicycle access routes (example: Minnehaha Parkway). The 29th Avenue parkway was suggested in the SEMI/Bridal Veil AUAR	SEMI/Bridal Veil AUAR (2001); SEH Inc. and Cornejo (2005)
University bicycle path	Bicycle path along University bus transitway connecting the St. Paul and Minneapolis campuses, the Twin Cities Bike map shows existing bike paths and suitability of roads for bicycle traffic	U of M campus master plan (2006); Met Council (2005)
Existing waterbodies	Wetlands and ponds are both included in this category derived from the NWI map, waterbodies are key natural components of a greenway system	National Wetlands Inventory map (note that NWI wetlands may have changed in size or been eliminated since inventory was done)
Existing brownfields	Abandoned industrial and/or contaminated sites that require remediation	Field observation and MPCA lists
Existing parks & natural areas	Provides the "core" of greenway network, this category includes campus natural areas, forests, community parks, the Mississippi River National Recreation Area and other natural sites	See Bridal Veil Creek & Pond Site Analysis (Kestrel Inc, 2004); Bridal Veil Creek Vegetation Restoration and Management Plan (Kestrel Inc, 2005)

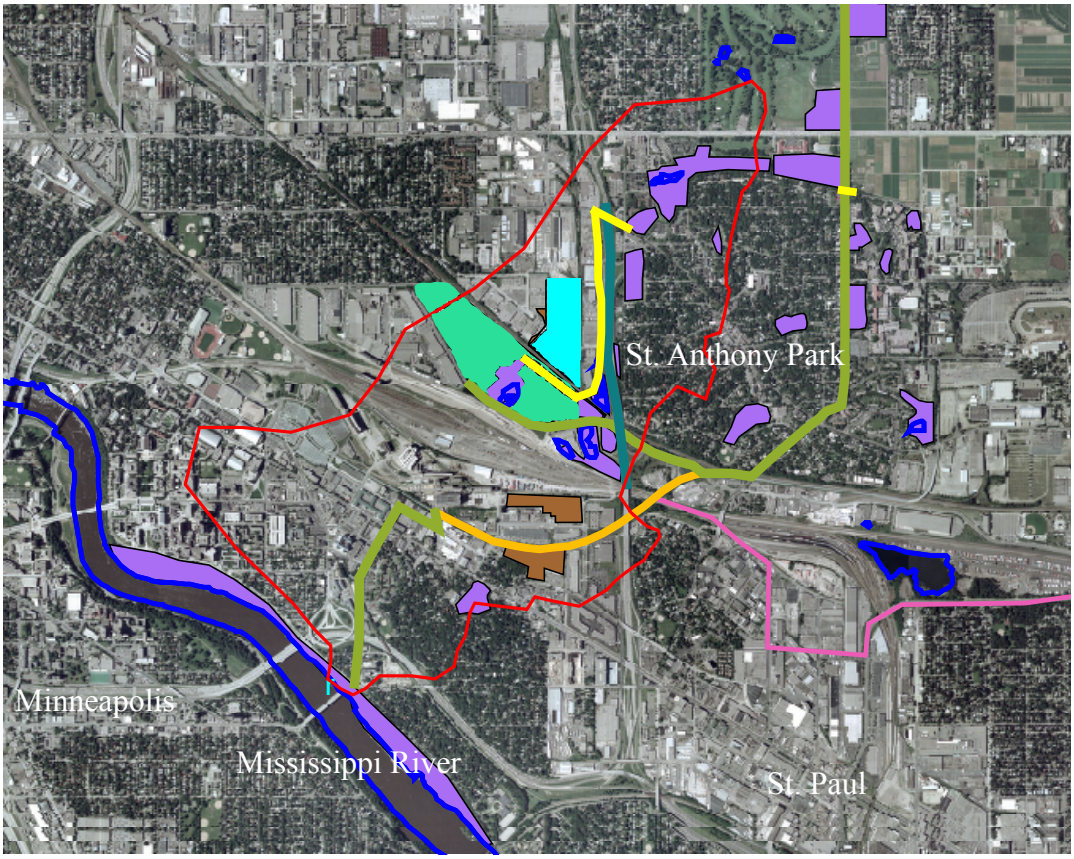


Figure 39: Preliminary Greenway Plan for BVC Watershed

- Proposed Pedestrian Linkages
- Proposed Reduced Speed Parkway
- Proposed Parkway
- Existing University Bike Path
- NWI Wetland
- Existing Brownfield
- Existing Park or Natural Area
- Elm St. Ash Dump
- Valentine-Clark Superfund Site

Bridal Veil Creek

Community Level
Potential areas for native plant community restoration or native landscaping should be investigated in more detail than is presented here. Opportunity sites include Langford Park and College Park in St. Anthony Park as well as the wetlands along Highway 280. Both of these would be excellent spots for wetland restoration or infiltration areas, as they were originally lakes or wetlands. Native plant corridors could also be established along Energy Park Drive and the University Transitway. Energy Park Drive was proposed as a greenway corridor in the SEMI AUAR report (MCDA and SEED, 2001).

Stream Restoration
As most of BVC has been placed in pipes, re-establishment of natural channels is the primary stream restoration objective. Opportunities for daylighting Bridal Veil Creek and re-establishing surface channels and associated ecological functions have been identified, building on the report "Daylighting Streams in Hennepin County" by Cornejo (2005). Locations that allow for restoration of ecological and/or hydrologic functions such as flood storage, velocity dissipation, and baseflow maintenance should be prioritized. Opportunities for restoring aesthetic features and recreational opportunities are also important in areas of high pedestrian use, such as the Luther Seminary and Eustis Avenue apartments. A significant concern is the location of toxic soils in the superfund site and Elm Street Ash Dump just west of Highway 280. Any stream daylighting plans will have to address these issues or relocate the channel away from the contaminated sites. Restoration of natural features at the Valentine-Clark superfund site is a long-term prospect that can not occur until the site is fully remediated, which will be years from now.

One opportunity for natural channel design exists in a concrete-lined channel east of Eustis Avenue and south of Larpentuer Avenue in the parking lot of an apartment complex (west end of BVC restoration area 2). This channel drains from a wetland in the southwest Lauderdale area, with flow originating from the southwest corner of the U of M golf course. Though not part of the existing Bridal Veil "sewershed", this area is part of the historic BVC watershed. A natural channel design in place of the concrete channel in this location could provide numerous benefits. Hydrologic benefits include stream flow velocity and energy reduction, dampened hydrograph peak, and filtration of stormwater. The restoration would also provide an aesthetic and recreational resource in an area frequented by families and small children.

Another opportunity for stream restoration exists in the Bridal Veil Pond itself (BVC restoration area 1 in Fig. 38). The Bridal Veil Pond could be restored to a more natural condition by recreating a stream channel through the pond with wetlands restored alongside it. Prior to excavation of this artificial pond, a stream and wetland complex existed in the area. This strategy would represent restoration of the stream's pre-disturbance morphology and ecological function. This alternative will require further investigation as there are numerous issues involved. Once the Bridal Veil Pond site is remediated for contaminants that were transported downstream from the Valentine-Clark site, this restoration option will become more feasible and beneficial from an ecological perspective. It will help also to minimize public exposure to toxic compounds (see (STS, 2006) for a preliminary discussion of remediation alternatives).

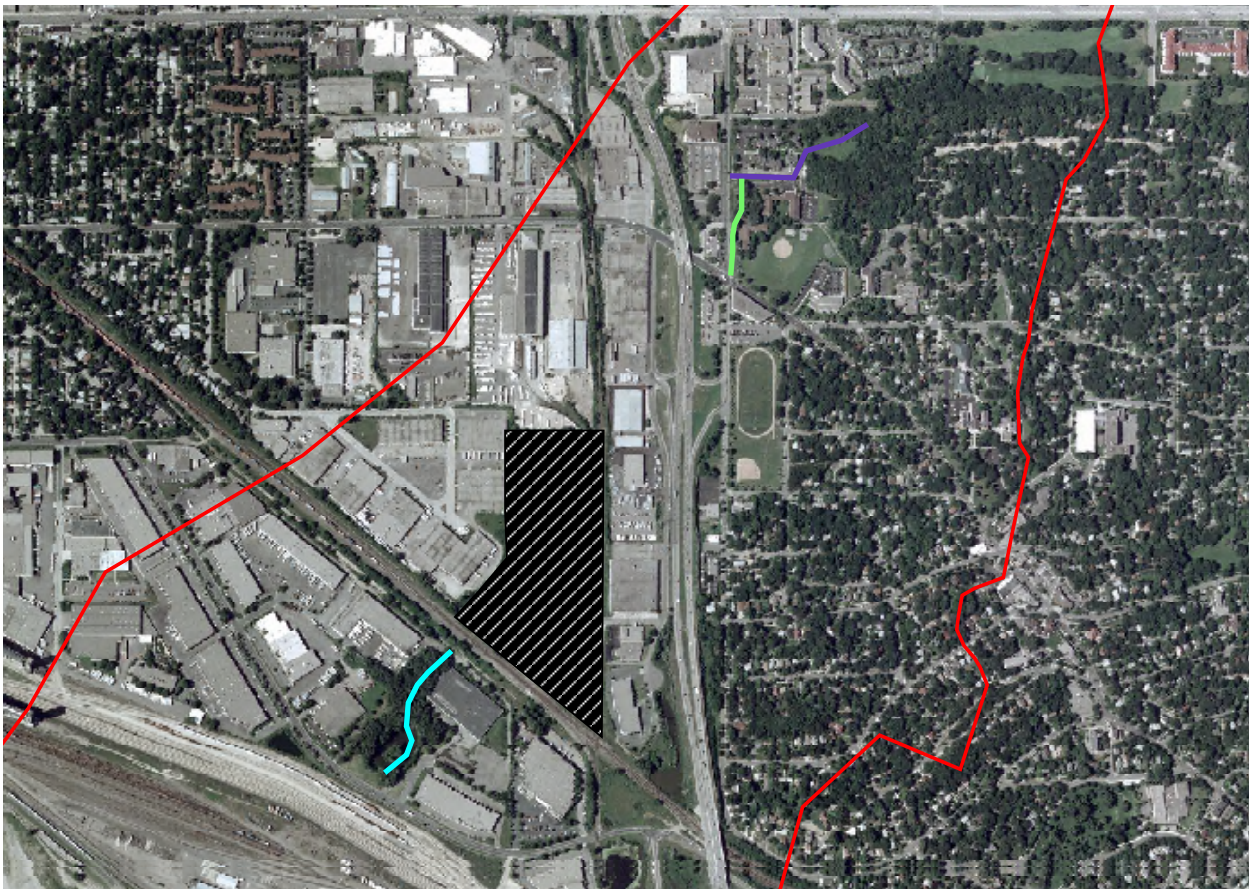


Figure 40: Potential Locations to Re-establish Bridal Veil Creek

Bridal Veil Creek

Wetlands
In addition to the Kasota and Bridal Veil Ponds area, a wetland exists in Lauderdale just east of Eustis Avenue and north of the Luther Seminary. The Lauderdale wetland currently is dominated by reed canary grass, though patches of sedges and other species exist. This area should be managed to increase plant diversity, reduce exotic coverage and re-establish more natural channel conditions. Other wetland-like areas within the study area include the Sarita wetland, several golf course ponds on the university course and a shallow marsh in a city park along Cleveland Avenue north.

Uplands
The forest and savanna communities may have the greatest restoration potential, simply in terms of available area. Forests in College Park, Langford Park and on the university golf course could be managed to improve tree stand diversity and age-structure. Exotic species control and native plantings could be done to improve mid-story and understory diversity. (See the Bridal Veil Pond restoration plan, Kestrel Inc, 2005). Savanna areas, such as the large median strip (50-100 feet wide) on Commonwealth Avenue could be planted with understory prairie/savanna seed mixture, Examples of this planting type are found along parts the East and West River Road in Minneapolis along the Mississippi River parkway.

Watershed Management - Data Gap Analysis

Hydrologic Analysis

- **Hydrologic Modeling of sediment, nutrient and pollutant loading in BVC watershed**
  On a sub-watershed (sewershed) basis, estimates of sediment, nutrient and pollutant loading to Bridal Veil Creek and Mississippi River should be estimated using a modeling approach (e.g. HydroCad, P8 and/or XP-SWMM) verified with monitoring data. MWMO is currently working on watershed management plans to improve the management of water going to the Mississippi River. This will facilitate identification of the major source loading zones of TSS, phosphorous, nitrogen and pollutants such as hydrocarbons, heavy metals and chloride. Peak runoff rates were calculated by city engineering departments to select appropriate sewer pipe sizes. However these modeling calculations provide no information on baseflow conditions nor water quality.

- **Groundwater studies are needed between 280 and the St. Paul Campus**
  In order to determine groundwater gradients near the base of St. Anthony park hill and along Highway 280, further studies are needed. In-depth groundwater studies have been conducted on the University of Minnesota's St. Paul campus by Alexander et al. (2005). Groundwater contamination studies have also been done near the Bridal Veil Pond and the Valentine-Clark Superfund site (STS, 2006). The area that has not been studied thoroughly lies in between the U of M campus and Bridal Veil, between St. Anthony Park and Highway 280. In order to better understand the groundwater dynamics in these areas, a transect of wells and peizometers could be installed starting on St. Anthony Park

Hill near Lauderdale and ending near Highway 280. The quantity and direction of the groundwater flow from St. Anthony Park towards the historic Bridal Veil Creek valley would then be better understood, facilitating future management of the Kasota and Bridal Veil Pond areas. This would also help to clarify groundwater dynamics in this area to facilitate selection of stormwater BMPs and their appropriate locations. Alternatively a geochemical sampling approach could be utilized to identify water sources

Future Monitoring and Research

One of the largest gaps in information for Bridal Veil Creek is the lack of stream discharge data. The only location where it is possible to monitor surface water flow, (besides at St. Anthony Falls), is at the open segment of Bridal Veil Creek. Stream flow data would provide valuable information concerning the effective discharge and hydrologic regime needed in stream restoration planning. Stream flow data, particularly data on bankfull flow (the flow with a 1.5 year recurrence interval) is needed in the natural channel design approach to select appropriate channel dimensions (width, depth, entrenchment, slope, etc.) when daylighting or reconstructing natural channels. Streamflow data would also be useful for the plans to remediate contaminants at the Bridal Veil Pond area and future restoration activities following clean-up.

Installation of an automatic water level recorder (a level logger or submerged probe) and establishment of a stage-discharge relationship would provide a stream discharge record for the creek. Alternatively, an area-velocity meter alone provides the data needed to calculate discharge, though these devices are problematic under certain flow conditions such as intermittent discharge and low turbidity.

In addition, continuous discharge monitoring at the watershed outlet of Bridal Veil Falls is invaluable for purposes of watershed modeling and management. However, since water has been shunted from the BVC sewershed into a pipe east of BVC falls, monitoring at this station does not represent the cumulative discharge of the entire BVC watershed. Total flow data would be much more valuable for watershed management purposes, but may be impossible to obtain, given that the stream is contained in pipes before the flow is split off.

BMP Implementation

Locations for implementation of BMPs such as infiltration basins and rain gardens should be further investigated, building on the preliminary list in Table 10. Potential recharge areas were identified by locating areas of open space with sufficient soil types and separation from the water table. Further infiltration sites may be identified utilizing the land cover and groundwater maps developed for this project in addition to soil survey, wetlands, and topographic layers (See Figure 31). Further analysis is necessary for specific infiltration projects in order to determine if adequate infiltration rates and separation from the water table exist.

Stormwater BMPs to Reduce Runoff at Site Scale

A variety of techniques exist for reducing runoff at the scale of individual lots or roadsides.

Bridal Veil Creek

Green roofs, rain gardens, permeable pavement, and vegetated swales are just a few of the BMPs that should be utilized in the BVC watershed. A brief summary of recommendations for these practices is provided below.

• **Rain gardens and vegetated swales** may be installed on most residential lots within the watershed, and many commerical sites Vegetated swales are particularly useful on roadsides and in parking lots or other large impervious areas. Areas alongside Hwy. 280, Como, Energy Park and Kasota Avenues are likely to have locations suitable for vegetated swales.

Table 10: Potential Locations for Infiltration Basins (see Figure 31 for Locations)

Site	Map #	Location	Notes
Soccer Field (site of future Bell Museum)	P1	Larpenteur and Cleveland	Bell Museum Master Plan includes infiltration basins and trenches, green roof and rain gardens
St. Paul campus main quad	P2	Cleveland and Buford	Campus Master Plan includes infiltration basins and trenches, rain gardens
College Park	P3	Raymond and Carter	Open space, upland
Langford Park	P4	Langford and Hillside	Location of Langford Lake historically
Community park and track	P5	Como and 280	At foot of St. Anthony Park Hill a former pond area in 1940s
Soccer Field	P6	Como and 280	On the foot of St. Anthony Park hill a former pond area in 1940s
Natural area	P7	Eustis and Idaho	On foot slope of St. Anthony Park hill appears to be discharge area in Gasparre Pond and wetland area

•**Green roofs** provide immediate runoff reductions and energy savings over long time-scales. Though more expensive to install, green roofs provide savings in the long term. Green roofs are applicable in a variety of settings, particularly large buildings with flat roofs. On many of the large industrial buildings on the Minneapolis side of Highway 280, great cost savings could be obtained with green roofs by reduction in storm water utility fees. For example, KDG, Inc. has worked with a large warehouse owner in this area to implement stormwater BMPs to reduce stormwater utility fees. In addition, the new Bell Museum of Natural History on the corner of Larpenteur and Cleveland Avenues will have a green roof built.

•**Permeable pavement** may be useful in the redevelopment of old industrial and brownfield sites along Highway 280, given the large impervious surface area these sites comprise.

Analysis and Recommendations

Despite recent gains in the popularity of alternative BMPs it is important to keep pursuing stormwater "retrofitting" opportunities for improved water quality discharge to the Mississippi River.

•Infiltration basins and stormwater ponds
At a subwatershed scale, opportunities for surface water treatment and storage should be pursued to replace the historic loss of wetlands and ponds in the watershed. At present the Hwy. 280 "valley" is perhaps the most appropriate location to locate surface water detention, water quality treatment and infiltration basins There were numerous ponds east of Highway 280 prior to the construction of the highway in the 1950's serving to store excess stormwater runoff. Given that this area is mostly open space and supported wetlands historically, this is the most logical location for larger stormwater ponds and infiltration basins. However, since this area was traditionally a wetland zone with groundwater discharge, the suitability of soils for infiltration and depth to water table need to be examined in this area.

WATERSHED EDUCATION AND AWARENESS
Public education on the history of the Bridal Veil watershed is vital for the long-term success of management & restoration plans. The lack of awareness in the community concerning Bridal Veil Creek and its wastershed was evident from this study. Creating a plan or vision for the BVC watershed that people can relate to will help gain public support for restoration and management plans. Tying into the history of BVC watershed would be helpful in this respect (this is discussed in more detail in Appendix A, in the summary of interviews on page. 80). Hopefully, the proposed greenway plan and recommendations made in this report will serve as a catalyst for further watershed improvements. Both SAPCC and MWMO will pursue public education opportunities in the future.

RESTORATION CASE STUDIES: EXAMPLES FOR THE BVC WATERSHED
When ecological restoration and greenway development opportunities arise it is helpful to have analagous case studies from similar urban watersheds. We collected examples of comparable restoration projects including greenways, urban parkways, wetland and stream projects and urban stormwater BMP implementation.

Greenways: Trout Brook Greenway, St. Paul, MN
The Trout Brook project in St. Paul is a good example of a linear urban greenway incorporating stormwater treatment and restoration of surface water features (EOR, 2004). The concept of linking stormwater ponds with a restored surface channel and native plant communities may be applicable in the Bridal Veil Creek area near Valentine Clark once the site is cleaned up. Areas along the east side of Hwy. 280 and along 29th Avenue heading south to Bridal Veil Falls would be good spots for greenways as well.

Parkways are distinguished from greenways as being designed primarily as scenic, reduced speed driving routes often with separate pedestrian/bicycle trails. The Twin Cities' Grand Rounds system has several examples of well-designed parkways that could serve as models

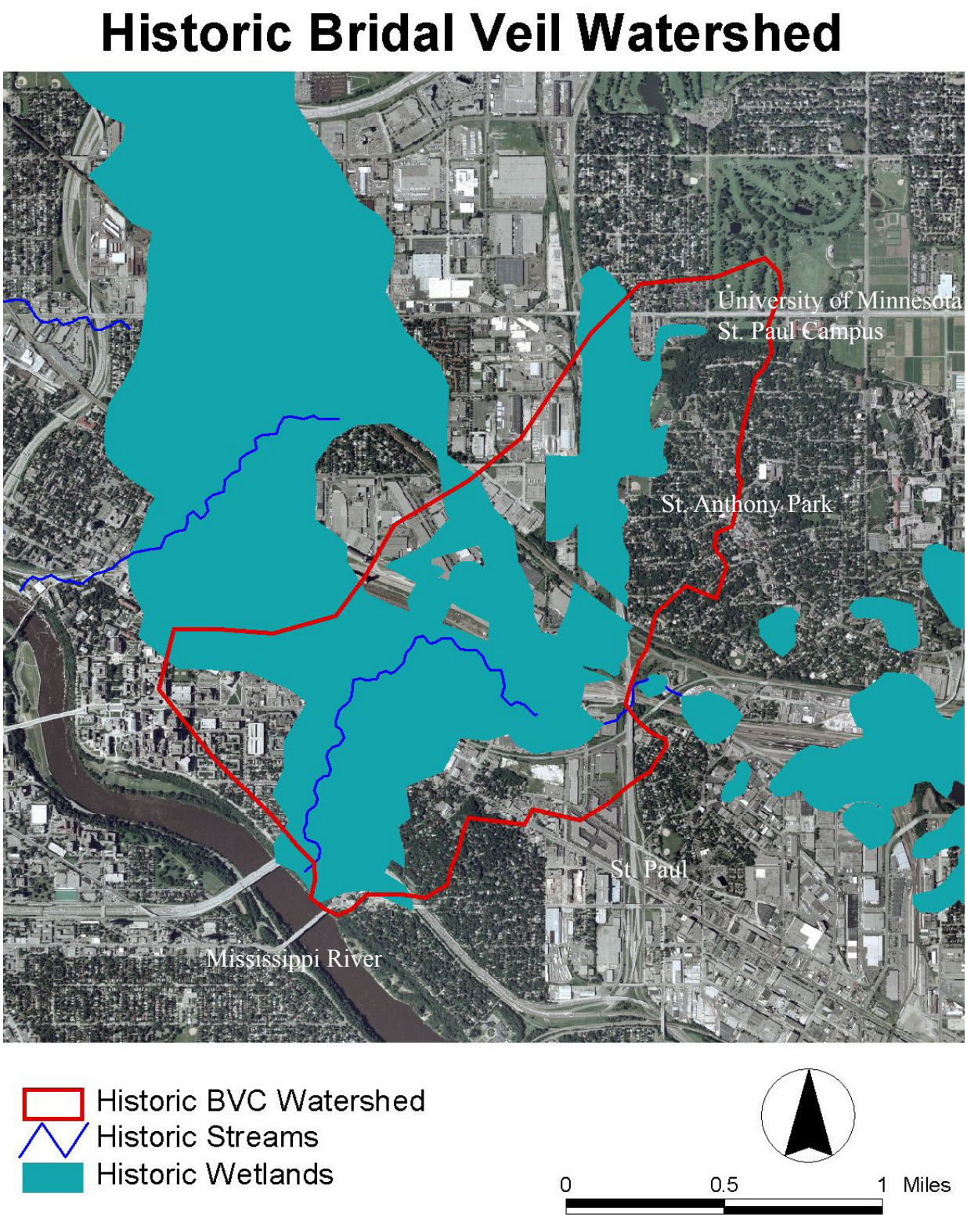
for the BVC watershed including Minnehaha Parkway and the East and West Mississippi River Boulevards in St. Paul and Minneapolis. A reduced speed parkway has been proposed along 280 to improve safety and aesthetics.

Ecological restoration:
Streams
There are several examples of good urban stream restoration projects in the Twin Cities metro that have been completed or are in the planning stages. These include Bassett Creek, Pike Creek, Minnehaha Creek and the Prior Lake outlet channel. These projects represent a range of restoration intensiveness from re-establishing natural channels from piped streams (daylighting) to streambank stabilization via bioengineering. The Bassett Creek Valley Master Plan involves daylighting and natural channel design of an urban stream segment (City of Minneapolis, 2000). Pike Creek in Brooklyn Park and the Prior Lake outlet channel involve a combination of natural channel design and streambank stabilization via soil bioengineering. Minnehaha Creek used soil engineering primarily to stabilize the stream channel using a combination of plant materials, rock and erosion control practices.

Eventually when the Bridal Veil Pond site is remediated for contaminated soil, stream restoration will likely be done on that site (STS, Inc. 2006). The design will require a combination of natural channel design and soil bioengineering techniques in assocation with wetlands re-establishment in the area of the pond.

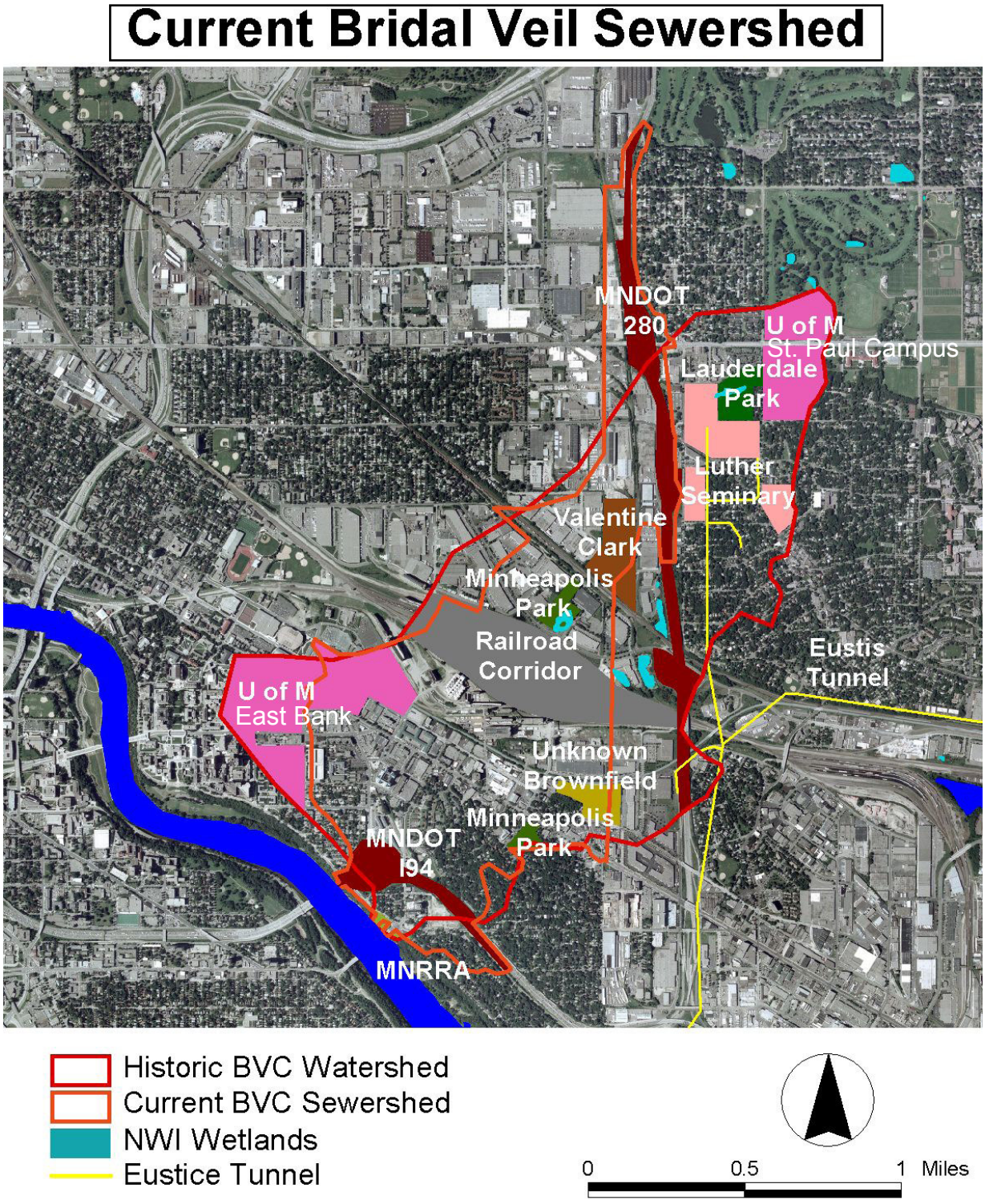
Wetlands and Ponds
The Bridal Veil Pond could eventually be restored to wetlands, as it was prior to pond excavation. (In 1971 the duck pond was dredged and the island created.) Before any restoration work can occur, contamination has to be cleaned up that was transported to the site from the Valentine-Clark Superfund site. Other wetlands include one of the few remnant natural wetlands in the watershed in the Lauderdale City Park just east of Eustis Avenue. This wetland would benefit from vegetation management to control exotics and improve native plant diversity. The other major wetland/shallow ponds are the Kasota ponds near Energy Park Drive and Hwy. 280. Restoration and management actions that could improve the ecological health of these ponds would most likely involve stormwater runoff treatment and vegetation management to improve diversity (Eckman and Magee-Hill, 2001). Examples of urban/suburban restoration of shallow ponds and wetlands include the McCarron Lake (Capitol Region Watershed District, 2003) and the Fish Lake Projects (Prior Lake-Spring Lake Watershed District, 2005). Concerns identified in the McCarron Lake project include water quality improvement, nuisance aquatic plant control, Eurasian watermilfoil, fisheries, recreational use, winterkill, wetland system operation and coordination among jurisdictions. In contrast the Kasota Ponds do not support recreational uses or fisheries so the primary issues are water quality and vegetation management.

Figure 41: Restoration and management planning: locations of historic wetlands.



Bridal Veil Creek

Figure 42: Restoration planning: current watershed setting with locations of some of the largest landowners.



Restoration & management planning

Figure 41 shows the extent of historic wetlands in the BVC watershed. It is clear from the large area of wetlands lost that restoration of surface waters features for stormwater management and/or ecological restoration should be a high priority. Many of the stormwater storage areas on the east side of Hwy. 280 were lost when the road was built. Therefore the Hwy. 280 valley, north of the railyards is the ideal location for stormwater pond construction and wetland restoration. Figure 42 shows the current configuration of the watershed with some of the larger landowners. Future managment of the watershed will require cooperation with these landowners as well as other key stakeholders, such as the cities of St. Paul, Minneapolis, Lauderdale and Falcon Heights. Detailed restoration and managment planning is beyond the scope of this study and will be the object of future work by the MWMO and SAPCC.

Bridal Veil Creek

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APPENDIX A

LOCAL HISTORY: INTERVIEWS OF LOCAL RESIDENTS AND EXPERTS

1. Scott Alexander, Geological Research Scientist, University of Minnesota
We discussed groundwater issues in the Bridal Veil Watershed and the University of Minnesota St. Paul Campus area. Stormwater flow in Bridal Veil Creek has been diverted from the outlet at Bridal Veil Falls and routed into large subsurface pipes near the Huron Boulevard overpass at Highway 280. As a result the Falls have almost no water flowing over them except at very high flows. The baseflow is near zero most of the year.

Another issue Scott identified was the springs near the bus Transitway by 29th Avenue that feed the creek. This issue is examined in more detail in the study, "Development Objectives for University Avenue SE and 29th Avenue." This area may be impacted by proposals to build a new football stadium for the University of Minnesota, though its location is not yet certain.

A third topic was research done by the hydrogeology classes at the University of Minnesota, led by Scott and the use of chemical signatures to determine sources of water, i.e. groundwater vs. surface. Often groundwater sources are higher in Calcium and Magnesium and therefore have higher conductivity than surface waters. Surface waters will often contain Fluoride, since drinking water is treated with fluoride and then flows into surface water bodies after human use. Water source studies could be useful in the Bridal Veil Pond and other waterbodies to determine sources of water: surface water runoff versus groundwater. For example, the ponds and wetland on the west side of St. Anthony Park and in Lauderdale could be investigated to determine flow paths, using the water chemistry approach, or using a series of wells and peizometers.

2. Rick Profaizer, Head of City of Minneapolis Sewer Department
We discussed the routing of stormwater flow in Bridal Veil watershed. The volume and routing of stormwater runoff changed significantly in the early 1990's with construction of the Dartmouth Interchange (Huron Avenue exits), the University bus transitway and associated parking areas. As the impervious area increased from the new construction, the peak runoff exceeded the capacity of the antiquated Bridal Veil Stormwater pipe. Therefore, about 90% of the flow was diverted into new pipes routed by Huron Avenue to the Mississippi River. About 10% of the flow was diverted into the old Bridal Veil pipes to maintain a baseflow over the Bridal Veil Falls. The diversion was accomplished using stoplogs placed in the pipe. Flow to the falls could be increased, simply by diverting more flow with the wood weir/stoplog.

Plans to remediate contamination at the Bridal Veil Pond site were also discussed. Apparently one of the remediation options considered has been filling in the pond and piping the surface flow around the site. This would conflict with native plant community restoration and management plans developed for the site by local community groups. Rick suggested that all the stakeholders

meet to discuss existing and future plans for the site. Rick mentioned that Bridal Veil Pond was not a designated stormwater pond maintained by the City of Minneapolis.

3. Greg Brick, Geology Professor, Normandale College
Brick did a report in 1997 for the Minnesota Ground Water Association entitled "Along the Great Wall: Mapping the Springs of the Twin Cities." Brick found that springs in the metro area followed predictable geological patterns, tending to occur where two distinct geological layers meet. In St. Paul they are often found at the border of the surficial glacial till layer with the Decorah Shale bedrock. One such spring in the BVC watershed is an unmapped spring located southwest of the University golf course, right on the Lauderdale city line (Figure 43).

The ravine here and downstream into the Lauderdale City Park historically flowed to the Bridal Veil Creek area, contributing to the baseflow of Bridal Veil Creek and the associated wetland complex. There were probably numerous other springs in the western St. Anthony Park hill area, sloping down to the historic Bridal Veil Creek area.

Brick had also mentioned that it is possible to walk through the current Bridal Veil Creek tunnel, which starts near Como Avenue and surfaces somewhere just north of the current Bridal Veil Pond. Brick observed minnows in the subsurface tunnels that were in a "stunned" condition, swimming around disoriented. This was attributed to toxic materials picked up by the stream flowing over contaminated soils, though the actual cause is unknown. In relation to the toxic materials, Greg said that this area used to be referred to as the "Valley of Drums" because of all the chemical barrels stored along the industrial sites. Many of the barrels stored "foots" a byproduct of the linseed oil production process that occurred at Arthur-Daniels Midland (ADM). The foots were not toxic in themselves but could dissolve toxins such as PCBs.

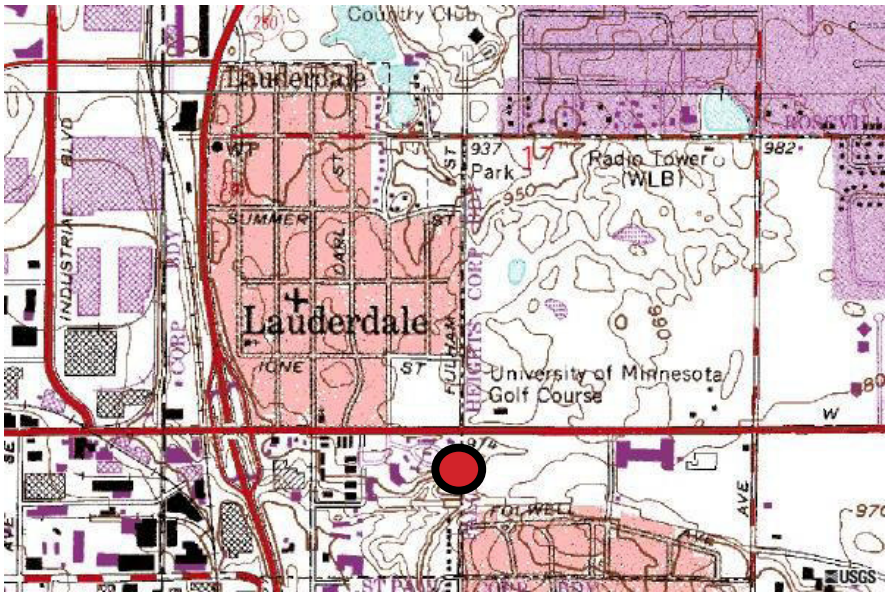

Figure 43: University Golf Course Springs

4. Mark Hove, Research Scientist, Macalester College and University of Minnesota
Aquatic biodiversity in the Kasota Ponds was discussed with Dr. Hove. Based on sampling described in the Eckman report, the diversity of fish, invertebrates and amphibians was found to be low in the Kasota Ponds area. Kasota Pond does support fathead minnows and brook stickleback, with some crayfish. The large un-named pond across the road contained an aquatic salamander with no fish, providing a predator-free environment to support the salamanders. Though diversity is low, the salamanders were somewhat of unique finding for a highly altered, urbanized environment. Bridal Veil Pond contained flathead minnows only.

Diversity in BVC itself is largely unknown. Historically Bridal Veil Creek likely supported a variety of stream fishes, mussels and aquatic insects. Research into the Bell Museum records did not reveal any additional species that existed in the area, as there was only one specimen recorded from BVC. While restoration options are currently limited due to the highly fragmented and altered environment, improvements to Bridal Veil Creek may eventually provide more suitable stream habitat for fish and invertebrates.

5. Barbara Hunn, Keys Restaurant Owner
Barbara did not have a lot of information concerning the watershed. She did not move to the area until 1960, which was when Highway 280 was constructed, altering the entire BVC valley. She did mention that there used to be large areas of open field in the area prior to highway construction. However, she could not recall any water in the area, creeks, ponds or wetlands. Probably the primary lesson learned from this interview was that the area changed dramatically in a period of about five-ten years, being converted from fields to large scale interstate highway.

6. Suzanne Maeder, Southeast Como Improvement Association, Garden Committee
A group called Citizens for a Better Environment did much of the early work on the Bridal Veil area, protesting the industrial waste products being disposed of and stored in the area. The large areas of industrial pollution and waste storage drove much of the original citizen activism in the area. Although not active in the area anymore, the group was a successful advocate for cleaning up the area.

Suzanne remembers the area in the late 1970s as she moved there in 1977. At that time there was more wetland areas by the railroad tracks along Raymond Avenue. Moving east along the tracks was a dump and wetlands at that time. The area was used as playground for kids up until the 1980s. This area was apparently graded and filled in during the 1980's or 1990s.

Suzanne also recalled the history of bird kills and fish kills that occurred in Bridal Veil Pond in the 1990's. The kills resulted from upstream dredging of the Valentine-Clark site that washed toxins downstream into the area. Although this occurred about ten years ago, it raises concerns for any future plans to grade in the area without further clean up.

Appendices

7. David Lanegran, Professor, MaCalester College
Professor Lanegran, a history Professor for MaCalester College, worked on a history report for St. Anthony Park's centennial in the 1980's. There is a great deal of historical information at the St. Anthony Park library from this report, including photos and oral histories collected for the project. Unfortunately most of the information was not relevant to this project.

Additionally, Lanegran provided information and potential contacts on Bridal Veil Creek history. The area around Highway 280 used to have several horse farms, with the wetland and grassland areas used as pasture, prior to the construction of Highway 280. David knew one person who's father owned and operated one of these horse farms. The Bridal Veil Valley (Highway 280 area) was also the center of a drainage tile industry prior to highway construction (pre 1960).

8. Diane Pederson
Diane Pederson grew up in the Southeast Como neighborhood in the 1940's. At this time the area was described as a kind of urban wilderness where children played in the Bridal Veil Pond and "hobo jungles" or homeless camps were set up. In the 1940's the pond was covered with cattails and was used widely for swimming. It was referred to by young kids as "BAB" (bare a__ beach), as kids would jump in and swim out to a raft in the pond. According to Diane, the girls did not participate in this activity. The area was very blue-collar, as many of the workers were rail yard workers loading grain onto train cars. Diane's grandfather worked with the CIO union organizing grain workers. The area was also characterized by the diversity of ethnic and economic diversity with homeless camps in the wilderness, blue-collar in the Bridal Veil/ SE Como area, with college professors and wealthier people in Prospect Park.

This area was one of the oldest industrial zones in the Twin Cities. The route that Highway 280 occupies dates back to the early days of Minneapolis as an entry road to the rail yards south of Bridal Veil Pond. Originally there was just a sandy road that went up to the edge of the pond. This was altered and replaced with the construction of Highway 280. Diane also mentioned that railroad lines commonly were built on old streambeds, since it was the lowest, flattest route. The streams were diverted and replaced with railroads sometimes right over the old streambed. This occurred at the 15th Avenue bridge where Tuttle Creek used to exist.

9. Bob Bacon
Mr. Bacon has lived in the same house, located in the BVC watershed, since the 1940's. He bought his house there when he was in his early 20's. Bob remembers walking his dog in the fields of the BVC valley and scaring up pheasants. He used to take a rope and drag it over the grass to flush out pheasants. Other wildlife in the area included foxes, according to Bob. He described a rolling landscape with tall grasses.

He also swam in the Bridal Veil Pond in the late 1940's and early 1950s, indicating that water quality was much better than today. He described the pond as a shallow, marshy pond that was not over his head when he was a kid (approximately <4 feet deep), though there was a deep spot

for diving into. The pond was ringed with cattails and contained some algae in the summer. A stream ran into the pond from the north end. He remembers the stream as a small channel that was easily crossed by children on foot. Finally, Bob also remembers that this open-field area was used by university researchers for animal science investigations, the exact nature of which he was uncertain.

Summary of Lessons Learned from Interviews

1. The complexity of water management in urban areas was made apparent in discussions with Greg Brick and Rick Profaizer, particularly when Superfund sites are involved. The large extent of contaminated soils just west of Highway 280 and north of the railyards make wetland and stream restoration planning very difficult. The Valentine-Clark Superfund site and subsequent contaminant transport downstream into the Bridal Veil Pond will make water and natural resources management more challenging in that area. The Elm St. ash dump, a large contaminated site also extends for hundreds of meters to the east and west of Bridal Veil pond. In addition, the complex history of drainage alteration and layout of the current stormwater systems of the two cities pose challenges to day-lighting or reestablishment of natural surface channels. One relatively simple "restoration" project is to restore flow over the Bridal Veil Falls. It would be relatively easy however to divert more flow over the falls at low flow levels.

2. There was rapid change from a semi-natural area used for recreation into an industrial corridor unsafe for recreation. Secondly, it is clear from the historical residents that the area changed radically over a period of just twenty years from the 1940's to the 1960's. The area had some relatively valuable environmental features as recently as the 1940s. It was used for swimming by children and people actually drank water from the springs bubbling up near the wetlands. Diane Pederson's characterization of this area as a playground for children, an "exciting wilderness for kids" is striking when you consider the nature of the Highway 280 corridor today: a highly contaminated industrial corridor with low aesthetic and recreational value.

Later residents, as recently as new settlers in the 1960's apparently have no memories of this urban wilderness. As time passes on, fewer and fewer people will have memories of the pre-Highway 280 Bridal Veil valley. It is important to maintain a sense of history in order to perpetuate memories of Bridal Veil valley as a valued place that is worth the time and money required for management and restoration.

3. A need exists to record local history and incorporate it into a community vision for the future. Without knowledge of the past, the significance of different parts of the watershed are lost on recent settlers to the area. The historical accounts and records of natural features provide direction for a "vision" of the future. Disconnection from the past can breed indifference for the future, particularly in an area as altered as the BVC valley. Therefore it is important to make people aware of the natural history of the area, the value of existing natural areas and the potential for improvement through restoration, natural landscaping and greenway development.

Appendices

APPENDIX B

Mississippi Watershed Management Organization Water Quality Sampling Parameters (collected at a stormwater outfall at watershed mouth near Bridal Veil Falls)

Sampling Parameters

Dissolved Oxygen
Temperature
Transparency
Water Stage
Conductivity

Base Flow and Storm Event Sampling (chemistry)

Inorganic (grab samples)
Total Chlorides
Oil and Grease
Total Chemical Oxygen Demand (COD)
Hardness

Total Metals:(Ag,Fe,Al,Hg,As,Mn,B,Ni,Be,Pb,Cd,Cr,Se,Sb,Cu,Tl,Zn)
Soluble Metals
Alkalinity
Total Sulfate

Organic (grab samples)
Fecal Coliform Bacteria
E. coli
Total Biological Oxygen Demand (BOD) 5-day
Carbonaceous Biological Oxygen Demand (CBOD) 5-day
Total Organic Carbon
pH
Total Phosphorus
Dissolved Phosphorus
Ortho-Phosphate as P
Total Suspended Solids
Volatile Suspended Solids
Total Dissolved Solids
Total Kjeldahl Nitrogen
Total Nitrate/Nitrite Nitrogen
Total Ammonia Nitrogen

APPENDIX C

Abstracts of Key Scientific, Management, Planning and Historical Documents

Author	Title	Year
Alexander, S., E.C. Alexander, Jr., and H. Pfannkuch	Hydrogeology of the St. Paul Campus	2005
Arey, Richard Fred	Waterfalls of the Mississippi: The Story of Eight Waterfalls Found in St. Paul and Minneapolis.	1998
Brick, Greg	Along the Great Wall: Mapping the Springs of the Twin Cities. MGWA Newsletter 16:1. March 1997.	1997
Burns, M., M. Gullickson, D. Schall	University of Minnesota- East Bank Campus Watershed Management Plan	2001
Cornejo Consulting, for Hennepin County	Daylighting Creeks in Hennepin County: Alternative Implementation Strategies for Daylighting Portions of Bassett Creek, Shingle Creek, and Bridal Veil Creek.	2005
Eckman, K. and H. Magee-Hill	What We Have Lost and What Remains: Options for Managing and Connecting Habitat in St. Anthony Park with Surrounding Communities	2001
Kestrel Design Group,	Bridal Veil Creek & Pond Site Analysis	2004
Kestrel Design Group	Bridal Veil Creek & Pond Vegetation Management and Restoration Plan	2005
Pardee, Walter Stone	Autobiography of W.S. Pardee	1922
Peer Environmental, Inc.	Southeast Minneapolis Industrial (SEMI)/Bridal Veil Area. Minneapolis/St. Paul, Minnesota Alternative Urban Areawide Review (AUAR)	2001
SEH, Inc. and Cornejo Consulting, for Hennepin County	University Avenue SE/29th Avenue SE Transit Corridor Development Objectives	2005
Steinhauser, Frederic	St. Anthony Park: History of a Small Town,	1970
URS Corporation and Minneapolis Office of the Major	Bridal Veil Falls Area Study: Feasibility Report	2004
Wirth, Theodore	Minneapolis Park System 1883-1944: Retrospective Glimpses into the History of the Board of Park Commissioners of Minneapolis, Minnesota and the City's Park, Parkway and Plaground System	1944

Appendices

Title: Hydrogeology of the St. Paul Campus

Author: Alexander, S., E.C. Alexander, Jr., and H. Pfannkuch
University of Minnesota, Twin Cities
Department of Geology and Geophysics
310 Pillsbury Drive SE
Minneapolis, MN 55455

Date: 2005

Key Areas of Relevance to BVC: groundwater flow patterns, infiltration in upland soils, location of boundary between Bridal Veil Creek (BVC) and Sarita watersheds

Summary and Significance for Bridal Veil Watershed:
Groundwater data has been collected in the General Hydrogeology class for 3 semesters (2002 to 2004), including water quality data, land cover data and determination of the magnitude and direction of groundwater flow. There are large areas of potential groundwater recharge on the campus golf course and agricultural research fields. These areas have large glacial deposits of sand and gravel with high infiltration rates, underlain by bedrock that serves as a barrier to downward groundwater movement. A tile system in the fields and the storm sewer system in impervious areas insures that most rainfall is carried off as runoff or interflow, rather than infiltration. Some recharge occurs on the golf course, however.

Generally the flow of groundwater on campus is to the south, towards the Sarita wetland, which serves as a collection point for surface runoff and shallow groundwater flow. The vast majority of the campus area does not affect the hydrology of the Bridal Veil watershed. Topographically, the Bridal Veil watershed is separated from the Sarita watershed by the St. Anthony Park hill near Cleveland Avenue. However, the current "sewershed" places the boundary just east of Highway 280 with all pipe flow east of Highway 280 carried away from the Bridal Veil watershed. The far western portion of the University golf course appears to be part of the BVC watershed, with surface water flow towards the southwest.

Title: Waterfalls of the Mississippi: The Story of Eight Waterfalls Found in St. Paul and Minneapolis,

Author: Arey, Richard Fred

Date: 1998

Key Areas of Relevance to BVC: movement to save BV Falls

Bridal Veil Creek

Summary and Significance for Bridal Veil Watershed:
On pages 17-23, Arey describes the present falls, and provides an extended quote by Otto Schussler from Riverside Reveries describing the historical disappearance of the falls due to storm sewer rerouting. Arey indicates that the Falls were saved by citizen appeals to MNDOT during the construction of Interstate 94, though the top of the falls were lowered slightly.

Title: Along the Great Wall: Mapping the Springs of the Twin Cities. MGWA Newsletter 16:1. March 1997.

Author: Brick, Greg

Date: March 1997

Key Areas of Relevance to BVC: groundwater discharge (springs) locations and spatial patterns of occurrence

Summary and Significance for Bridal Veil Watershed:
Greg Brick, a hydrogeologist working for a consulting company at the time, mapped the occurrence of known springs in the Twin Cities metro region. Generally the springs occur at the interface of two bedrock layers, such as the Galena Limestone-Decorah Shale line. The two major spring ”lines” in the Twin Cities occur along the wall of the Mississippi River gorge and just north of the river in St. Paul along the “diamond necklace.” Although Bridal Veil watershed does not fall within either “spring line,” the report is helpful in identifying characteristics of places where springs may occur: at the interface of geologic boundaries, and at the bottom of steep slopes. Brick also points out that many historic springs have been lost to development or hydrologic alteration, which is certainly the case in the Bridal Veil Watershed.

Title: University of Minnesota- East Bank Campus Watershed Management Plan

Author: Burns, M., M. Gullickson, D. Schall

Date: December 10, 2001

Key Areas of Relevance to BVC: watershed management, land-use history, stormwater management, BMPs

Summary and Significance for Bridal Veil Watershed:
A history of the campus area and hydrologic alteration as well as stormwater management options are presented by three U of M graduate students. Land-use in the watershed is discussed and its impact on the hydrologic cycle. Impacts on biological communities and water quality are

also assessed. Current management activities are assessed and management recommendations are made. Four major recommendations evolved from the report: 1) complete a comprehensive survey and analysis of the storm and sanitary sewer system, 2) complete an analysis of groundwater hydrology in the watershed, 3) identify locations in watershed for stormwater BMPs to decrease runoff volume, 4) develop a watershed management pan with input of the community to maintain or reduce nutrient loads from 0 - 25%.

Title: Daylighting Creeks in Hennepin County: Alternative Implementation Strategies for Daylighting Portions of Bassett Creek, Shingle Creek, and Bridal Veil Creek.

Author: Cornejo, D. (Cornejo Consulting, for Hennepin County Department of Housing, Community Works and Transit.)

Date: 4/15/05

Key Areas of Relevance to BVC: restoration options for Bridal Veil Creek, watershd-scale planning

Summary and Significance for Bridal Veil Watershed:
The Hennepin County Board allocated $300,000 to investigate opportunities for restoring urban streams that are currently in pipes, hidden by development and/or otherwise degraded. Dan Cornejo conducted the planning study with 5 major aspects: 1) inventory existing conditions, plans, and reports, 2) describe jurisdictional and governance arrangements, 3) identify benefits and challenges to daylighting creeks, 4) provide information on the range of daylighting projects undertaken elsewhere, illustrating best practices and lessons learned, and 5) identify alternative implementation strategies for daylighting portions of Bassett Creek, Shingle Creek and Bridal Veil Creek.

Throughout Minneapolis and urban areas nation-wide, streams have been lost to urbanization and routing of water into stormsewer pipes. In addition to restoration of natural features, daylighted channels can provide functions such as flood storage and water treatment in addition to aesthetic and recreational benefits that support community development. Unfortunately, it is often difficult to locate suitable locations for daylighting, due to flood elevations, lack of open space, depth below ground and other issues. Within Bridal Veil Creek, the 27th Avenue corridor was identified as the most feasible spot to attempt daylighting. If it is not possible to restore a flowing-surface channel, an alternative linear greenway providing infiltration and stormwater runoff storage was proposed. This greenway/waterway would recreate some functions and aesthetic benefits of the original stream, but would not function as a stream hydrologically or ecologically.

Bridal Veil Creek

Title: What We Have Lost and What Remains: Options for Managing and Connecting Habitat in St. Anthony Park with Surrounding Communities: Final Report of the SAPCC Natural Resources Inventory and Planning Initiative, 2000 DNR Metro Greenways Planning Grant

Author: Eckman, K. and H. Magee-Hill, editors.

Date: 2001

Key Areas of Relevance to BVC: biological communities of St. Anthony Park, natural history of the area, water quality

Summary and Significance for Bridal Veil Watershed:
With funding from a MN DNR Metro Greenways Grant, nearly 40 citizen volunteers collected data on insects, fisheries, amphibians, mammals, birds, and aquatic plants. A tree inventory of local parks was conducted. Water quality, hydrology and soil information was also collected. The Kasota Ponds wetland complex supports a diversity of bird species, with 118 recorded over ten years. Water quality, though not ideal, was found to be sufficient to support a wide range of aquatic organisms. Hydrologically, much of the water supply is from surface runoff routed from the Highway 280 vicinity. However, groundwater discharge occurs in the area as well, with Skonard Spring discharging into one of the Kasota ponds. One of the major management problems for these natural areas is fragmentation. Future studies will target strategies for improving connectivity of wetland and upland habitats in the watershed.

Title: Bridal Veil Creek & Pond Site Analysis

Author: Kestrel Design Group, Inc.

Date: 2004

Key areas of relevance to BVC: native plant communities, Bridal Veil Creek geomorphology, landscape-scale land cover

Summary and Significance for Bridal Veil Watershed:
An inventory of the plant communities surrounding Bridal Veil Creek and Pond were completed as well as stream classification work and a land cover inventory of the area using the Minnesota Land Cover Classification System (MLCCS). The Bridal Veil Pond forest consisted of a canopy of aspen, cottonwood, and boxelder with buckthorn and boxelder abundant in the mid-story. The understory was low in species diversity. Bridal Veil Creek was found to be a storm-water dominated system, though some baseflow exists because of local groundwater discharge. Recommendations were made for forest and stream restoration. Landscape-scale connectivity of natural areas was examined and recommendations made for establishing greenways and wildlife corridors.

Appendices

Title: Bridal Veil Creek & Pond Vegetation Management and Restoration Plan

Author: Kestrel Design Group, Inc.
(prepared for Southeast Como Improvement Association)

Date: 2005

Key Areas of Relevance to BVC: ecological restoration, native plant communities, Bridal Veil Creek ecology and geomorphology

Summary and Significance for Bridal Veil Watershed:
A detailed plan for ecological restoration of the upland forest and oak savanna plant communities surrounding Bridal Veil Creek and Pond is presented. A conceptual stream restoration plan is also presented until such time that water contamination issues are straightened out by the Minnesota Pollution Control Agency. The plan proposes elimination of exotic species (primarily buckthorn) in the forested areas, with subsequent planting of lowland to mesic forest tree seedlings to enhance diversity. Herbaceous understory plants (spring ephemerals and others) will be planted as a final step. The lawn area will be "restored" to an oak savanna by killing off the grass and placing a 2" layer of compost overtop. Prairie plants will be seeded in the fall of 2005 with oak seedlings planted afterwards.

Title: Bridal Veil Falls Area Study: Feasibility Report

Author: URS Corporation
(prepared for the Minneapolis Office of the Mayor and Dept. of Public Works)

Date: October, 2004

Key Areas of Relevance to BVC: historic appearance and flow patterns of Bridal Veil Falls, baseflow of Bridal Veil Creek, hydrologic alteration of watershed, restoration of BVC baseflow and aesthetic benefits

Summary and Significance for Bridal Veil Watershed:
The report includes an examination of neighborhood history, the establishment of Guiding Principles for improvements to the Bridal Veil Falls area and options for restoring the baseflow and views of the fall. Historically, Bridal Veil Falls was an attractive falls with constant baseflow, so that it appeared as a falls year-round. The area drew considerable interest from tourists and sight-seers. Construction of a bridge in 1940 covered up the remaining falls. In the meantime, paving of the watershed reduced baseflow to the creek and routing of stormwater into sewer pipes reduced flow over the falls. While restoring views of the falls would involve rerouting of traffic along East River Parkway, there would be considerable benefits, including enhanced soundness of bridge structure, better trail linkages and reduced pedestrian/vehicle conflict.

Bridal Veil Creek

Title: Southeast Minneapolis Industrial (SEMI)/Bridal Veil Area. Minneapolis/St. Paul, Minnesota Alternative Urban Areawide Review (AUAR)

Author: Peer Environmental, Inc. for the City of Minneapolis, Minneapolis Community Development Agency (MCDA), and Southeast Economic Development (SEED) Committee.

Date: May 2001

Key Areas of Relevance to BVC: industrial pollution, watershed-level planning

Summary and Significance for Bridal Veil Watershed:
An AUAR was conducted by PEER Environmental, Inc for the City of Minneapolis and other stakeholders in order to assess land management and development issues in this area that has suffered from industrial pollution and urban blight. Redevelopment of abandoned urban areas is a high priority for the Southeast Economic Development (SEED) Committee. This AUAR was initiated to develop an updated master plan for the Southeast Minneapolis Industrial area (SEMI) - Bridal Veil area. The report consists of four major components:

1) Refined master plan
2) Stormwater hydrology summary and mitigation plan
3) Traffic/transportation analysis and mitigation plan
4) Contaminated sites and mitigation plan.

The report developed some interesting management options, such as the Greenway/corridor along Kasota Parkway with raingardens and vegetated swales. However, the document does not present a coherent vision for managing the SEMI-Bridal Veil area.

Title: University Avenue SE/29th Avenue SE Transit Corridor Development Objectives

Author: SEH, Inc. and Cornejo Consulting, for the Hennepin County Department of Housing, Community Works and Transit.

Date: 2005

Key Areas of Relevance to BVC: development plans in watershed, streams and natural areas as amenities.

Summary and Significance for Bridal Veil Watershed:
The report contains an inventory and analysis of existing land-uses and the need for enhanced public transit. A shared vision and principles of transit-supportive development were articulated in the report. Development objectives are laid out along with urban design and transportation goals. While this report revolves around development planning, environmental issues are briefly addressed. One of the stated development principles is to “Respect the natural environment;

protect, enhance and connect to the natural ecosystem; create new green spaces and vegetation to attract and connect residents, workers and visitors, and complement and soften the built environment."

Therefore restoration efforts along Bridal Veil Creek fit in with proposed development plans. However, increased development could increase runoff causing further degradation of the stream and the Mississippi River.

Historic Notes and Photographs Relating to Bridal Veil Watershed
Beyond the historic record provided in maps and reports, our document search turned up a few, non-scientific sources of information on pre-settlement and early settlement history of the Bridal Veil Watershed. A limitation of the historic research into urban watershed history is the limited availability of anecdotal and scientific data regarding a highly altered landscape where industry and development preceded rigorous scientific study of the area. The most valuable historic documents found during the course of this study are summarized below.

Title: Historic Photograph Record of St. Anthony Park, Southeast Como, Prospect Park and the Minnesota Historical Society

Author: various

Date: late 1800's to early 1900's

Key Areas of Relevance to BVC: early landscape characteristics, hydrologic connection of eastern watershed to Bridal Veil Creek

Summary and Significance for Bridal Veil Watershed:

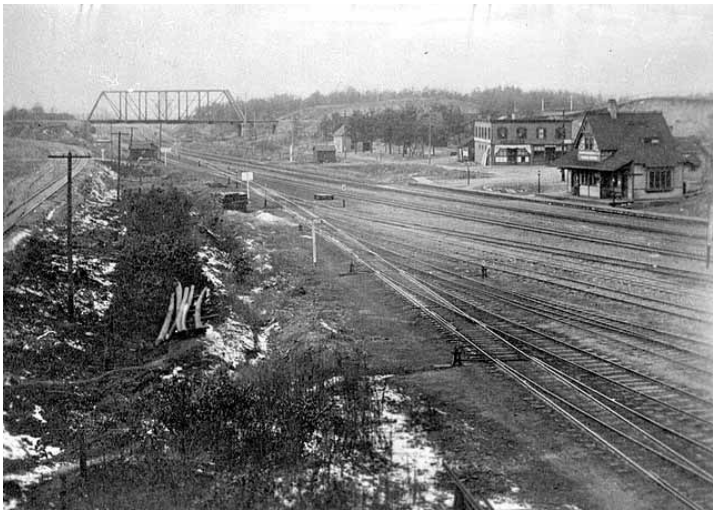

Figure 44: 1896 View from the Raymond Avenue Bridge looking to the west, through the Hghway 280 divide showing linkage of eastern watershed to Bridal Veil Creek (St. Paul Sewer Department)

Bridal Veil Creek

Historic Photo Record – The photographic record of St. Anthony Park, southeast Como and Prospect parks is extensive. The Minnesota Historical Society as well as Ramsey County and Hennepin County Historical Societies photographic records were searched for images that provided clues into the history of the watershed. While photographs depicting the cultural history, railroad and industrial development are common, few of the photographs located for this study provided definitive evidence for wetland delineation or for a new understanding of watershed history. Figure 44 offers a prime example of the challenges of using the photographic record as a tool. This view, looking west from the Raymond Avenue Bridge appears to show downward sloping rail lines. However, it is also appears from this image that steeply sloping banks of the hillsides to both the north and south of the rail corridor have been cleared of trees, and most cases are bare soil. It is likely that much of the lower portions of the land in this photograph is comprised of fill material from the upper slopes, and the ditch located on the left side of this photograph may have been placed after the installation of the first railroads in the 1860s.

The photographic record for the Bridal Veil Watershed found in the historic society records and St. Paul Public Works includes numerous images of the picturesque Bridal Veil Falls and the various waterbodies within St. Anthony Park, but none were found of the railyards prior to full build out.

Title: Autobiography of W.S. Pardee

Author: Pardee, Walter Stone

Date: 1922

Key Areas of Relevance to BVC:

Summary and Significance for Bridal Veil Watershed:
Walter Stone Pardee, a long time resident of Minneapolis and St. Paul's Midway areas provided a type-written autobiography to the Hennepin County Historical Society, dated 1922. Significant portions of the autobiography that relate to the Bridal Veil Watershed follow:

"Bridal Veil the beautiful, came from a small part of the big swamp east of town: and this swamp soon was drained to the destruction of the brook and Fall (pg. 85)." Further: "I had no interest in the brooks themselves, for they wound thru the mud of swamps, and across sandy streches to the Gorge. No rocks enlivened their currents and not a tree nor a bush stood on their banks, except that "little part of the Bridal Veil ravine near University Avenue was tree grown.; but the falls were interesting (pg. 85)." "Bridal Veil was no more than a thin veil of water, gently dropping and was not high (pg. 85)."

He continues on page 165: "Up to this time, St. Anthony had been a little hindered in growth southeasterly, by a ravine that carried Bridal Veil Brook (near the falls)." This was about 9th Avenue S.E. Main Street (University Avenue) as passable there for the ravine did not come so far: and 5th Street, between 7th and 8th Avenue, and (a) slight and low bridge would do and was built. But at 4th Street and 3rd Streets S.E., especially at 3rd Street, the ravine was impassable without a considerable bridge. 4th Street was left unbridged."

Pardee is describing the combination of University Crossings at Tuttle's Brook and Bridal Veil Creek. It would appear as though the route taken for University Avenue was in part dictated by ability to cross the narrowest portion of Bridal Veil Creek. Pardee describes the way along Territorial Road built by the "Government" in 1873: "Now the Territorial Road (University Avenue) took generally a straight way to St. Paul Center: for the first few blocks thru fine deep sand-likely par of the big deposit of sand that seems to cover the ledge in St. Anthony, and that is said to have been blown in when winds were strong. The sand in these few blocks was too high to be covered with marsh, but a bit further on the way was all marsh, and a corduroy road was built across it, to a similar sand bank on the further side. This was covered with scrub oaks." Thus University Avenue route seems to be chosen as a connection to elevated sand islands in a sea of marsh.

Title: Theodore Wirth Minneapolis Park System 1883-1944: Retrospective Glimpses:

Author: Minneapolis Parks

Date: 1941

Key Areas of Relevance to BVC: alteration of Bridal Veil Falls in 1930's – 1940's

Summary and Significance for Bridal Veil Watershed:
This book is a compendium of writings and recordings of the Minneapolis Park System by it's Park Commissioner and Board. On pages 157-159, River Road East plans are described as they relate to the Park System and Bridal Veil Falls. Old Bridal Veil Falls Bridge (installed in 1894) was replaced as a part of the Work Projects Administration in 1940-1941. This document describes Bridal Veil Falls as the drainage of "the section of our city in the vicinity of Como Avenue (that) was at one time largely swampland which drained into a small creek. As the area was gradually filled in and converted to city lots, the source of water supply for the falls was gradually eliminated and the waterfall became almost extinct." Stormwater drains were installed post-development into the alignment which, following precipitation, provides "an attractive cataract with an abundance of water." In 1938, the Rapinwax Paper Company was granted permission to divert clean water from their cooling system into the stormwater drainage system to create the "present Bridal Veil Falls."

Bridal Veil Creek

Title: St. Anthony Park: History of a Small Town,

Author: Frederic Steinhauser

Date: 1970

Key Areas of Relevance to BVC: early characteristics of wetlands

Summary and Significance for Bridal Veil Watershed:
Frederic Steinhauser provided a general history of St. Anthony Park with a focus on small town community character. Relevant hydrological information is described in terms of waterbodies, wetlands and springs. Pg 7: "Langford Park was once a small lake called 'Rocky Lake'…. A slough-peat bog existed on the east side of Cleveland Avenue, near where Como and Raymond join... Well into this century the area in the vicinity of Eustis, Commonwealth, Hillside and Gordon provided a hunting ground for men and boys, as ducks and blackbirds were available there. A beautiful spring existed near the corner of Commonwealth and Keston which provided refreshment and relief from a not-too-trustworthy water supply." The final portion of this brief history provides a geological summary of the formation of St. Anthony Park.

Appendices

Appendix D: List of known and potential sources of groundwater contamination (inventory by the MPCA)

Known and Potential Sources of Soil and Groundwater Pollution: Minnesota Pollution Control Agency

Map ID	SITE_NAME	Map ID	SITE_NAME
1	Up - Oak Street	49	Northern Star ADM
2	Lorrain Larson Property	50	Lewis Bolt and Nut
3	Gopher Oil Company Delaware (Housing)	51	Metal Coating Co.
4	Longyear	52	CSN
5	Twin City Tile and Marble	53	Westgate
6	Motley Bypass Site	54	ADM Linseeds, Epoxides Spill
7	University Health Care	55	HB Fuller (St. Paul)
8	Gopher Oil - Thornton Street Site	56	Carpenter's School
9	Malcolm Avenue Transfer and Recycling St	57	Valentine Clark Corp.
10	Gopher Oil Company Delaware	58	Industrial Air Systems
11	American Can	59	Minikahda Mini Storage
12	University Professional Center	60	Goodwill Industries
13	Diagnostics Inc.	61	Aspen Waste System
14	University Proposed Steam Plant	62	Portec-Pioneer
15	Kempf Paper Building	63	Veit Container and Recycling System
16	U OF M - IWMF	64	Greater Huron Development Corp.
17	Indoor Women's Hockey Arena	65	Midwest Book
18	Translational Lab Site	66	American Excelsior Company
19	McLaughlin Cormely King (MGK)	67	Impulse Group
20	Midwest Warehouse Building	68	Warren Shade
21	SOO Line Century Mill	69	Northwestern Warehouse
22	Center for Magnetic Resonance Research	70	Lightning and Transients Research
23	REPUBLIC CREOSOTING CO	71	Historic Stone
24	SEMI STORMWATER POND	72	Paper Calmenson and Company
25	REICHOLD INC.	73	Highcrest Park
26	Group Health University	74	Wintz Companies
27	Boesser, Inc.	75	Multilayer Technology, Inc.
28	Minnesota Medical Foundation	76	UNISYS, Inc.
29	ADM Grain Storage Facility	77	Space Center
30	Abrams Metals	78	US Filter Recovery Services
31	CNW East Minneapolis Yard	79	Minnesota Solvents
32	Northstar Specialties	80	Williams Pipieline Surface Imp and Spills / 1
33	Mueller Family Limited Partnership Apts.	81	MEAM Properties
34	Burlington Northern South Right of Way	82	Williams Pipiline Sruface Imp and Spills / 3
35	Hennepin County 37	83	Williams Pipeline Surface Impound and Spills/2
36	Globe Tool	84	Ryan Twin Lakes III
37	Pella Investments	85	Track-A-Twin Lakes
38	Vogel Manufacturing	86	Cummins Diesel
39	Elm Street Ash Dump	87	Midwest Motor
40	Unisource Building	88	Twin Lakes Parkway Corridor
41	La Canasta Addition	89	Great Dane
42	Elm Properties	90	Steel Siding Supply
43	Delmar Elevators	91	Ideal Security Hardware
44	ARCHER DANIELS MIDLAND PROPERTY	92	Pacific Mutual Door
45	Mel's Metal Deburring	93	Arthur Street ROW
46	Malcolm and Fifth Street SE	94	Abandoned House in Roseville
47	H. B. FULLER	95	Healy Ruff
48	Northern Star Westgate	96	Gortner Parking Ramp, U of M

Bridal Veil Creek

Known and Potential Sources of Soil and Groundwater Pollution: Minnesota Pollution Control Agency

Map ID	SITE_NAME
97	St. Paul Chiller Plant
98	Como Avenue and Packard Street Dump
99	General Foam
100	Minnesota Wire and Cable
101	Energy Park West Site
102	State Fair Demolition
103	Shafer Construction Demo
104	Great Northern Railway Site
105	Cemstone Products
106	Brissman-Kennedy
107	Worum Chemical Company
108	Quality Tool
109	Fisher Nut Facility
110	Univar Corp Van Waters and Rogers Divisi
111	National Mower Company
112	Wycliff Street
113	Hampden BLDG.
114	Vacant Building - 1
115	Standard Storage Battery Company
116	Flexopack Facility (Former)
117	SAFT American, Inc.
118	Mel's Direct Service Truck Stop
119	Welsh/Office Warehouse
120	University Crossing
121	Specialty Manufacturing
122	Midway Substation
123	McKay Manufacturing Anderson Estate BL
124	Zane May
125	Bonded Transmission
126	MBM Property
127	Griggs Midway Building
128	Griggs-Midway
129	Harcos Chemicals, Inc.
130	Concordia Avenue Property
131	Co-Operative Plating
132	Metro Transit Snelling Garage
133	Dakota Bank
134	Spruce Tree Center
135	Hamline Cleaners
136	Energy Technology Center
137	Energy Park Plaza
138	Veit Disposal Systems-Recycling and Transfer
139	Raymond Auto Body
140	Burlington Apartments
141	1125 Energy Park Drive Site
142	Atrium Office BLDG. and No. 7W Ramps
143	Children's Museum
144	North Parking Ramp-Bandana Square
145	Bandana Parking
146	Chemtron Corporation Lime Sludge Storage
147	Aries Precision Sheet Metal
148	Kippers Coke-US Bank
149	US Bank Stormwater Pond
150	Litho Specialties
151	Energy Park Parking Lot
152	Energy Park Place
153	Energy Park Parcels A-C
154	Koppers-Coke Hamline
155	Energy Park Vacant Lot
156	Remmele Engineering
157	Former Super America
158	Larpenter Avenue and Fernwood Street Dump
159	Larpenter Estates Apartments
160	Grand Cleaners
161	Chicago Northwestern
162	TI-Kromatic Paints, Inc.
163	Lapham Hickey Steel Site
164	Quality Metals, Inc.
165	Flint, Inc.
166	Conwed Plastics
167	U of M Como Transfer Station
168	Como Transfer, U of M EXTSD
169	Children's Home Society
170	Koch Trucking, Inc.
171	1919 University Avenue
172	McGill/Jensen
173	UNISYS Midway
174	Midway Transfer Station
175	GNB
176	Carpenter Technology Corporation
177	Anne Gendein Trust Property
178	Bureau of Engraving - Broadway
179	Roseville Gateway
180	Williams Pipi Line Co. / 1
181	Roselawn Village