Feasibility Report on

Mailand-McKnight Road Gully Erosion Cities of Maplewood and St. Paul, Ramsey County

Prepared for
Ramsey-Washington Metro Watershed District

February 2005

BARR

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1.0 Introduction

The Ramsey Washington Metro Watershed District (District) became involved in an intercommunity stormwater issue at Mailand and McKnight Roads at the request of Terry Noonan of Ramsey County Public Works. Prior to this contact, the Ramsey Soil and Water Conservation District manager, Tom Petersen, had been approached by landowners in the area seeking help with gully erosion and sediment deposition on their properties. Although all the properties lie west of McKnight Road, in St. Paul, the majority of the drainage area is in Maplewood. (Figures 1 and 2.)

This report summarizes the issue, discusses potential solutions and makes recommendations for repair and flow mitigation.

2.0 Background and Drainage Patterns

Historic airphotos show that the land in the study area was partly agricultural and sparsely populated in 1953. In 1974, it was undergoing development, with earth being moved and road networks developing north of Mailand and east of McKnight. By 1985, the lots contiguous to McKnight Road appear much as they do today and, by 2002, areas further east, including Dorland Road, were also fully developed.

According to landowner Patty McDonald, her father-in-law, Ted Anderson, noticed drainage changes in the area in 1977, and the beginning of what will henceforth be referred to as the Mailand gully or “the channel.” (Anderson purchased 2191 Mailand Road in the late-1950s.)

Three drainage areas drain into Mailand gully, as shown in Figure 2. Water enters the channel in two ways: (1) overland (from adjacent land and from McKnight Road overflows that proceed down a driveway at 461 McKnight); and (2) from a pipe that collects runoff from the upstream drainage areas and outlets in the side/back yard of 451 McKnight. (Figure 3.)

The pipe outlet dates from 1965, when Ramsey County installed a 24-inch corrugated metal pipe to convey street drainage entering catch basins along McKnight Road as well as drainage from the wooded wetland northeast of McKnight and Mailand. (NOTE: Catch basins are the boxlike below-grade structures that collect stormwater runoff entering through grates or other openings along street curbs.)

In subsequent years, the City of Maplewood constructed storm sewer pipes eastward along Mailand Road and throughout the residential area immediately east of the wetland. Both these pipe systems contribute flow to the channel. The Mailand Road storm sewer was approved for connection to the county pipe below McKnight Road in 1977.

Approximately 8.3 acres drain to the wooded wetland northeast of the McKnight and Mailand intersection. (Figure 2). The wetland, drained by a 12-inch corrugated metal pipe that connects to the McKnight Road storm sewer system, has the capacity to store 0.5 acre-feet of water without overtopping onto McKnight. A 1974 study for the City of Maplewood by Barr Engineering Company estimated that approximately 12 acres of land would drain to the wetland and recommended that the wetland be designed to accommodate 2 acre-feet of flood storage. Although less land than planned drains to the wetland, the available storage and/or discharge capacity is still inadequate to prevent the wetland from overtopping, even during relatively small rainfalls. All water that overtops the wetland basin flows over McKnight Road, down the driveway at 461 McKnight Road and into the channel.

Water draining out of the wetland combines with drainage from the 14.1-acre watershed to the south. The southern watershed is predominantly low density residential land use that slopes north to Mailand Road. A storm sewer pipe in Mailand Road drains to the west and connects with the storm drain in McKnight Road before discharging into the gully.

The 10.1-acre area that contributes overland flow to the channel is evenly split between mown residential lawns with canopy trees and undeveloped natural areas. McKnight Road residential lots slope steeply to the west, to a lower area dominated by old field (former farmland, now open herbaceous land dominated by non-native plants) and ecologically degraded woods. All runoff from this area drains to the channel.

3.0 Existing Channel Conditions

The drainage channel extends from the pipe outlet located at Station 1 (Figure 3.) and runs approximately 850 feet in a generally west-northwest direction before emptying into a reed canary grass wetland. While some areas of the channel are nearly flat, with no sign of erosion, other segments are severely eroded, with active downcutting occurring as recently as summer 2004, according to McDonald.

Erosion is immediately apparent at the pipe outlet, where the homeowner recently placed concrete blocks in an attempt to armor the sandy soil (Photo 1). Beginning approximately 100 feet down-channel, in a segment that veers north across the backyards of 451 and 443 McKnight, the channel cuts down to a depth of 2.5 to 4 feet near Station 2 (Figure 3). As water heads northwest, it moves through a small grassed swale running alongside a "mini-berm" that was constructed in the backyard of 2221 Mailand Road to control the flow of water across their property.

Photo 1. *Outlet on 451 McKnight Road property*

At Station 6, north of 2191 Mailand, the deepest gully erosion occurs (Photo 2). Following a sharply curved area, the water has cut 5 feet into the sandy soils. While some weedy herbaceous vegetation is growing in portions of the eroded area, the channel is largely characterized by bare soil, open to further erosion. The surrounding area is dominated by aggressive vegetation, including non-native reed canary grass and smooth brome and native Canada goldenrod.

Photo 2. *The deepest gully erosion (Station 6)*

At Station 8, near the channel terminus, a roughly circular, depressed sandy area appears to have both eroded and served as a deposition area for sediment from upstream. The rim of this area, which Patty McDonald describes as a former fire pit, is punctuated by old tires and partially buried construction debris.

At the terminus of the channel, northeast of Station 8 (see Figure 3), the topography is very flat, allowing the water to spread out and infiltrate in a reed canary grass-dominated wetland southeast of the Highwood Hills Elementary School ball fields. No outlet is apparent in this wetland.

Infiltration, which occurs not only in the wetland, but to some degree throughout the undeveloped land in the neighborhood, is one of the most cost-effective and ecologically sound ways of managing stormwater. Naturally vegetated areas with relatively sandy soils, like the Mailand Road properties, are ideally suited for infiltration, which helps dispose of excess stormwater, sustain plants and recharge groundwater. When runoff flows rapidly over the ground and through pipes, it is less likely to infiltrate, or percolate into the soil. When this happens, the excess water can create flooding problems downstream.

3.1 Keys Factors for Erosion

Erosion occurs when the force of water flowing over soil is greater than the soil's ability to resist that force. The susceptibility of a certain area to erosion is dependent on three key factors:

1. The velocity of water: The faster water moves, the more energy (and erosive force) it has. The slope of the channel usually dictates the velocity of water. Steeper slopes result in higher velocities.
2. Vegetative cover: A vegetated surface generally resists erosion better than bare soil. Plant leaves and stems slow runoff and provide a protective buffer between flowing water and soil; roots help hold the soil in place and encourage infiltration instead of runoff.
3. Soil type: Certain types of soil resist erosion better than others. In general, silts and clays are more cohesive (and resistant to erosion) than sandy soils.

3.2 Runoff Rates and Soils Information

Soil samples were collected and characterized at eight points along the channel. Figure 3 shows soil sample locations and Table 1 summarizes the findings. The data indicates that the soils are widely varied, ranging from coarse and sandy to fine and silty. As mentioned above, sandy soils are generally less cohesive and are therefore more erodible than silts or clays. At the most severe erosion locations, the soils are a mix of sandy and silty soils.

In general, the velocity of water flowing over exposed sandy soil should be less than 3 feet per second to prevent erosion. Higher velocities are permissible if the soil is armored in some manner, either with vegetation, boulders, concrete or soil stabilization fabric.

Hydrologic modeling shows that peak flow rates occur through the pipe and channel during short-duration, high-intensity rainfall events, i.e. "gully washers." The model predicts that 20 cubic feet per second (cfs) would discharge from the outlet pipe (Station 1) during a 10-year design storm (2.1 inches of rainfall in 1 hour). The resulting velocity would be approximately 4 feet per second between Stations 1 and 2. Further down the channel at Station 6, the flow rate would increase to approximately 30 cfs as contributions from the surrounding watershed boost the flows. At a flow rate of 30 cfs, the velocity of the water through the channel at Station 6 is approximately 6 feet per second.

4.0 Assessment of Problem

The progressively worsening erosion on the Mailand-McKnight properties is most likely due to a combination of factors, including runoff changes following development, area soil characteristics and inadequate storage in the wooded wetland. As the watershed surrounding the channel became more impervious (characterized by more roads, rooftops and other hard surfaces), stormwater flow rates and velocities increased. Water overtopping the wooded wetland contributes to this increased flow.

At one time, cohesive topsoil, stabilized by plant roots, likely covered the area. Over time, flowing water broke through a disturbance in the vegetative cover (such as a tire rut) and exposed the sandy, erosive subsoils. Since these soils were not cohesive enough to resist the erosive force of the water, the channel continued (and continues) to erode with each runoff event.

4.1 General Remediation Options

In order to remedy the situation, the key erosion factors need to be addressed. Since it would not be feasible to change the soil, the repair options focus on reducing flow velocities and improving vegetative cover. The following summarizes the general approaches considered.

1. Re-route Maplewood sewers in order to reduce runoff entering the gully. The most expensive and disruptive option, this would also be the least feasible. Additional work would be required to repair existing damage to the properties in St. Paul.
2. Pipe the water through the gully area, eliminating the channel altogether. While this would accommodate runoff and solve surface erosion, it would decrease infiltration and potentially lead to other problems downstream, in the wetland area near the school. It would also be expensive and disruptive.
3. Construct a defined channel for the entire length and armor the channel with soil stabilization material. Also an expensive option, this would entail major land reshaping and many tree removals. Tree removal is an issue from both an aesthetic and soil stability standpoint, due to lost root structure.
4. Increase the storage capacity of the basin northeast of the McKnight & Mailand intersection to prevent overflows onto McKnight Road and down the driveway of 461 McKnight Road. This would entail tree removal, grading and revegetation. At present, this option is not possible because the District's classification of this wetland does not allow it to be excavated to accommodate additional stormwater. However, the wetland is scheduled for reevaluation in the spring of 2005. If a downward change in quality classification occurs, we strongly recommend incorporating this remediation option.

5. Install energy (velocity) dissipation measures and repair only the deepest gullies. This option would retain the natural appearance of the area and pose the least disturbance to soil and vegetation. It would both repair the worst erosion and help reduce the velocity of the flow at the outlet. It is also the least expensive remedy.

5.0 Recommended Strategy

A combination of options 4 and 5 is recommended: energy dissipation at both the outlet and the steepest portion of the channel, along with gully repair and increased storage capacity east of McKnight Road.

5.1 Outlet Reconstruction, Selective Channel Repair and Planting

Starting at the pipe outlet, an energy dissipation structure would be installed. The structure would consist of a 60-inch diameter manhole with a 2-foot deep sump that would connect to the end of the outlet pipe. A larger (36-inch) outlet pipe placed at a 1percent slope or flatter, with a flared end section and grate or trash rack, would extend from the manhole to create the new outlet. (See Figure 4.) The drop inside the structure would serve to dissipate some of the water's energy and velocity. The structure's outlet, placed at a lower elevation than the current outlet, would reduce the initial channel slope and spread the water wider, thus reducing its erosive force. The pipe and manhole would be covered with topsoil to match the existing slope of the yard and the outlet area would be armored with fieldstone riprap.

Properly installed and carefully maintained plantings are a key part of this strategy. At the outlet, a clearly defined area of tough, deep-rooted native plants would help stabilize soil, trap sediment, camouflage the large pipe and reduce the harsh look of the riprap (Figure 5). Some plants could be tucked into soil placed in the voids between individual riprap stones.

The channel adjacent the outlet, along with one of the deepest eroded areas (at Stations 2 and 3) would be graded to form a channel base at least 6-feet wide with a maximum 3:1 side slope (Figure 6). Implementing these recommendations will reduce the design storm velocities to approximately 3.5 feet per second. To prevent erosion at this rate, vegetation and erosion control blankets would have to be installed.

All disturbed areas not subject to inundation should be seeded with non-invasive species; areas where channel flow will occur should be planted with small live plants, or plugs, which will mature quickly and be less easily disturbed during heavy rainfalls. In addition, the most visible upland areas could receive plant plugs following seeding in order to hasten vegetation development and increase aesthetic appeal.

At Station 5 and 6, where the erosion is the most severe, a rock drop structure designed by a professional engineer should be installed. The structure would consist of strategically placed boulders and riprap that would allow water to drop 4 to 5 vertical feet without causing erosion. The final product would resemble a section of rapids on a river, though it would not remain wet at all times. (See Photo 3, which shows a constructed rock drop structure in Battle Creek Park, St. Paul and Figure 7.) The drop structure would allow the water's energy to be dissipated through the rocky areas and provide a flatter slope from the structure to the channel terminus.


Photo 3. *Rock drop structure at Battle Creek* Park.

All of the disturbed areas would be restored with native vegetation. Native plants would help promote a more sustainable channel structure due to their deep, vigorous root systems and tolerance to temperature and moisture extremes. They would also help to diversify area vegetation and provide more habitat for birds and other wildlife. Residents could enjoy the variety of bloom colors and textures throughout the seasons. A short list of plants that might be appropriate in the sunny restored areas:

For areas subject to water flow	**For dry upland areas**
Switchgrass	Little bluestem
Blazingstar	Sideoats grama
River bulrush	Prairie dropseed
Oxeye	Meadow blazingstar
New England aster	Wild bergamot
Sawtooth sunflower	Gray coneflower
Canada anemone	Stiff sunflower
Blue vervain	Heath aster

At portions of the gully near Stations 2 and 3, it will be important to consider more shade-tolerant species. Shrub plantings may be appropriate in some locations. Further guidance for plants could be obtained by consulting the District's biologist, Bill Bartodziej. He can be reached at (651) 704-2089.

Installing plants in repaired areas of the channel is an important part of the solution, and offers both aesthetic and cost benefits. But relying on plantings also introduces a degree of risk, especially during the establishment period. Proper installation, regular inspection and judicious maintenance of the plantings are critical if they are to thrive and thus fulfill their role in helping stabilize the channel.

Maintenance, including hand-weeding and possibly spot-spraying herbicide, will be especially important in the first 3 to 5 years, when the young plants will be competing with aggressive weeds nearby. This work could be done by a contractor, residents, or a combination of both. (The cost for professional maintenance is included in the estimate at the end of report.) In order to ensure proper access to the site for the purpose of channel maintenance, a perpetual drainage easement should be secured for the entire length of the channel.

It is also important to recognize that a number of deer occupy the area, and could pose a threat to new plantings unless special precautions (such as fencing) are taken. Again, District biologist Bartodziej could provide guidance.

5.2 Increase Stormwater Storage Capacity in Wetland

Another improvement, which should be completed in conjunction with the measures described above, is an increase in stormwater storage basin capacity. As mentioned, the District staff will be reevaluating the classification of this wetland in the spring of 2005. If the classification is downgraded, changes to this wetland are recommended. The wetland northeast of the Mailand-McKnight intersection retains little water at this time, but could be redesigned to accommodate more runoff from the north and east. The soil material could be excavated from the parcel to create a pond with a permanent pool and additional flood storage.

Adding storage capacity to this area would require acquiring the property, which is currently privately owned. Property acquisition issues should be addressed at the time the project is pursued (the cost estimate does not include property acquisition).

Any excavation activities on the property to increase storage capacity would first require the removal of many trees. But it should be noted that the area is not ecologically pristine or indeed particularly healthy now, dominated by aggressive boxelder, disease-susceptible elm and other species. Judicious re-planting of the basin, especially the perimeter, could result in a more attractive area that functions better both for wildlife and stormwater.

6.0 Cost Estimate

Cost for outlet reconstruction and selective channel repair is estimated at $46,000; costs for increasing basin capacity to accommodate a 10-year storm event is estimated at $74,000. Total estimated project cost is between $109,000 and $139,000. (See Table 2.). This cost includes all equipment, labor and materials to install pipes and erosion control blanket, all clearing, grubbing and earthwork activities, plant installation and four years professional maintenance.

Tables

Table 1
Soil Classification Summary
McKnight Mailand Gully Erosion
St. Paul, Minnesota

ABBREVIATIONS	
bgs = Below ground surface	CL = Lean clay
fg = Fine grained	SC = Clayey sand
mg = Medium grained	SM = Silty sand
cg = Coarse grained	SP = Poorly sorted sand
	SC/CL = Both clayey sand and lean clay (slash indicates both present)
	SP-SC = Soil sample lies between poorly sorted sand and clayey sand (dash indicates between classes)

Sample ID	Screening Interval (feet bgs)	Soil Classification (ASTM)	Description
1	**Soils observed from the south bank of ~ 3-feet deep gully, approximately 6 feet south of the culvert.**		
	0-0.4'	SM	Topsoil. Dark brown silty sand, mainly mg with trace lg sand, 15-20% fines.
	0.4-2.0'	SC/CL	Increased fines from above to approximately 40-50%, dark brown clayey sand to sandy clay.
	2.0-3.0'	CL	Light brown/tan, clay with fg sand and embedded gravel and trace cobbles, very firm. Cobbles up to 4-inch diameter, gravel and cobbles comprised of mixed lithologies, mainly subangular.
	Channel Base	-	Concrete blocks (reportedly placed by homeowner to slow erosion), thick vegetation.
2	**Soils observed from the east bank of ~ 4-feet deep gully, west of the third house from the corner of McKnight and Mailand.**		
	0-0.4'	SM	Topsoil. Dark brown silty sand, mainly mg with trace lg sand, 15-20% fines.
	0.4-1.5'	SC/CL	Increased fines from above, dark brown clayey sand to sandy clay, mainly fg-mg sand.
	1.5-2.5'	CL	Light brown/tan, clay with fg sand and embedded lg sand and gravel, firm. Gravel is up to 1-inch diameter, comprised of mixed lithologies, mainly subangular.
	2.5-4.0	SC/CL	Dark brown, clayey sand/sandy clay as above.
	Channel Base	-	Surface is mixed lithology gravel and cobbles, mainly subrounded, up to 6-inch in diameter over dark brown sandy silty clay as above with sand grains coarsened to mg-lg.
3	**Soils observed from the east bank of the ~ 2.5-feet deep gully, west of the forth house from the corner of McKnight and Mailand.**		
	0-1.5'	SC/CL	Dark brown clayey sand to sandy clay, mainly fg-mg sand.
	1.5-2.5'	SP-SC	Coarsens from above to sand with 10% fines. Sand is fg to cg poorly sorted sand with mainly subrounded grains.
	Channel Base	-	Surface consists of 4-inches of loose poorly sorted sand with trace fines, followed by dark brown sandy silt/clay.

Sample ID	Screening Interval (feet bgs)	Soil Classification (ASTM)	Description
4	**Soils observed from the south bank of the ~ 1-foot deep gully, north of mowed lawn. Hand auger used to collect sample.**		
	0-0.3'	SM	Topsoil. Dark brown silty sand, mainly mg with trace lg sand, 15-20% fines.
	0.3'-1.0'	SC/CL	Increased fines from above, dark brown clayey sand to sandy clay with mainly fg sand.
	Channel Base	-	Surface consists of 6-inches of loose poorly sorted sand with trace fines, followed by dark brown sandy silt/clay.
5	**Soils observed from center of gully flowline just east of large gully. Hand auger used to collect soil samples.**		
	0-0.3'	CL	Dark brown, sandy clay with fg sand.
	0.3-0.8'	SC	Reddish brown clayey sand, sand fg to mg.
	2.0-3.0'	CL	Dark brown, sandy clay as above.
6	**Soils observed from the north bank of the large ~ 5-foot deep gully.**		
	0-0.3'	SC	Reddish brown clayey sand, sand fg-mg.
	0.3-1.3'	SM	Dark brown silty sand with fg to mg sand and 20% fines.
	1.3-2'	SP-SC	Reddish brown fg to mg sand with 5-10% fines.
	2-5'	SC	Light brown/tan clayey fg sand with embedded gravel and cobbles, subround to subangular grains, mixed lithologies
	Channel Base	-	Surface consists of mainly subround gravel and cobbles up to 1-foot diameter cobbles.
7	**Soils observed from the north bank of the ~ 4-inch deep gully, north of abandoned trailer. Hand auger used to collect sample.**		
	0-0.7'	SM	Dark brown silty sand with 15-20% silt. Mainly fg sand with grain size coarsening downwards.
	0.7-1.0'	SM	As above with sand grains fg to cg with some small gravel pieces.
	Channel Base		Surface lined with subround an subangular mixed lithology cobbles 3 to 4-inch diameter, followed by 5-inches of fg to cg sand with trace fines overlying silty sand from above.
8	**Soils observed from the south bank of the ~ 6 to 8-inch deep gully, south of school. Hand auger used to collect sample.**		
	0-0.3'	SM	Dark brown silty sand with 15% silt, fg to mg sand.
	0.3-1.0'	SP-SM	Decreased fines to 5-10%.
	Channel Base		Surface 2 to 3-inches of fg sand with some mg sand and trace fines.

Table 2
Cost Estimate

Item	Unit	Quantity	Unit Price	Extension	
Channel Repair					
Mobilization/Demobilization	lump sum (LS)	1	$3,500	$3,500	
60-inch Diameter Man Hole	each	1	$3,500	$3,500	
30-inch Diameter Concrete Pipe	linear ft.	16	$85	$1,360	
30-inch Diameter RCP Flared End Section w/ Grate	each	1	$1,500	$1,500	
Channel Grading	LS	1	$2,800	$2,800	
Remove Excavated Soil	cubic yd.	100	$15	$1,500	
Import Topsoil	cubic yd.	50	$25	$1,250	
Riprap - Class III	cubic yd.	10	$65	$650	
Rock Drop Structure	LS	1	$10,000	$10,000	
Erosion Control Blanket	square yd.	400	$7	$2,800	
Planting (seed and live plants)	square ft.	5500	$2	$11,000	
Professional Maintenance *	year	4	$1,200	$4,800	
Mesh Deer Fencing	linear ft.	400	$3	$1,200	
Subtotal				$45,860	
Basin Excavation					
Mobilization/Demobilization	LS	1	$7,000	$5,000	
Clearing and Grubbing	LS	1	$7,000	$7,000	
Strip, Stockpile and Replace Topsoil	LS	1	$6,000	$6,000	
Excavation with Off-Site Disposal	LS	1	$45,000	$45,000	
Plantings (seed, shrubs, trees)	acre	0.75	$15,000	$11,250	
Subtotal				$74,250	
Total Construction Costs				**$120,110**	
				$108,099	-10%
				$138,127	+15%

* Includes 3 -4 visits during growing season for mowing, herbicide spot spraying, weeding. Some or all of this work could be done by property owners, thus reducing overall cost. Less intensive management will be necessary in subsequent years, following successful plant establishment.

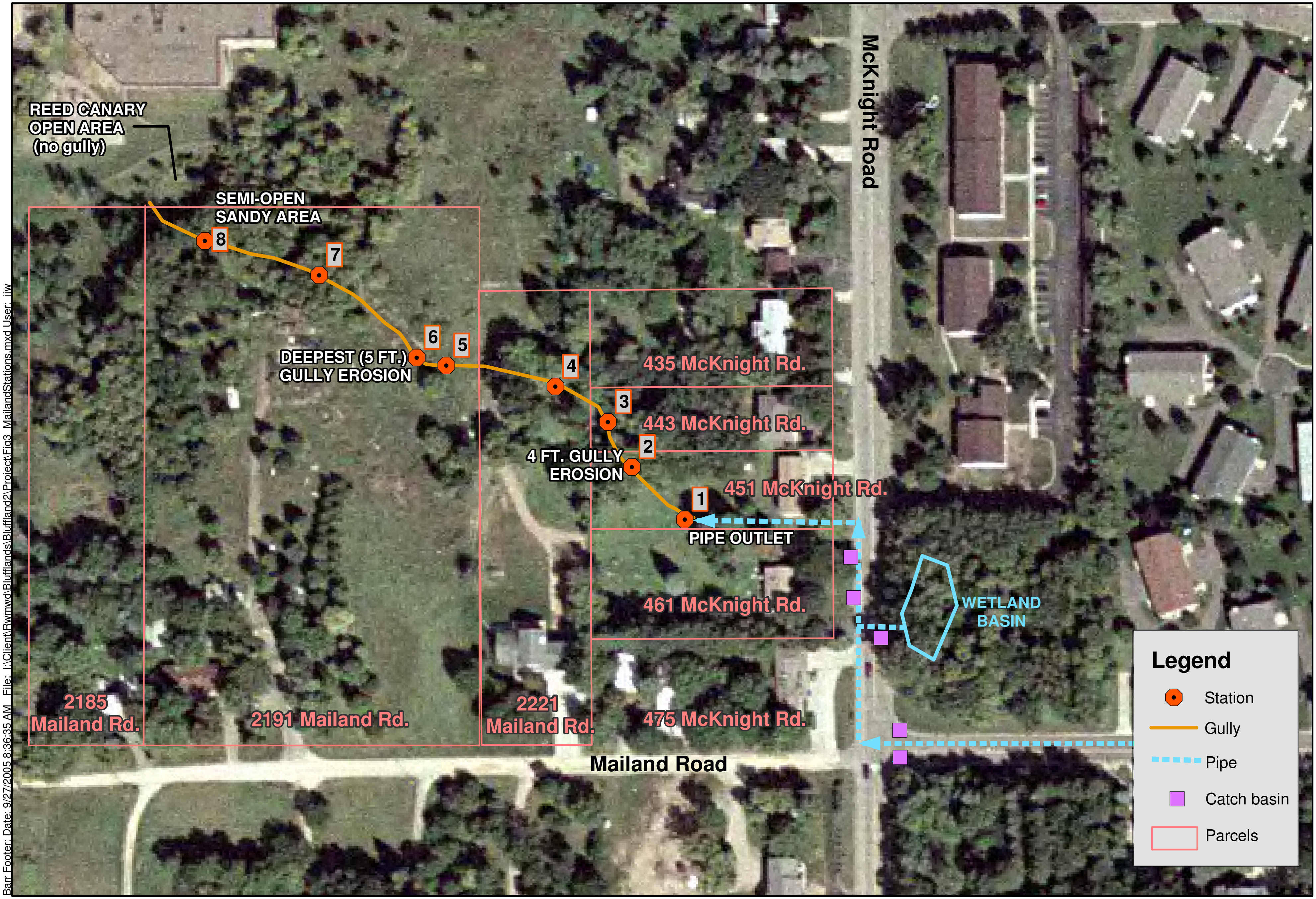
Figures

Figure 1
Mailand Gully Location
Ramsey Washington Metro Watershed District

0 100 200 400 Feet

2002 Airphoto

Figure 2
Mailand & McKnight Drainage Areas
Ramsey Washington Metro Watershed District

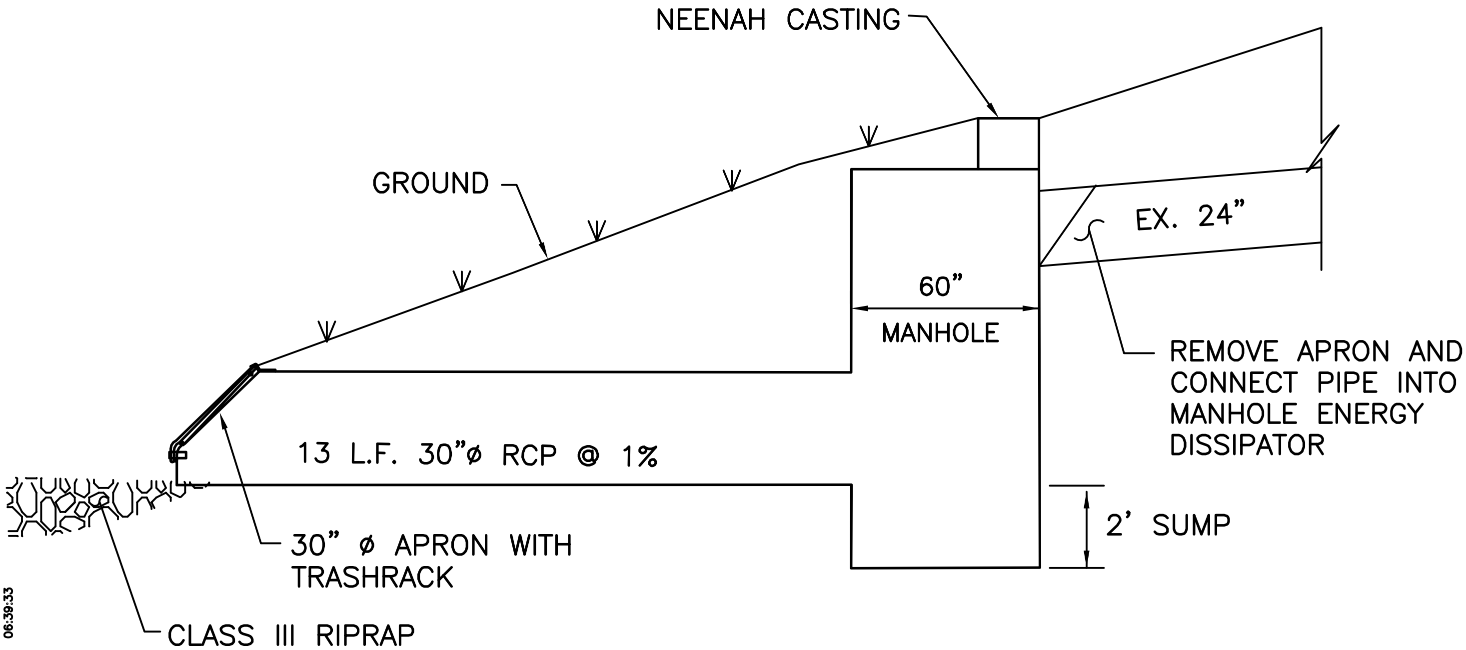


0 50 100 150 300 Feet

2002 Airphoto

Figure 3
Mailand Gully Erosion
Ramsey Washington Metro Watershed District

Figure 4
Outlet Reconstruction Detail



1 C– **SECTION: ENERGY DISSIPATOR (TYPICAL)**
NOT TO SCALE

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BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Scale	AS SHOWN
Date	11-16-04
Drawn	DRAWN
Checked	CHECKED
Designed	DESIGNED
Approved	APPROVED

RWMWD

MAILAND–McKNIGHT GULLY
OUTLET RECONSTRUCTION

BARR PROJECT No. 23/62-031
DWG. No.
SHEET No.
REV. No.

Figure 5
Outlet Reconstruction and Planting (Plan)

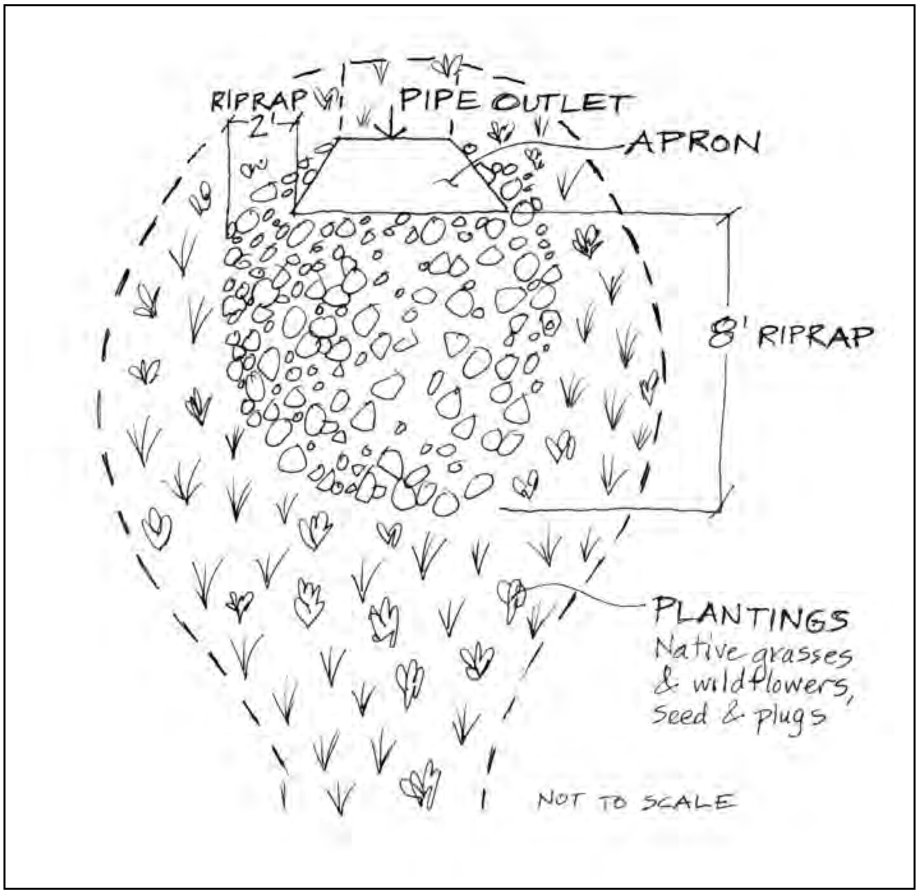

Figure 6
Channel Cross-Section

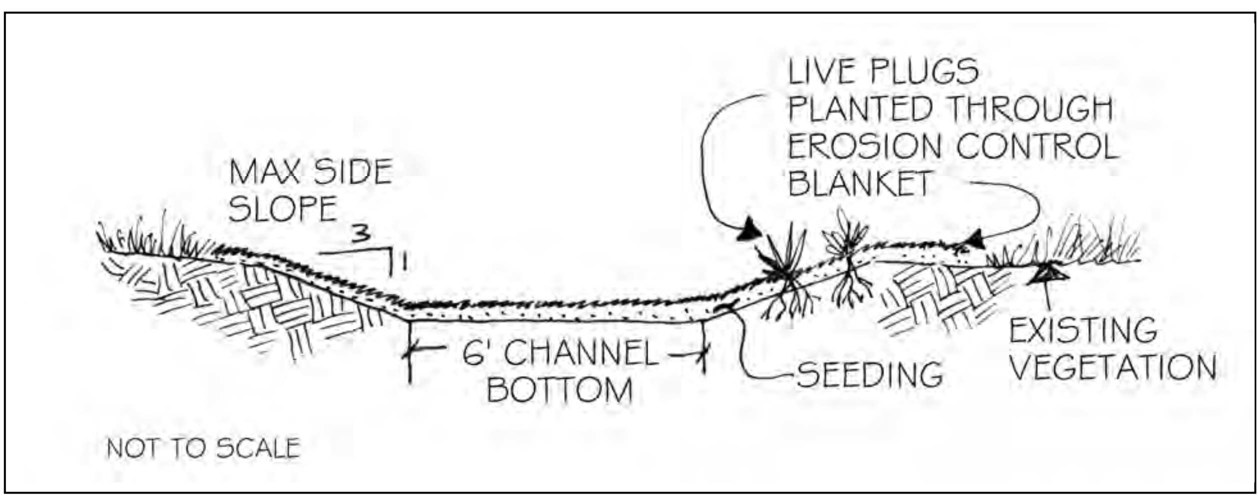

Figure 7
Rock Drop Structure
Schematic Profile