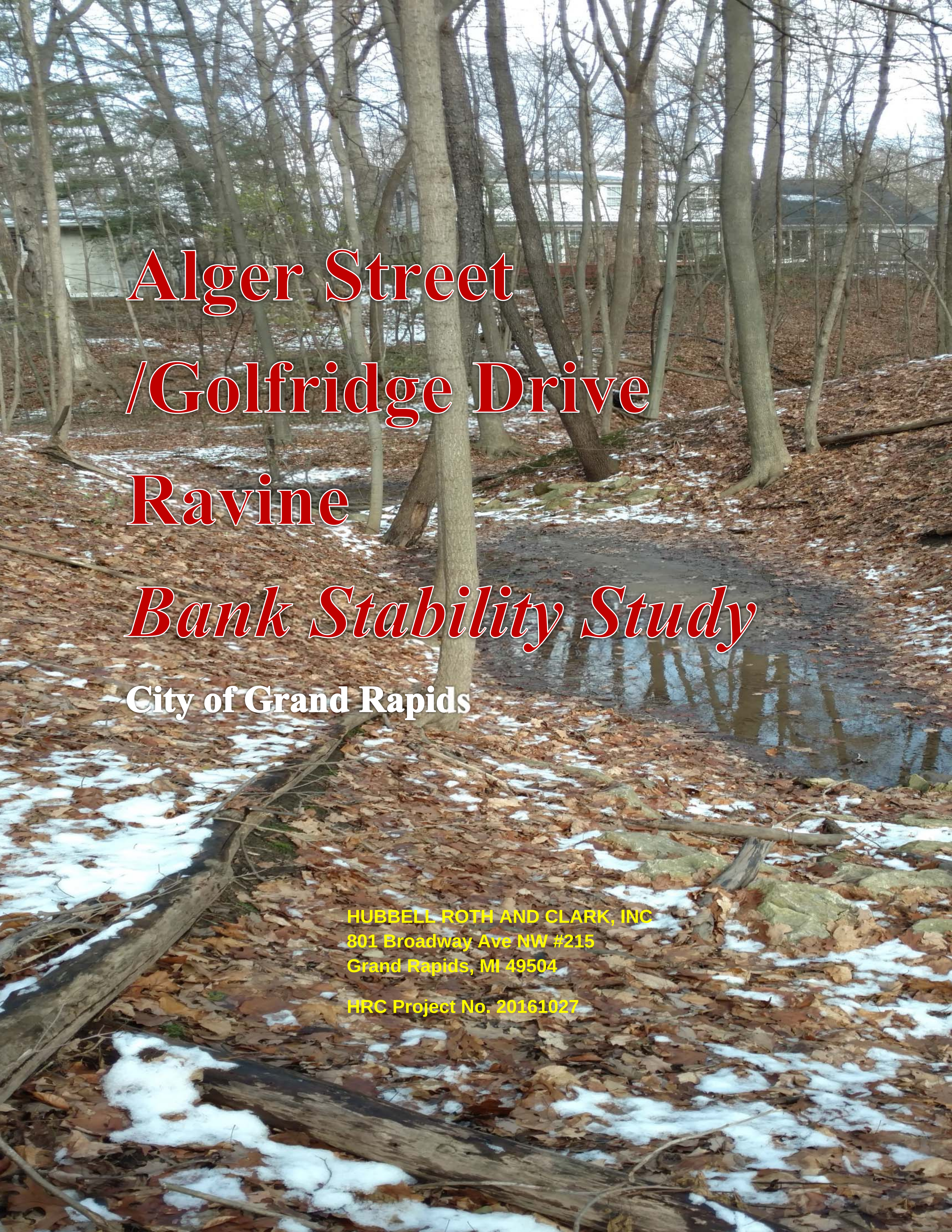

Alger Street /Golfridge Drive Ravine

Bank Stability Study

City of Grand Rapids

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HRC Project No. 20161027

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Chapter 1 - Understanding the Project

The City of Grand Rapids was approached by a group of residents to investigate the continued slope and bank erosion that has been occurring along a reach of a first order natural stream behind their homes. The concern is that the continued erosion will jeopardize their properties and structures. Several residents stated that they are currently experiencing erosion on their properties despite a past project in 2004 to solve this issue. The residents are interested in determining what could be done to the stream to halt the erosion and prevent the further degradation of their properties.

This report and study is to evaluate these concerns and the existing condition of the stream corridor reach in order to determine the specific causes of the continued erosion and to identify specific restoration and stability management practices that could be implemented to rectify the situation.

The project study area is located east of Breton Road SE and between Alger Street SE and Golfridge Drive SE as shown on Figure 1.

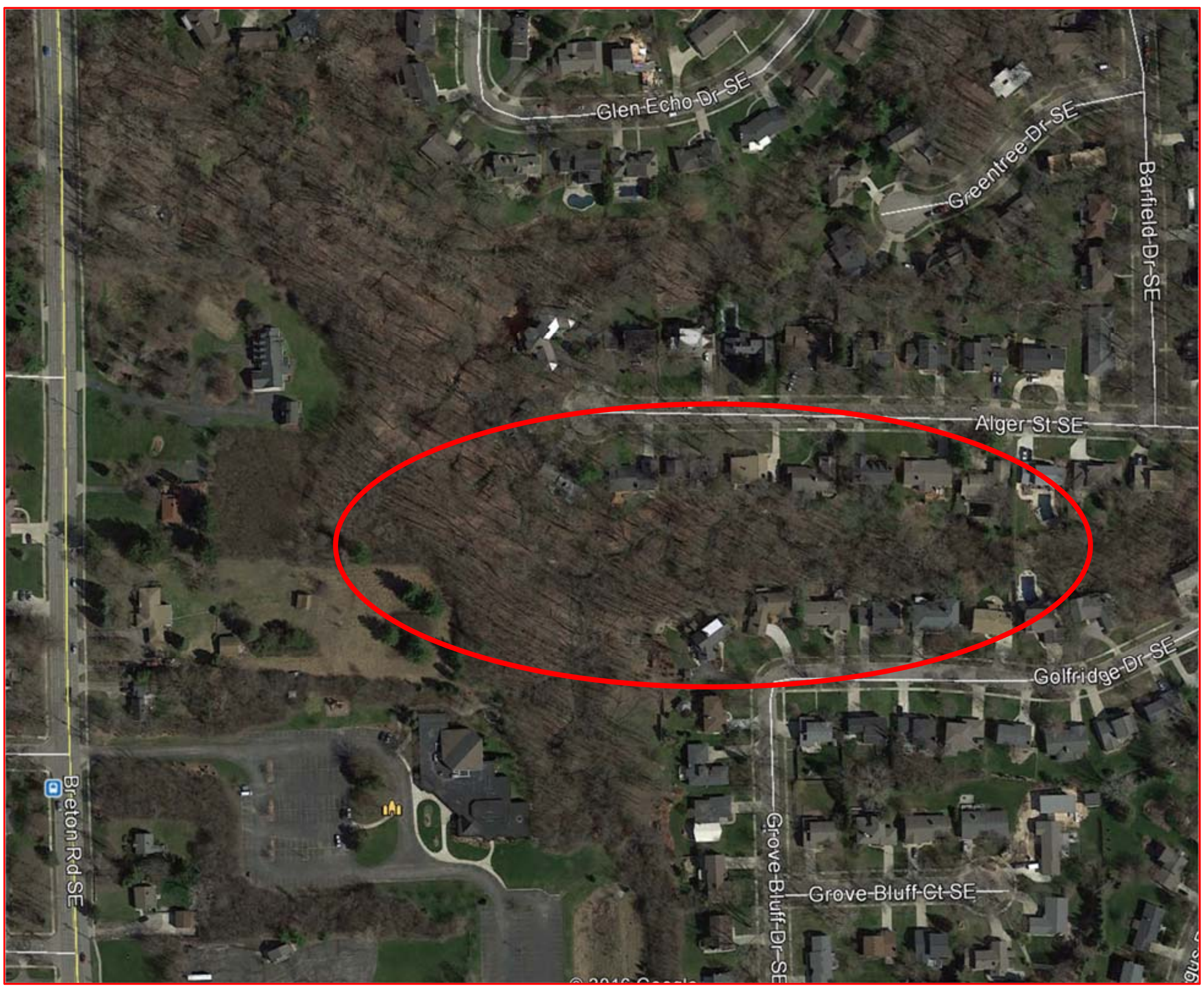


Figure 1 - Project Location Map

Study Area History

In order to validate the concerns of excessive streambank instability and higher than normal bank erosion, an understanding of the historical disposition of the stream was conducted. Reviewing topographical and drainage maps it was determined that the study area contains a perennial first order tributary stream that drains approximately 33.13 acres or about 0.05 square miles of watershed that eventually empties into another first order stream just north of Alger Street. Most of the drainage area contributing to this stream comes from a 21-inch culvert that discharges storm runoff from approximately 26.6 acres of residentially developed area that is fully developed and enclosed within storm sewers and was likely developed between the 1960's and 1980's. Upon review the drainage characteristics of the watershed area the watershed is vegetated and stable and does not produce significant sediment.

Figure 2 - Typical Alger Street Ravine Drainage Channel

Figure 2 indicates what was typically observed throughout most of the study reach. The width of the active channel represented in this photo measured out to be approximately 9.5 feet. It was very difficult to determine what the bankfull channel is in this reach due to the lack of geomorphic features that could be measured. This suggests that the water forces and flow rates that created the channel are likely sediment starved.

Chapter 2 – Hydrology and Geomorphic Analysis

Understanding the cause of the erosion within the study reach and whether or not this erosion is on-going or has been arrested is an important task of this study. It is also important to determine whether improvements to the geomorphology of the stream course can be completed to alleviate the bank erosion that has been observed. By definition, stream stability is defined by:

> "A rivers ability, in the present climate, to transport the flow and sediment from the watershed, over time, such that the channel maintains its dimension, pattern, and profile without aggrading or degrading." *Dave Rosgen, 2000*

On December 7, 2016 a site visit was conducted to measure the plan, profile, and dimension of this stream reach, in order to determine if and where excessive bank erosion is occurring and to determine if the stream has, and is continuing to, depart from its historical reference condition. On the date of this visit there was partial snow cover over portions of the valley. Tentative measurements were made due to a pending imminent snow storm. The following observations were made:

- A modified Rosgen Level II field evaluation was conducted to develop an understanding of the type stream and current streambank stability issues. Based on our preliminary measurements and observations we have determined that the stream is moderately over widened and incised. There are areas of the study reach where, in the past, large boulders have been placed in an effort to slow the flow and reduce the erosive nature of the discharge. Those armored areas appeared as check dams and were, in our opinion, marginally effective in reducing the instability.
- A bankfull width of approximately 9.5 feet and a bankfull depth of approximately 1.1 feet was measured in a few locations and are not consistent with a stream with a contributing watershed of approximately 0.05 square miles. The stream is classified as a Rosgen B 4-5 stream. This means that the stream has significant slope (above 0.5%) and its bed is composed of predominately gravel and sand. Bankfull features were very difficult to determine within the study reaches and there was poor connection with the flood prone flood plain due to the over-widened channel, steep valley slopes, anthropogenic confinements and continuing bed incision.
- The stream has historical sinuosity but the width to depth ratio is excessively high which means that bankfull flows will likely not be effective at forming a new bankfull floodplain elevation. This is one of the causes of the erosion observed.
- Overall the steam is entrenched, but is appropriate for this type of single thread channel.
- High or very high bank erosion hazard index (BEHI) locations were noted in many locations. These locations were found where the channel was incised (typically just downstream of the boulder rock check dams) or where sharp bends have occurred in the channel. The remainder of the study reach exhibits general incision but with moderate to active erosion.
- Dynamic equilibrium is a condition where what is naturally eroding is then deposited on the next downstream point bar (a very natural and healthy process for a stream). Equilibrium has not been achieved on this stream due to the fact that the flow coming from the 21-inch culvert is generally clean water and thus has little sediment content. This creates an imbalance in the

geomorphic stability of the system and is a contributing factor in the rate of down steam bank erosion. To better understand this principal see Figure 7 on page 11.

- Overall, the confinement of the stream is not an issue except where heavy boulder was previously installed which creates a threshold streambank (hardened) channel. Most of the residential homes that are riparian to the stream corridor have all been constructed up on the high terrace, well above the flood prone area and eroding channel.
- Four homes that are immediately downstream of the 21-inch storm sewer outlet on the right bank are affected by bank erosion or failure due to stream bank erosion issues. Figure 3 is a typical picture of an actively eroding area that was observed.
- The property improvements made by some of the riparian residents have, for the most part, been successful on the stability of the stream where armoring has occurred.
- Generally mature native forest vegetation has established within the valley and there is some evidence of surface soil erosion due to the lack of understory vegetation. However a complete analysis of the vegetation present, it's effectiveness on soil stability and the degree of soil erosion occurring cannot be determined due the winter season present during this study.

Figure 3 – Eroding Area behind the homes on Alger St.

After evaluating the entire length of the study area, there are areas that can be considered as stable as these bank areas are either reinforced by the existing vegetation or are areas hardened by boulders.

The bank sections that were observed to be eroding are generally short in length and the sediment contributions from those reaches are very low. The sediment within the bottom of the channel appears to be relatively mobile. Due to the age of the sediment and the fact that the channel is over widened suggests that the stream does not have adequate sediment which, if available, would form a much narrower baseflow bankfull channel. Boulders appear to have been placed in areas to reduce storm discharge velocities as is shown on Figure 4 below.

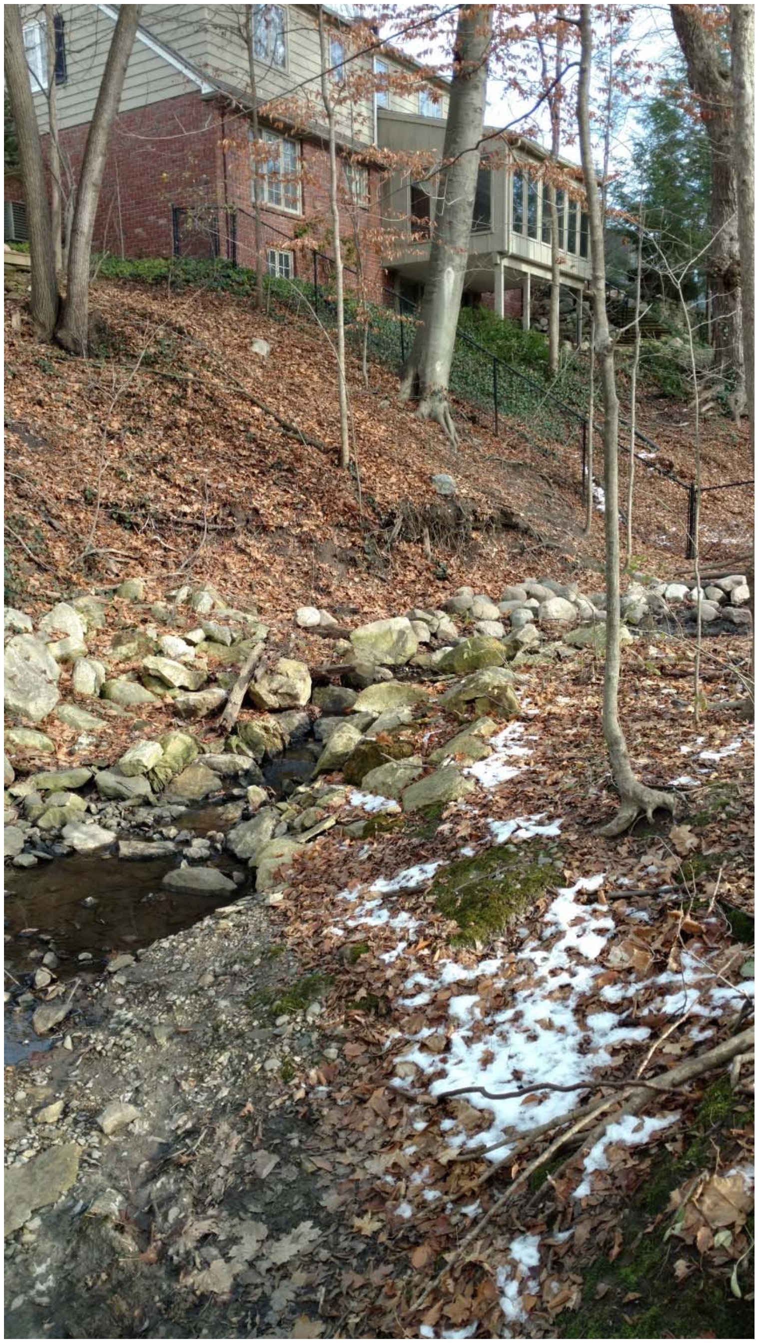


Figure 4 – Stream banks and bed stabilized by heavy boulder installation

Chapter 3 Characterizing the System

Understanding Stream Evolution

It is well documented that urbanization of a watershed has a deleterious effect on the rivers and streams receiving the watershed's storm runoff. As the watershed is urbanized, flows and soil erosion runoff typically increase. Typically within an urban setting streams and rivers respond to the changing watershed by incising or down cutting and then over-widening. This is followed by the stream utilizing the excessive sediments generated from bank erosion to create a new bank full flood-prone floodplain. Table 1 is a progression chart that documents the typical transformation processes that occurs when streams are affected by a change to their hydrology, sediment supply or both. There is always a degree of down cutting and widening before stability is restored. In this particular case, progression no. 6 is what we believe to be occurring in this study reach. At this time the stream channel is at stage G in that it is in the process of over-widening, eroding the banks and incising is occurring.

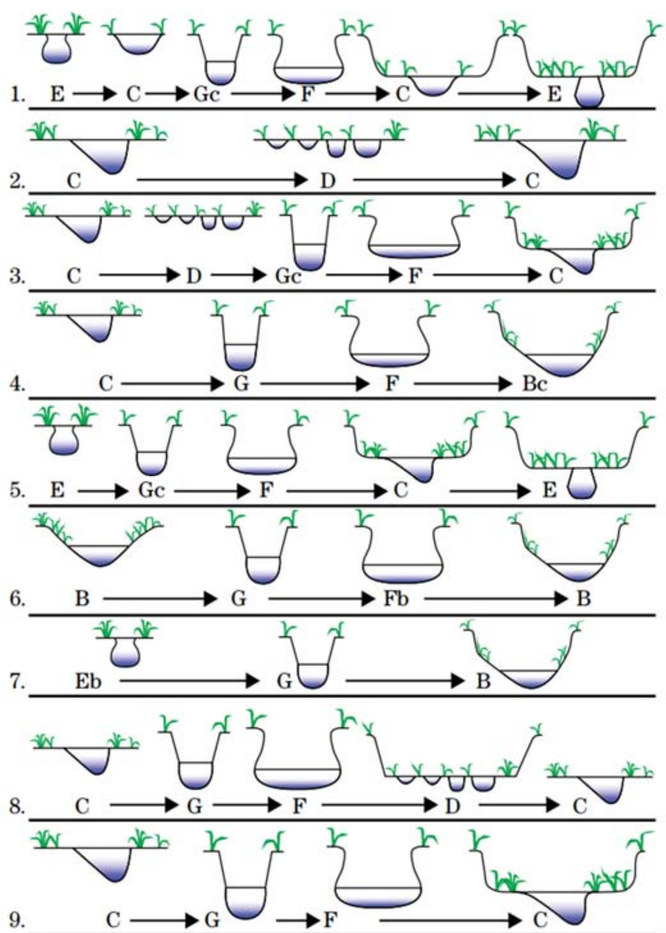


Table 1 Successional stages of channel evolution (Rosgen, 2007)

The study area's urbanized watershed is contributing flows that are significantly altering this reach. The 21-inch storm outlet pipe is discharging flow from the Golfridge Drive SE and upstream residential areas south of this watercourse, may not have been originally totally part of the watershed hydrology that historically created the geomorphology of this watercourse since the natural contours in this area would have directed the drainage from the areas of Heathcliff Drive, Argus Drive and Grove Bluff Street to the north-south channel whereas this 21-inch sewer now concentrates all of this drainage into the east-west channel north of Golfridge Drive just east of the confluence between the E-W and N-S channels . The addition of this drainage area may have caused the watercourse to become unstable. In 2004, the City had constructed a series of rock or boulder check dams to reduce the erosive forces of the flow. While reviewing the plan, profile and dimensions of this stream it was observed that additional riffles are forming in between the check dams. This suggests that the slope of the channel has not been effectively controlled by the placement of the check dams. Additional check dams will not address the horizontal movement of the stream. Most storm generated runoff in developed urban areas is generally clean water. This means that the flow will not likely contain a sufficient quantity of sediment to naturally create the bankfull channel or stable flood plain in the progression evolutions presented in Table 1 above. A few riffle areas were observed to be developing shown in Figure 5.

Streambank Erosion Control

All stream banks erode. The question is whether or not the rate of erosion is natural or accelerated by anthropogenic (man-made) influences. It is evident by our observations that the shifting of the drainage area into the E-W Channel north of Golfridge Drive which was made by the construction of the 21-inch storm water discharge pipe coming from Golfridge Drive is still causing a continued progression of erosion, as presented in Table 1, to occur.

Figure 5 – Where sediment is available, riffles have developed. Eventually, with enough erosion, bankfull features will become visible.

Chapter 4 - Recommendations

HRC was retained to review the project study area stream reach from the Golfridge Drive Storm water outlet pipe to the end of the cul-de-sac on Alger St. in order to identify the presence of stream bank erosion that may be potentially threatening riparian owner's properties and to develop recommendations for stabilizing any areas of concern. At the City's request, our recommendation was intended to provide a recommended strategy for stabilizing the banks and the channel by utilizing natural stream channel design protocols, if possible and feasible, as opposed to alternatives that would require heavy equipment to be utilized to facilitate their implementation.

Based upon our analysis of the erosion occurring within the stream valley, it appears that the majority of the erosion is moderately occurring all along the stream within the sturdy area with several locations exhibiting excessive erosion. It was further determined that the erosion noted by the riparian residents is limited generally to the toe of the slope and not on the upper stream valley side slopes.

If the goal of this project is to stabilize the entire stream reach's eroding stream banks, we recommend that a series of riffles, log vane structures, rock and roll log structures, bankfull bench and boulder toe protections be installed at appropriate locations according to the geomorphology present in this system. There is little that can be done to increase the sediment load for the stream to naturally create an appropriate bankfull channel and flood plain which the stream is trying to naturally do. Therefore creating a bankfull channel and minor flood plain in consort with controlling the flow generated shear stresses causing the horizontal erosion, installing the appropriate bank stability measures and vegetation establishment and woody management will provide the needed stability to control the storm flows in this system. It is noted that some of the homeowners have already installed flexible plastic drainage tubing from along the upper valley banks to contain the erosive energy of the flowing water descending down the banks. While this may be unsightly, it is effective at preventing erosion from the upland drainage as it descends into the valley and could encourage other riparian property owners to do likewise.

If the goal is to also address just the erosion instability at specific critical locations, then a limited installation of the techniques outlined below can be installed within the stream channel and a number of physical alterations to the channel banks can be used in order to create a stable stream channel as shown on pages 11 through 14.

Physical modifications to the stream reach

There are a number of issues that present themselves when contemplating an urban streambank restoration project. The following is a list of issues to be considered:

- Access. There is really no good open access to this valley. In 2004 access was afforded by creating a route from the channel from the south behind the Christ Church on Breton Rd.

Significant removal of existing vegetation and grading would likely be required to create this access route. Restoration of the access route would also be significant and expensive. Access easements would be needed to utilize this access route to reach the work areas. In addition, contractors would likely need space to stage their equipment and materials. There is no obvious staging site location except at the church. Significant clearing and erosion protection (both temporary and permanent) will be necessary to allow for even small off-road vehicle access to the eroded areas in the valley.

- Permitting. The Michigan Department of Environmental (MDEQ) Quality is generally supportive of stabilizing stream banks and beds because of the ecologically beneficial effects to downstream reaches. Stability of the tributary streams and rivers throughout the watershed reduces sediment loading which does affect critical habitat downstream. We believe that the State would be in favor for this stream to be restored to a natural channel plan, profile, and dimension that recognizes the alterations that have occurred to the watershed. In order to be as thorough as possible in our assumed position concerning our understanding of the MDEQ's position, we recommend petitioning the MDEQ to review the study reach and the streambank erosion issues so as to gather their support and comments for approval.
- Costs. Due to the fact that the stream study reach is within a very steep valley, the logistics of accessing the eroded bed and bank areas will be difficult and costly. The techniques shown below would utilize local wood and boulders in the design. It is somewhat difficult to develop a solid cost estimate for this type of stream restoration, but based on using an assumed number for the bed stabilization techniques for the area described above plus adding in the difficulty of access, our opinion of project cost is approximately $180,000 to accomplish erosion protection for the entire study reach. A breakdown of this opinion is included in the Table 2 below. The critical areas that should be addressed are shown in red on Figure 6, below. Full stream bed restoration along the entire stream reach included within this study is probably not warranted since the erosion that is occurring at other locations (left or south bank) does not appear to be causing any imminent failures or immediately threatening the safety of existing structures or properties.
- If no action is taken at this time, we believe that the existing rate of streambank erosion in the areas shown in red on the right or north bank will continue its horizontal northward movement (see Figure 6). It was also noted that some of the residents have taken effective action to stabilize their specific properties. The placement of bank boulders is providing some stabilization. However we feel that the construction of these boulders has not properly been done to ensure a long-term solution and some adjustment is likely necessary.

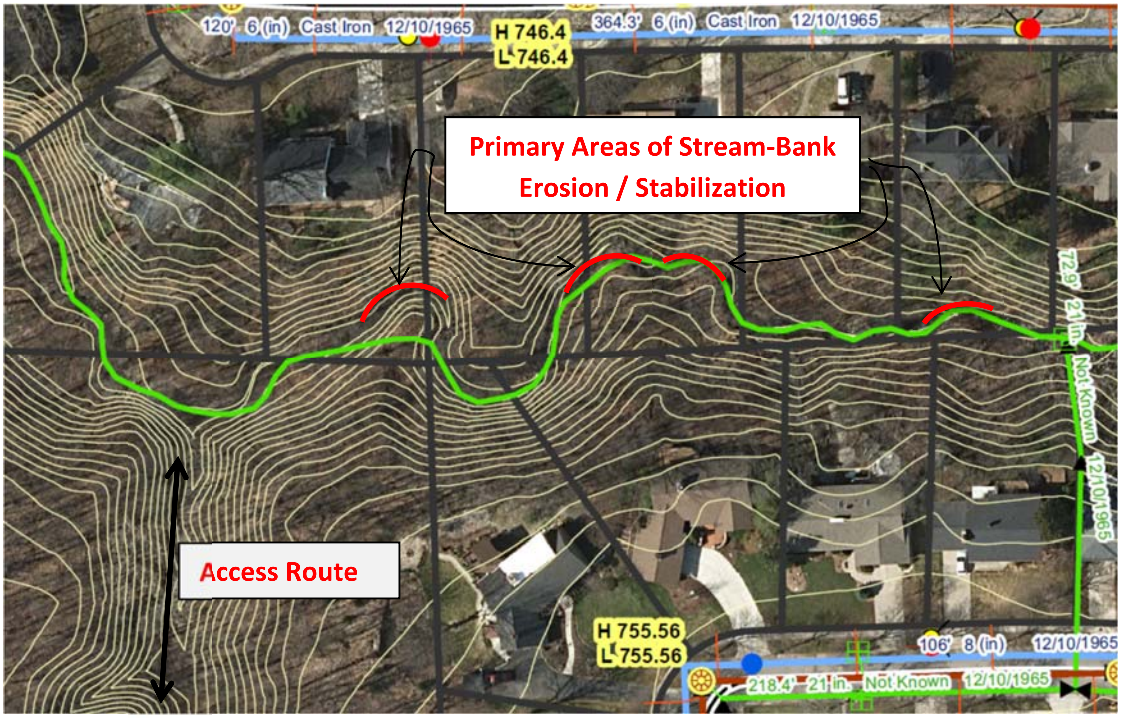


Figure 6 - Proposed Area of Streambank Stabilization and Potential Access Route for a limited streambank stabilization project. Only the specific areas in red would be addressed.

Table 2

Project Cost Opinion for Streambank Stabilization – Alger Street Golfridge Drive Ravine Watercourse

Description	Units	Unit Price	Quantity	Total Price
Mobilization	LS	Lump Sum		$ 8,500
Remove Tree, over 6 inch to 18 inch	EA	$500	20	$ 10,000
Remove Tree, 19 inch to 36 inch	EA	$1800	10	$ 18,000
Stone Toe Structures	LF	$45	250	$ 11,250
Earth Excavation and Bankfull Bench Creation	CY	$30	1200	$ 36,000
Reuse of existing Boulders Check Dams	EA	$550	5	$ 2,750
Log Vane	EA	$2,500	5	$ 7,500
Rock n roll Log structures	EA	$3,000	4	$ 12,000
Erosion Control Blanket (C 250)	SY	$4	300	$ 1,200
Access Restoration (earthwork, planting, etc.)	acres	$20,000	1.5	$ 30,000
Seed Mix – Dense Shade Woodland Streambank Mix	acres	$4,500	0.5	$ 2,250
Shrub Plant Plugs 12" pots	EA	5.5	250	$ 1,375
Riffles	EA	$1,500	4	$ 6,000
Estimating Contingencies	LS	5%		$ 7,341
TOTAL CONSTRUCTION COST OPINION				**$ 154,166**
Engineering and Construction Contingencies	LS	25%		$ 25,000
TOTAL PROJECT COST OPINION				**$ 179,166.**

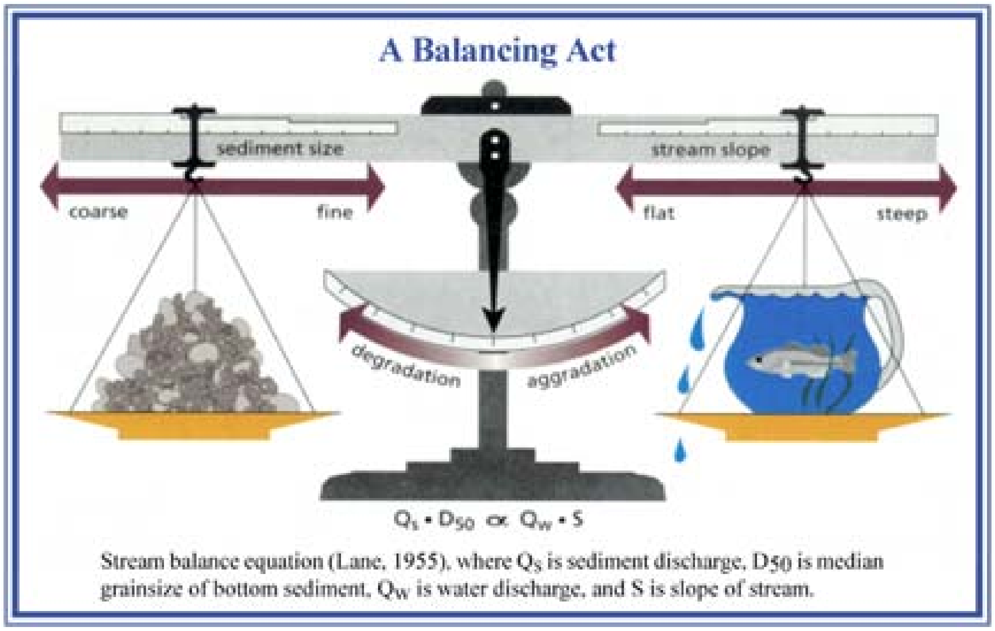


Figure 7 – Lane's Stability Equation

Recommended Streambank and Bed Stabilization Techniques

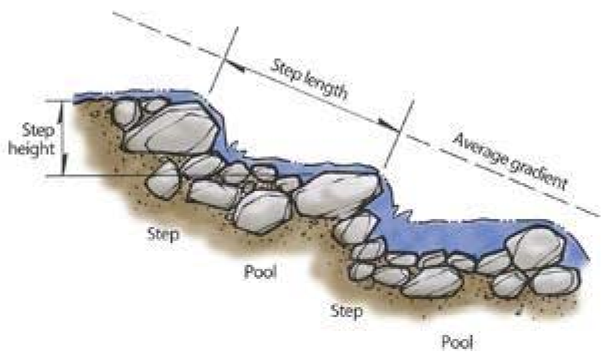
The specific installation of each of the following structures is dependent on further design and geomorphic calculations.

Stone Toe Detail

The Stone Toe Structure is typically used on the outside bends of a stream channel to prevent lateral scour and channel movement. These features use existing boulders placed during past restoration efforts and are found within the specific construction area.

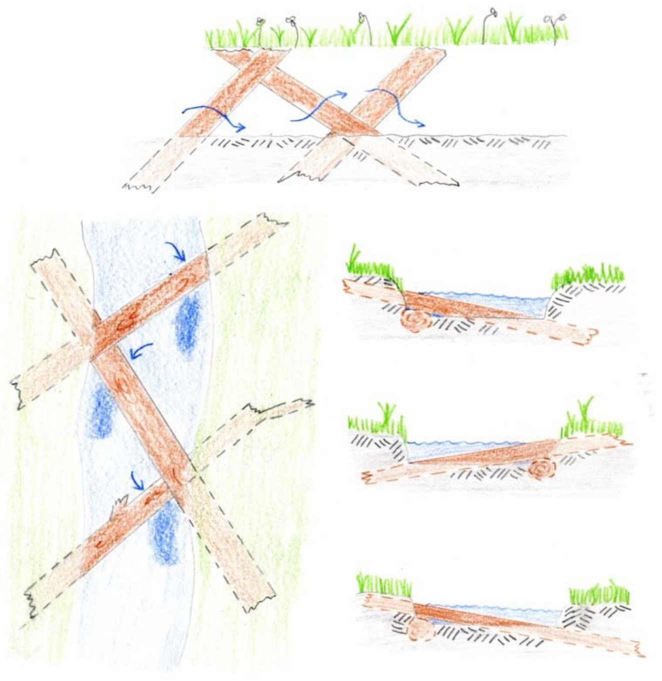
Log Vane Detail

The Log Vane Structure is used to divert flow stresses away from the outside bank of a stream channel. The flow stress is the force that accelerates bank erosion. Log Vane Structures could be constructed using the trees that would be removed to allow for equipment access.



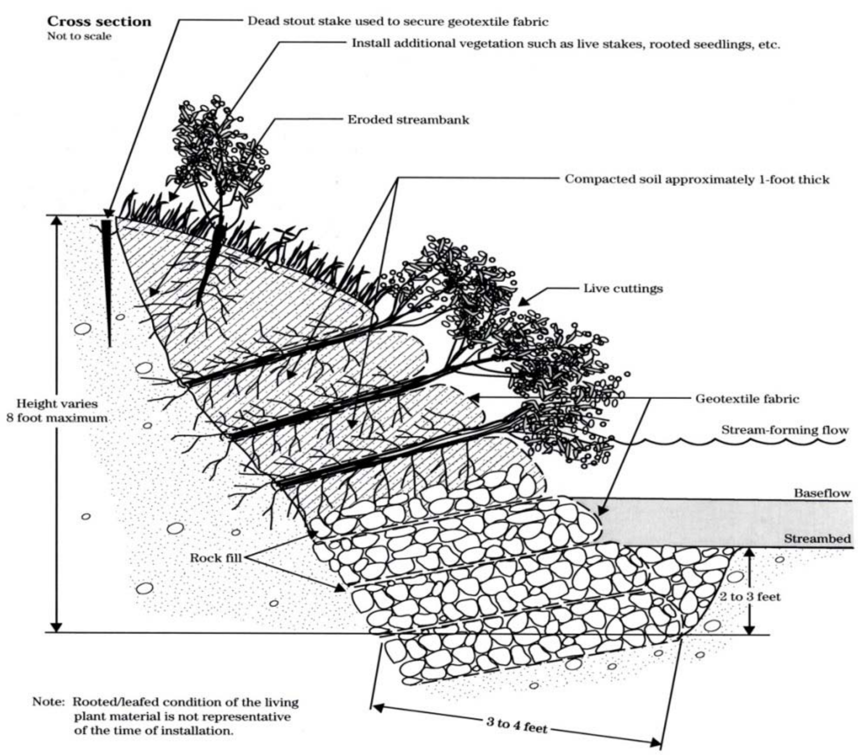
Step Pool Cross Section

Step pools, as shown above, are installed throughout a stream reach to reduce channel slope while providing bed stability in a relatively short distance. Rock materials are sized so that the flows are not able to dislocate the steps. The spacing of the steps would be in accordance with the observed riffle-pool sequence presently occurring in the watercourse.



Typical Sketch of a Rock and Roll Vane Structure

Rock and Roll Structures are constructed to utilize trees found within or obtained from the stream channel valley. These structures also decrease channel slope, provide roughage and reduce the 21-incherosive forces of the flow.



VRSS Streambank Stabilization Structures.
Typically used on outside channel bends where expected erosive forces are higher.

Chapter 5 - Photographs

The following photographs are of selected features taken to convey the appearance of the project area. The progression of the photographs is from upstream, beginning at the 21-inch storm sewer outlet and progressing downstream.

21-inch Corrugated Metal Culvert Structure Discharging from Golfridge Drive.

Stream channel immediately downstream of the 21-inch Culvert. The banks are relatively stable at this location.

Stream Channel has split. Good location for a Bankfull shelf

Most of the stream bed is composed of rock at this Check Dam. This location is effective and stable however excessive rock is present here can be used in other locations.

Bank protection installed by riparian property owner is effective however not very natural

Erosion on the North or right bank is not significant and does not present any imminent problem to riparian property owners.

Over widened channel with no defined bankfull features. Riffle is forming in center of this section.

Confluence with the ravine from the south (behind Christ Church) (proposed as the access route).


Terraced Timber wall Slope Stabilization by riparian property owner


Highly eroded stream banks.