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Civilian Conservation Corps Rubble and Masonry Dams and Gully Morphology in Northeastern Iowa

Timothy Robert Beerman

CIVILIAN CONSERVATION CORPS RUBBLE AND MASONRY DAMS AND GULLY MORPHOLOGY IN NORTHEASTERN IOWA

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Timothy Robert Beermann

University of Northern Iowa

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ABSTRACT

The Civilian Conservation Corps (CCC) was created in 1933 in an effort to help solve the problems associated with the lack of jobs for young men, the nations dwindling natural resources, and problems associated with soil erosion. The CCC's work in Iowa was primarily in the areas of reforestation and erosion control. Company 1749 of Cresco, Iowa stands out as an example of how the CCC worked to halt erosion. As a part of their erosion-control strategy, Company 1749 built a large number of rubble and masonry dams on gullies. These dams were designed to trap sediments and prevent further gully erosion of agricultural fields. The purpose of this thesis was to determine the modern effects that these rubble and masonry dams currently have on the morphology of these gullies. Johnson Gully near Kendallville, Iowa in Winneshiek County was chosen for study.

This study includes a history of the erosion-control methods used by Company 1749, including a description of the dams that they built. The historical portion of the study was accomplished through a review of a number of library sources and newspapers. Field methods included a) measuring a longitudinal profile and a number of cross sections, and b) measuring and describing the conditions of the dams. Collectively, these data were used to reveal the modern characteristics of the gully and how the modern morphology of Johnson Gully is being influenced by the presence and conditions of the rubble and masonry dams that were built by Company 1749 over 65 years ago.

Three dams were built by the CCC in Johnson Gully in 1934. Dam 1 was built near the headscarp of the gully. Its failure within the last 5 years, which was caused by

the tipping of a tree along a sidewall of the dam, has led to renewed headward gully erosion around the side of the dam wall. Dam 2 was constructed one-quarter of the way down the gully. It is still working as an effective sediment trap today because of a modification of its spill way apron within the last 15 years by the landowner. Dam 3 is located in the lower reach of they gully near the floodplain of the Upper Iowa River. Dam 3 has trapped an enormous amount of alluvial sand behind it. Dam 3 is still an effective sediment trap, despite some solution of the limestone wall of the dam and a tunnel forming in the historical alluvium and the dam. Currently Dam 3 is in danger of being overwhelmed by alluvial sand.

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This Study by: Timothy Robert Beermann

Entitled: Civilian Conservation Corps Rubble and Masonry Dams and Gully Morphology in Northeastern Iowa

Has been approved as meeting the thesis requirement for the

Degree of Master of Arts

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7/27/2000
Date — Dr. John W. Somervill, Dean, Graduate College

For Amy

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CHAPTER 1

INTRODUCTION

The Civilian Conservation Corps (CCC) was formed in 1933 to help provide jobs for young men who could not find work during the Depression. The enrollees who made up the Corps worked in camps that were established in many different areas across the country. The jobs that the CCC provided were designed to help conserve and improve the natural resources of the United States. Conservation and improvement were achieved primarily through the reforestation of American lands and construction of erosion-control projects on agricultural land.

The state of Iowa became the home of a number of CCC camps. These camps performed a great deal of work in state and national parks, as well as on private lands. These works included reforestation projects, the construction of public buildings in state and national parks, and erosion control projects on public and private lands. Of these different types of works performed by the CCC in Iowa, perhaps their most important and extensive work in the state dealt with erosion-control. One of the best examples of a CCC camp that worked on erosion-control measures in Iowa is Company 1749, which was based in Cresco in eastern Howard County.

Purpose of Investigation

Of the many Civilian Conservation Corps companies that worked at one time or another in Iowa, Company 1749, located at Camp PE-67 in Cresco, Iowa, is unique in that "approximately 30% of the permanent structures that were built in Iowa by the CCC are located in the Cresco area" (Alleger, 1935, p. 54). This large percentage of dams in such a small geographic area is directly related to the high relief found in this region, the erosive characteristics of soils developed in loess, and the availability of limestone for dam construction.

Many of the rubble and masonry dams that Company 1749 constructed in gullies to help control erosion are still evident today. Johnson Gully in Fremont township near Kendallville, a small village to the northeast of Cresco, Iowa, was selected as a representative gully for this study. The emphasis of this research was on the condition of three rubble and masonry dams that were built in Johnson Gully and how effective the dams are today.

Research Question

What are the conditions of the rubble and masonry dams that were built over 65 years ago by Company 1749 in Johnson Gully and are they still fully functional as sediment check dams?

Objectives of Research

The objectives of this research were to:

1. Briefly describe the activities of Company 1749 in Cresco, Iowa, especially their erosion-control methods of constructing rubble and masonry dams;

2. Describe the dimensions and conditions of the 65-year-old rubble and masonry dams in Johnson Gully;

3. Measure multiple cross-sectional profiles and a longitudinal profile of Johnson Gully to determine how the failure of the dams (recently and in the future) has and will likely affect the morphology of Johnson Gully.

Characteristics of Study Area

The physical characteristics of the area where Company 1749 worked had a direct impact on the types of erosion-control efforts that they performed. Specifically, the high relief of the area and the many outcrops of limestone are two reasons why many rubble and masonry dams were constructed in the area. Johnson Gully is typical of gullies in the extreme northeastern portion of Iowa.

Physiographic Provinces

The town of Cresco lies very near a border between two natural physiographic provinces in Iowa. The Silurian Escarpment, which is a very durable and resistant outcrop of dolomite that is Silurian in age, marks an abrupt change in the type of landforms that are found in the Cresco vicinity (Prior, 1991). This escarpment runs roughly from northwest of Cresco towards the southeast (Figure 1).

The land to the west of the escarpment is known as the Iowan Surface. It is generally a landscape marked by gently rolling hills and low relief. The Iowan Surface is comprised of Pre-Illinoisan glacial drift that was deposited before 500,000 years ago. The area has since undergone intense erosion, which has created its modern characteristics of subdued topography. Loess deposits that are Wisconsinan in age top portions of the inter-basin divide areas (Prior, 1991).

The land to the east of the Silurian Escarpment is known as the Paleozoic Plateau; it is markedly different from the Iowan Surface. This area is dominated by exposures of Paleozoic-aged rock units, which exhibit a great deal of surface landform control (Prior, 1991). The study area, Johnson Gully, is within the Paleozoic Plateau.

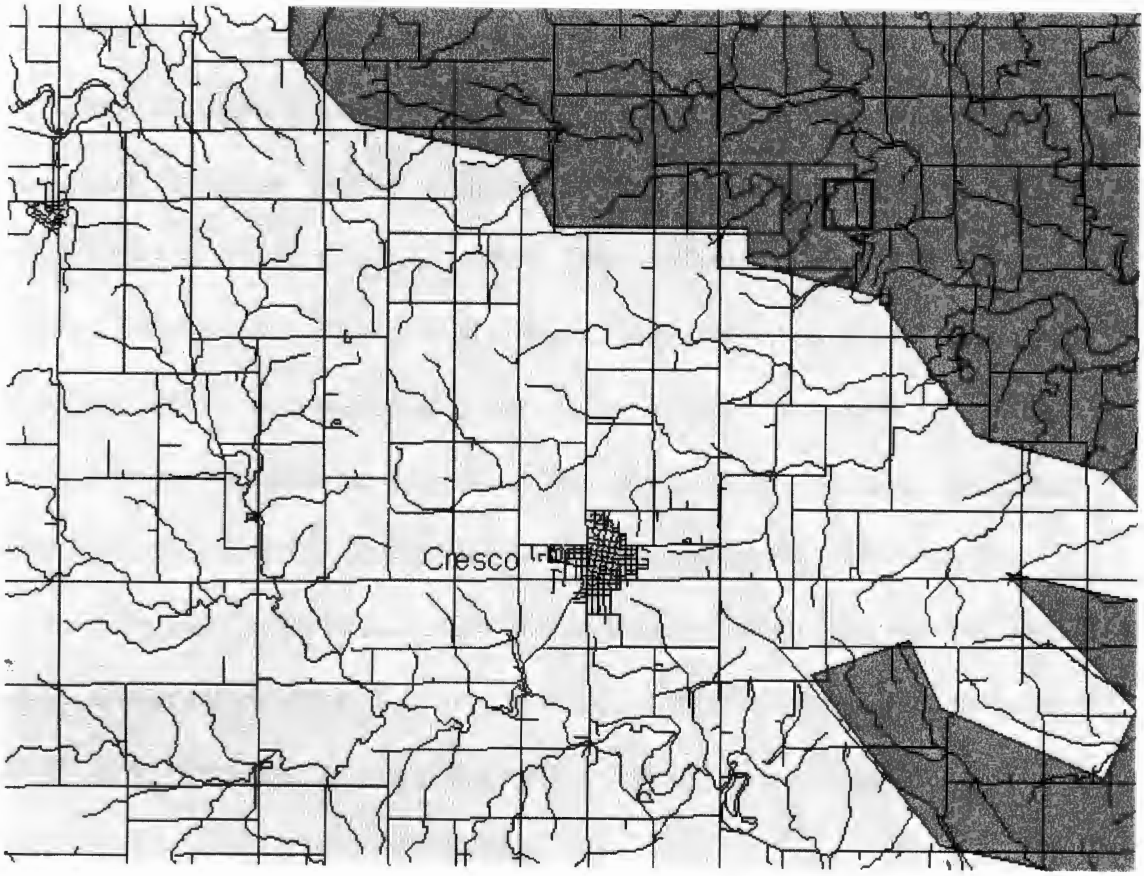

Figure 1. Landforms around Cresco area. Darker gray on right is the Paleozoic Plateau. The area on the left is the Iowan Erosion Surface. The general study area is outlined by a black square in the upper right hand corner. (Data From: Iowa DNR, 1999).

The nature of the Paleozoic Plateau landscape east of Cresco had a strong influence on the work that was done in the area by the CCC. The high relief of this region, and the soils formed in loess, have made this area very prone to gully erosion. It is much more susceptible to erosion than the till-derived soils of the Iowan Surface (Frank Moore, personal communication, November, 1998).

The Upper Iowa River Basin

Many of the gullies that were worked in by members of Company 1749 drain directly into the Upper Iowa River (Figure 2). The Upper Iowa River basin is characterized by narrow, incised, meandering valleys, with steep bluffs that can range from 10 to 200 feet in height (USDA, 1968). The bluffs along the river are comprised of carbonate rocks, which were deposited as marine sediments when shallow inland seas covered the state of Iowa during the Ordovician period (Anderson, 1998). These ancient, marine sediments lithified into dolomite and limestone, which are heavily jointed and fractured (Knudson, 1971). Springs are quite common along the Upper Iowa River because these joints in the bedrock allow groundwater to quickly filter down through the bedrock to near the elevation of the river (USDA, 1968). Gullies that drain the upper interfluves down towards the Upper Iowa River generally have a steep slope because the river is incised so deeply below the uplands.

Soils

The soils that are found along the Upper Iowa River are those of the Steep Rock Land-Dubuque-Dorchester association. The Dorchester soils are found near the river along the bottomlands of the valley, and the Dubuque soils are found at slightly higher elevations on the slopes paralleling the river valley. The area that separates these two soils is often very steep and is generally composed of loose carbonate rock (USDA, 1968).

The Dubuque soils dominate the slope between the bottomland and the upland ridge tops. They generally consist of between 15 to 30 inches of silty material over the

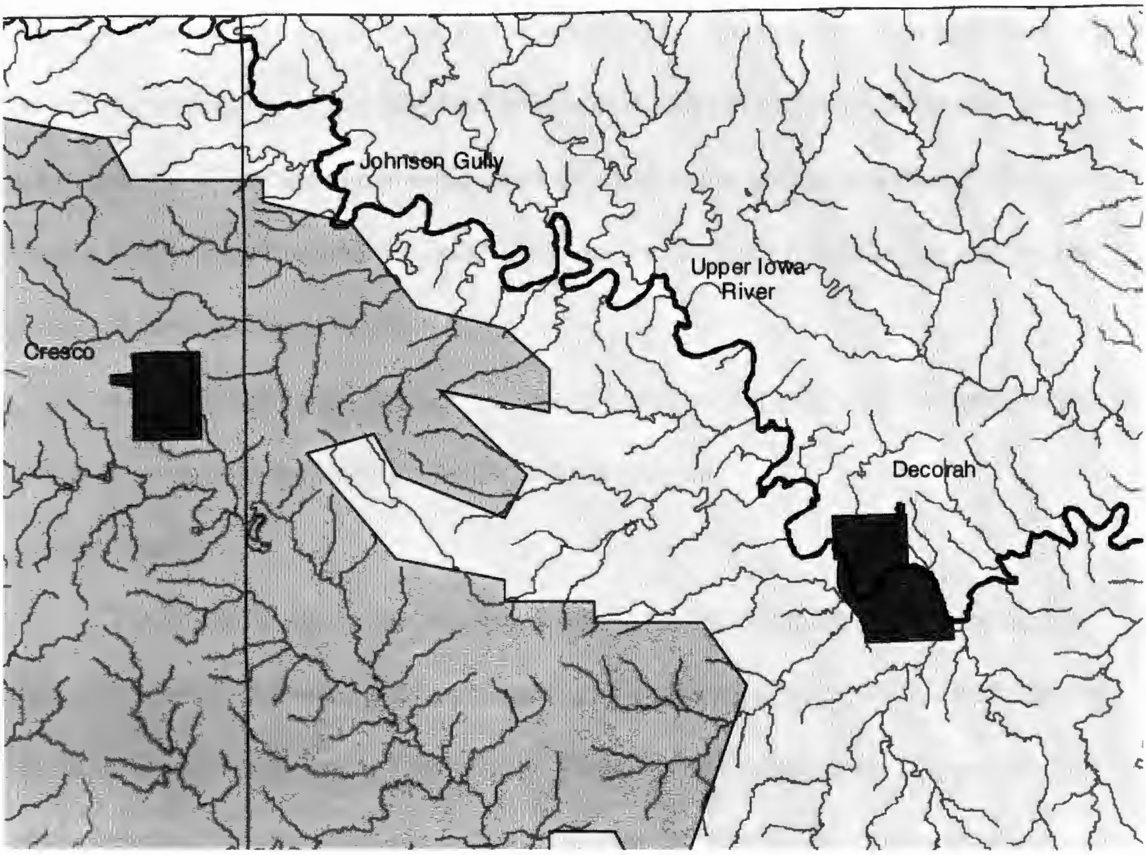

Figure 2. Upper Iowa River through Howard County to the west (left) and Winneshiek County in the center and east (right). The river flows to the east (Data From: Iowa DNR, 1999).

limestone bedrock. The surface soil tends to be rather light in color, while the sub-soil is more brownish and relatively free of mottling. The available moisture capacity of this soil ranges from low to medium, and rapid surface runoff can lead to severe erosion if vegetation is lacking (USDA, 1968). Many gullies have been formed in this soil as water drains from the uplands into the Upper Iowa River.

The Downs-Fayette soil association generally covers the slopes along the ridge tops that surround the Upper Iowa River valley. This soil association was formed in loess on hill slopes that are highly susceptible to severe erosion if conservation measures are not practiced. Carbonate bedrock is often exposed in the gullies that dissect these slopes. Outcrops of this bedrock on the floor of the gullies are knickpoints in the longitudinal profile of these gullies (USDA, 1968).

Johnson Gully runs through an area of Dubuque soil, although its upper drainage area is in an area of the Downs-Fayette soil association.

Johnson Gully

The site selected for this study is Johnson Gully. Johnson Gully is on a farm owned by Patricia Johnson just to the north of Kendallville. Kendallville and Johnson Gully are located in Fremont Township in Winneshiek County, Iowa (Figure 3). The entire length of Johnson Gully is found in Section 28, Township 100 North, Range 10 West.

The gully ranges from being very deeply entrenched in a wooded area near its head to being very shallow along its lower reaches, especially near the floodplain of the Upper Iowa River. In the Upper Iowa River Valley it disappears in places before reforming as it reaches the border of the Upper Iowa River flood plain. The gully contains several bedrock knickpoints, two of which are over one meter high. Personal observations by the author indicate that the gully generally only transports water and sediment after heavy rainfall or during snowmelt.

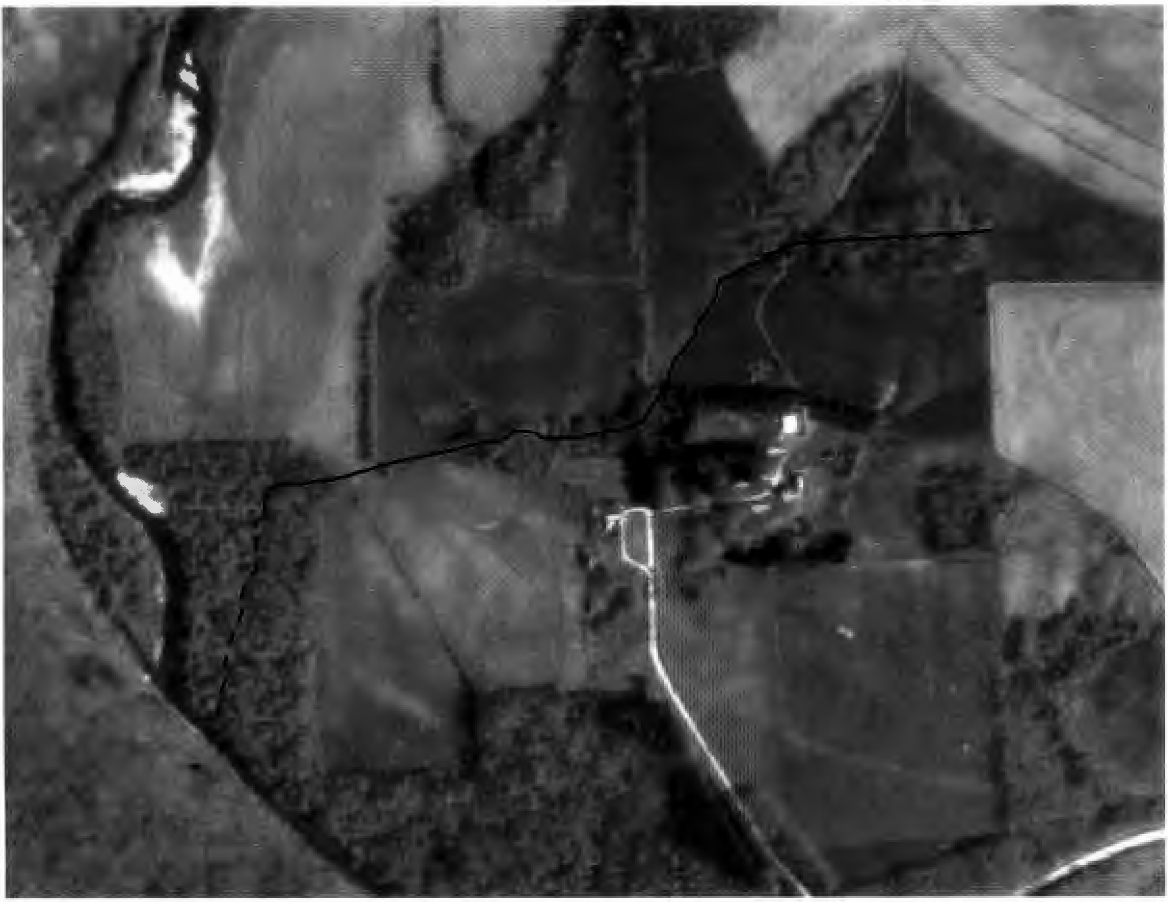

Figure 3. Johnson Gully. Top of image is north. Gully is shown in black and runs roughly from the eastern edge of the image, westward towards the southwestern edge of the air photo. The Upper Iowa River runs from north to south on the left side of the image. The dashed black line at the lower left indicates the route that water takes to the Upper Iowa River, although there is no coherent channel. The farm of Patricia Johnson is shown in the right central portion of the image. Scale unknown. (Photo from: Microsoft Corporation, 1998).

The remainder of the thesis outlines the research methods used in this study, the development of CCC Company 1749, the construction of rubble and masonry dams, the results of this study, and conclusions. The methods used for this thesis are discussed in chapter 2. Chapter 3 reviews the historical background of the CCC and Company 1749 and includes a discussion of the rubble and masonry dams that were built by Company

1749. The results of the data obtained from field work are discussed in Chapter 4 and are analyzed more closely in Chapter 5. Major conclusions are presented and discussed in Chapter 6.

CHAPTER 2

RESEARCH METHODS

Introduction

The research methods used for this investigation were designed to address two different aspects of the investigation. The first of these two aspects was a brief historical investigation of the CCC in Iowa, and Company 1749 in particular. The second portion of the study was a field investigation of Johnson Gully and the CCC dams that were built along it.

Methods for Historical Investigation

The historical investigation of the CCC in Cresco involved a brief study of the overall structure and purpose of the CCC on a national level, as well as at the state level in Iowa. The bulk of the historical research for this thesis dealt directly with rubble and masonry dams, as this is the type of dam that Company 1749 constructed in Johnson Gully. To establish the history of Company 1749's activities in the Cresco area, a number of library resources, newspapers, government agencies, and web sites were consulted.

Library research included a review of materials in the Rod Library on the University of Northern Iowa campus with information pertaining to the Civilian Conservation Corps, Emergency Conservation Work, the New Deal, and conservation practices in Iowa. The library literature search was expanded to include holdings in additional libraries in Iowa, including the University of Iowa Libraries in Iowa City, and Park Library at Iowa State University in Ames. The State Historical Libraries in Iowa

City and Des Moines were also explored. A great deal of information was also obtained from many other libraries through the Rod Library's inter-library loan program.

A number of newspapers that were published during the era of the Civilian Conservation Corps proved to be important sources. These papers included the Des Moines Register, the Cedar Rapid Gazette, and in particular, the Howard County Times. The Howard County Times was published in Cresco, Iowa, at the time that Company 1749 was at work, and recorded much of what was going on in the camp. In addition, the camp's newspaper, the Forty-Niner, was published in the Howard County Times starting in 1936.

The Howard County Times was a great source of information regarding the construction of check dams in the area. The newspaper published reports that were written by the camp superintendent. In these reports he indicated on whose farms dams were being constructed and the methods used in their construction.

Methods for Field Investigation

In order to see how the partial failure of some of the dams that were built along Johnson Gully has affected the gully's morphology, it was necessary to survey the gully. The measurements of the gully included the longitudinal profile of the gully and cross-sectional profiles of the gully at 37 locations. These measurements were used to show how the gully's morphology changes longitudinally and in cross section above and below the dams. These measurements also can be used to infer how Johnson Gully has changed in response to the partial failure of the dams.

The dimensional measurements of the dams included the height, length, and thickness of each dam. The descriptions of the dams also involved the overall condition of the dams, including the conditions of the lateral support walls and the aprons below the dams.

Measurements for Determining the Longitudinal Profile of Johnson Gully

The longitudinal profile of Johnson Gully was determined by surveying with an automatic level and a stadia rod. An automatic level is a leveling device that is used to sight on a level plane. During surveying sessions, the automatic level is first mounted on a tripod and leveled. Once mounted, the automatic level can be swiveled around on its base so that the telescope can be aimed at a stadia rod. The optics of the telescope portion of the automatic level are constructed so that there is a middle cross hair, which is read to determine the elevation of a point, and upper and lower stadia hairs, which are used to determine the distance between the automatic level and the stadia rod.

The stadia rod is a telescoping fiberglass pole that is marked off in metric units down to a thousandth of a meter. It can be extended upward to 7.5 meters. The stadia rod is used by placing it on the ground at a location where you desire to determine its elevation. The stadia rod is then sighted through the telescope of the automatic level. The elevation of the location on which the stadia rod is resting is read off of the cross-hair in the automatic level. The distance, in meters, between the automatic level and stadia rod is determined by subtracting the lower stadia reading from the upper stadia reading and multiplying by 100.

The first step in determining the longitudinal profile was the selection of a starting point. In this case, the starting point was established approximately halfway between the head of the gully and the drainage divide. Once selected, the starting point was marked using a metal fence post that was firmly planted into the ground. The starting point was marked in this manner so that it would be semi-permanent and could be quickly found and referenced. With the starting point marked, all future measurements could be referenced from the initial starting point. Measurements were started by setting up the automatic level about 10 meters downslope of the starting point, placing the stadia rod on top of the starting point, and determining the elevation of the level by adding the height of the level above the starting point to the estimated elevation of the starting point. The elevation of the starting point was estimated using a United States Geological Survey (USGS) 7.5 minute topographic map. Since the measurements used in the longitudinal profile are relative to one another, the absolute elevation of the starting point was not needed. The automatic level was then turned and sighted down the gully. At intervals of about one to two meters along Johnson Gully the stadia rod was placed on the floor of the gully, sighted through the telescope on the automatic level, and the difference in elevation between the instrument height and the gully floor read off of the stadia rod and recorded in a field book.

When the distance between the stadia rod and the automatic level became such that it was either too difficult to read, or the line of sight had become obstructed, the automatic level was moved to a position down-gully of the last gully-floor measurement. Once set up and leveled, the elevation of the automatic level at that new location was established by shooting back on the last point in the gully for which the elevation had been established (pivot point). Measurements of the longitudinal profile continued in this manner until the entire length of the gully had been measured.

The data that had been collected for the longitudinal profile were then entered into a spreadsheet using Microsoft's Excel software. Formulas were developed and entered to determine the differences in distance between point measurements along the gully floor. These individual differences were then added up so that total distance was determined between each measured point of the gully floor and the starting point of the longitudinal profile. Another formula was applied to determine the height of the instrument for each station that was occupied by the automatic level. The elevation measurements of the gully that were taken from each station were then subtracted from the elevation of the instrument to produce the elevation of each recorded point. The elevation of each point was entered in the spreadsheet with its paired distance from the beginning of the profile. The longitudinal profile of the gully was then constructed by plotting the elevations of the gully floor as a function of the distance down the gully. The longitudinal profile was then subdivided into 200-meter units so that sections of the gully could be more closely studied, particularly around the dam sites.

Measurements for Determining Cross Sections of Johnson Gully

Cross-sectional measurements of Johnson Gully were obtained by pulling a measuring tape across the gully from one side to the other at a 90° angle to the gully. After the tape was pulled taut, each end of the measuring tape was anchored to the ground using chaining pins. The elevations of points across the gully were then measured by placing the stadia rod on the ground at each point and sighting the rod through the level. While the stadia rod was used to determine the elevation of the selected point above the gully-floor, the measuring tape was used to determine the distance of the point from the automatic level (Figure 4).

Figure 4. Measuring cross-sections on Johnson Gully. The person in the foreground is sighting through the automatic level on the stadia rod held against the tape that is stretched across the gully. The location of this cross-section is just below Dam 2.

The selection of distances between measuring points along the cross-section was determined by the amount of elevational change. While a long gentle slope would not require many measurements, a steep slope warranted more measurements at close intervals. This was necessary to insure that the characteristics of the gully's cross-section were adequately captured. The locations of many of the cross-sections were immediately upstream of a dam, at a dam, or immediately downstream of a dam. A number of locations were selected between the dams to gather an overall picture of how the morphology of the gully changed in the downstream direction.

The cross-sectional data were entered into a separate spreadsheet using Microsoft's Excel software. For purposes of graphing using relative differences in elevations between each measured point in the cross-section, each elevation reading was subtracted arbitrarily from ten meters; the elevation readings for a single cross-section never ranged over more than ten meters. These values were then entered in the spreadsheet next to the distance of that point from the beginning of the tape measure. The cross section of the gully at each measured site was then constructed by plotting the elevations of the points across the gully as a function of the distance across the gully. The 37 cross-sections were graphed using Excel in a manner similar to the way that the longitudinal profile was plotted. The general location of each cross-section was also plotted on top of a digital orthophoto of the study area using Arc/View GIS.

Observations and Measurements at Dams

At each dam site the condition of each dam was described. This description focused on how structurally sound each dam was. Next, the dams were measured to document where the dams were deteriorating or failing. When this information was combined with the cross-sectional and longitudinal data it was possible to evaluate how much the gully had been altered by the deterioration of the dams.

The questions that were addressed while describing the condition of each dam were: a) does the dam still serve as a sediment trap, or has it partially or completely failed to retain sediment?; b) if the dam is in good condition, is that due to modifications that have occurred since it was first constructed?; and c) if the integrity of the dam has been compromised, by what process or processes did it fail? It was also noted whether or not any portion of the dam was being undermined by fluvial erosion.

The dimensions of each dam that were measured included the length of the dam, the height of the dam above the apron and above the floor of the gully, and the dimensions of the weir spillway notch through which water runs over the top of the dam. I also described and measured the dimensions of the apron onto which the water falls.

Several government agencies provided data and information used in this study. The Natural Resources and Conservation Service (NRCS) in Cresco has experience with modern projects involving soil erosion, and is familiar with the study area. The Farm Service Agency in Decorah, Iowa, the county seat of Winneshiek county, provided aerial photos of the area that showed how the land surrounding Johnson Gully has been used in the past. The Iowa Department of Natural Resources (DNR) provided digital data via their web site that were downloaded and used in a Geographic Information System (GIS). These data sets were used to create maps of the area around Johnson Gully.

Summary of Research Methods

The two general types of investigations that were undertaken were historical research and field research. From the historical research I developed a brief historical overview of the CCC that started on a national level and ended with information about the dams that were built by Company 1749 in Johnson Gully (Chapter 3). The field research included surveying the dams and Johnson Gully and led to the development of a longitudinal profile of the gully and 37 cross-sections of the gully. Many of these cross-sections are near the dams constructed by the CCC and reveal how the morphology of the gully is changing as the dams deteriorate (Chapter 6).

CHAPTER 3

HISTORICAL DEVELOPMENT OF THE CIVILIAN CONSERVATION CORPS, COMPANY 1749, AND RUBBLE AND MASONRY DAMS

Introduction

The Civilian Conservation Corps participated in many thousands of different conservation projects across the nation. When CCC companies came to Iowa, they started work on conservation projects that often dealt with soil-erosion control. With the rugged landforms that Company 1749 encountered near Cresco, Iowa, this emphasis on soil-erosion control was even more pronounced than in most other areas across the state where the CCC was at work. One of the most important efforts of Company 1749 to control soil erosion was their construction of rubble and masonry dams.

The Formation, Organization, and History of the Civilian Conservation Corps

The Emergency Conservation Work (ECW), as the Civilian Conservation Corps was originally named, was passed by the 73rd Congress under Public Act Number 5. The President signed it into law on March 31, 1933, as the "Reforestation and Relief Bill" (Sybolt, 1998).

Robert Fechner, an attorney with a strong background in labor relations, was selected as the first director of the ECW by President Roosevelt on April, 1933. Fechner remained in place as the leader of the ECW as it evolved into the CCC. When he passed away in 1939 he was replaced by the CCC's Executive Director, James McEntee. McEntee held this position until the CCC was liquidated in 1942 (Helms, 1980).

The purpose of the Civilian Conservation Corps was to attack the loss of America's natural resources through somewhat simple works. The CCC would be mostly used for a) forestry works, such as planting trees, b) erosion-control works, such as planting vegetation and constructing dams in areas prone to erosion, c) various types of works geared towards flood control, and d) other related projects that would help to conserve and improve America's natural resources.

The qualifications for enrollment into the CCC were that each man must be in good physical condition, unemployed, unmarried, and have dependents. The enrollee would be required to send the majority of his pay home to help support his family. Originally, 250,000 young men between the ages of 18 and 25 were selected and enrolled in the CCC. The requirements of age were modified in 1935 to ages 17 through 28 (Merrill, 1981).

Each enrollee received a wage of $30.00 per month, but was only allowed to keep a fraction of this pay; $25.00 of this was earmarked for the enrollee's family (Merrill, 1981). In this way the CCC was guaranteed to be used by those who truly needed it, specifically, young men and their families (Salmond, 1967).

Each camp was assigned a letter designation that indicated the types of works that it performed. Cresco, Iowa's Company 1749 camp designation of PE-67 stood for Private Land Erosion control camp number 67. These camps were run by the U.S. Forest Service, the state, and the Department of Agriculture (Sybolt, 1998).

The Civilian Conservation Corps grew and expanded throughout the nation as the years went on and it did much to alleviate the problems of unemployment and natural conservation. On June 28, 1937, by act of Congress, the Emergency Conservation Work was officially changed to the agency known as the Civilian Conservation Corps. Along with its new official designation came a much stronger emphasis in the camps on education and vocational training for the enrollees (Sybolt, 1998). The CCC remained in operation until the needs of war outstripped the needs of national conservation work. Against the wishes of President Roosevelt, the Civilian Conservation Corps was abolished on June 30, 1942.

The Civilian Conservation Corps in Iowa

Just prior to Roosevelt's signing of the Emergency Conservation Work Bill, Iowa's Lieutenant Governor Nels G. Krashcel and State Forester G. B. McDonald made a trip to Washington DC. The purpose of their visit was to submit a state proposal for conservation work to be done in Iowa.

Krashcel and McDonald's proposal was quite detailed. They presented an outline for the location, supervisory requirements, and the estimated cost of operation of 16 camps in Iowa during a six-month period. Robert Fechner, who had already been chosen to act as the head of the CCC, immediately remarked that the proposal submitted by Iowa, was "just what the President is looking for" (Merrill, 1981, p. 128). This occurred just days before authorization of the CCC camps became official (Merrill, 1981).

Company 1749 in Cresco Iowa

During the initial phases of development of CCC camps in Iowa in 1933, young men from the Cresco area who were qualified to enroll were sent to the Army station in Mason City, Iowa. From there they were transported to Fort Des Moines, Iowa, to report for duty. The young men who were successfully enrolled were then distributed to the various CCC camps across the nation.

Later in 1933 word came from Des Moines that a CCC camp was to be established at the Howard County Fairgrounds on the western edge of Cresco, Iowa. The primary purpose of the camp would be erosion control on private lands.

Company 1749 was formed and mobilized on June 1, 1933 at Fort Des Moines, Iowa, and consisted of 206 men. After receiving training, equipment, and general conditioning through the Army, Company 1749 was sent to Preston, Minnesota (Alleger, 1935). Company 1749 moved to Cresco on November 13, 1933. Company 1749 worked on erosion-control projects in the Cresco area until they were consolidated with the CCC camp in Decorah, Iowa, on November 1, 1938 (Patricia Johnson, personal communication, May 22, 1999).

While Company 1749 was similar to the many thousands of other CCC camps across the nation, the works that they performed were often quite different than works performed by the other camps. This is most notable by the large number of rubble and masonry dams that they built in a small geographic area. This high density of dams reflects the nature of the landscape on which Company 1749 was working to control soil erosion.

Construction of Rubble and Masonry Dams by Company 1749 in Cresco, Iowa

The mission of Company 1749 was to work closely with local farmers to implement projects that would halt the erosion of their farmlands. This was accomplished primarily through the planting of trees, the planting of grasses on slopes, the modification of slopes that led towards gullies, and the building of erosion-control structures, such as dams.

Compared to other CCC camps in Iowa, Company 1749 focused more on large, permanent, erosion-control structures. This emphasis was in response to the rugged landscape of the Paleozoic Plateau in northeastern Iowa, as well as the natural resources that were available to them for construction of dams. Gullies are natural landform features in this area, but farming reactivated many of them. The abundant outcrops of limestone in the Paleozoic Plateau provided a good source of rubble for use in constructing the permanent erosion-control structures in these large gullies.

Rubble and Masonry Dams

Rubble and masonry dams were ideal for drops of 10 feet or more (Ayres, 1936), which is characteristic of the sections of Johnson Gully on which they were built. Rubble and masonry dams were also well suited for the work done by Company 1749. This was because the limestone in the area was cheap to quarry, was fairly durable, and the dams could be constructed by the unskilled work force of which the Company was comprised (Ayres, 1936). The plans for building the rubble and masonry dams were easy to follow, and the only real cash investment was for the Portland cement that was used as the mortar (Ayres, 1936).

The dimensions of the rubble and masonry dams were determined by using the drainage area above their placement and the annual rainfall of the area and empirical equations that had been derived by the Engineering Extension Service in Ames, Iowa (Ayres, 1936). Published graphs and tables were used to determine the dimensions of the spillway notch, which needed to be capable of allowing a proper amount of overflow to ensure that the dam would not be washed out. If the spillway notch was too small, water would pool behind the dam and start to run around the sides. This would eventually lead to scouring along the sides of the dam that could ultimately cause the dam to fail (Ayres, 1936).

Once the location of the dam and the dimensions were established, the banks of the gully were sloped so that they were uniform, and the bottom of the gully floor was flattened. Next, a trench was dug across the gully to the top of each sloped bank. This trench served as the foundation for the main wall of the dam, which was built upwards from the floor of the trench. The trench was dug to a depth and width of at least1.5 feet.

While the main wall of the dam was being built upwards from its foundation in the trench, side walls were built parallel to the banks of the gully. These side walls were anchored into the main wall of the dam and laid directly on the cleaned and sloped banks of the gully. The side walls prevented scouring as water ran over the apron and prevented water and sediment from running onto the apron from the sides of the gully.

Both ends of the main body of the dam were extended across the floor of the valley outside of the gully. Typically, they were only a foot or so tall. These wall extensions were built to an adequate distance in order to help protect the flanks of the dam from scour. Scour around the ends of the dam could have occurred if water pooled behind the dam and then ran around the sides of the dam. If this were to happen, fluvial erosion could eventually leave a worthless dam isolated in the middle of the gully.

The apron was then built below the dam where the water would fall to prevent a deep plunge pool from forming (Figure 5). A small retaining baffle wall was built at the end of the apron to help dissipate the energy of the flowing water and prevent downstream erosion by pooling water on the apron before it was released back into the gully (Ayres, 1936).

Figure 5. Undermining due to apron failure. This dam is located west of Kendallville. It will eventually be undermined due to the failure of the apron as the plunge pool enlarges.

The rubble and masonry dams built by Company 1749 helped to slow gully erosion by altering the morphology of the gully in which they had been built. The general idea was to reduce the erosive velocity of the water in the gully by constructing a series of rubble and masonry dams that acted as "checks" (Ayres 1936). These checks changed the longitudinal profile of the gully from a nearly uniform, concave-upward profile that was usually quite steep, to a "stepped" profile with long, flattened areas immediately behind each dam (Ayres, 1936).

Rubble and Masonry Dams in Johnson Gully

The three dams that are in Johnson Gully were built in 1934. They were built in three different locations along the gully, and are currently in three different conditions. They were constructed of limestone rubble and Portland cement. The nature of the limestone has resulted in the dams being slowly eroded by solution, and pried apart be freezing and thawing, as well as by trees taking root between the limestone blocks.

The purposes of these dams were to act as sediment traps and to slow erosion by altering the gradient of the gully locally. Since the dams were made of limestone, they will not last forever. If the dams are not maintained, they will eventually fail, and the gully will then, presumably, revert back to its pre-dam morphology. The dams that are still in good condition provide evidence as to how the dams have worked to modify the gully's morphology and prevent further gully erosion. Those that are in the process of failing offer a glimpse of how the gully will respond when the dams are no longer operational.

CHAPTER 4

RESULTS OF FIELD INVESTIGATIONS

This chapter describes the results of the field investigation of the CCC dams in Johnson Gully. The data obtained from the investigation includes descriptions and measurements of each dam, and a topographical survey of Johnson Gully. Emphasis is placed on the relationships between the conditions of the dams and the morphology of the gully in the vicinity of the dams. The possible future of each of the dams is also explored.

Dimensions and Conditions of Dams in Johnson Gully Compared to Local Gully Morphologies

Three rubble and masonry dams were built by Company 1749 along Johnson Gully in 1934 (Figure 6). Two of these dams were built in the upper reaches of the gully where the hillsides are steeply sloping. The third dam was built on the lower, less steep reach of the gully very near the floodplain of the Upper Iowa River.

Dam 1

The first dam (Dam 1) along Johnson Gully was built very near the head of the gully about 400 meters from the local drainage divide. The location of this dam is also the edge of a wooded area that follows the steep sides of the gully down to the second dam along Johnson Gully (Figure 6). Dam 1 has failed sometime within the last 5 years, and is slowly being destroyed by continued erosion.

The purpose of Dam 1 was to permanently fix the location of the head of the gully (gully headscarp) at the location where the dam was constructed. The dam was

Figure 6. Location of all dams on Johnson Gully. Locations of dams are indicated by white squares. Top of image is north. Scale unknown. (Photo from: Microsoft Corporation, 1998).

constructed to not allow the headscarp of the gully, which was active in the 1930s, to retreat further up the swale into the farmer's agricultural fields.

Dam 1 is no longer serving as a sediment trap because its northern side has been destroyed and water is now able to run around this side. The landowner estimated that Dam 1 was probably fully functional within the last five years (Scott Johnson, personal communication, March, 1999). The dam currently stretches in length from the south side of the gully 7.17 meters to the north. The full extent of the dam to the north when it was first built is not know, as it is the northern part of the dam that has been destroyed.

The destruction of Dam 1 occurred because a tree became established along the northern side wall of the dam sometime after its construction. As the tree grew it exerted a great deal of pressure on the north side wall of the dam. As the tree continued to grow, so did the pressure on the side wall. Eventually the pressure on the side wall exceeded its resistance and the side wall collapsed. When this happened, the base and roots of the tree shoved the side wall and a portion of the apron inward towards the center of the gully. The tree now rests with its base and roots in the middle of the gully on top of the old apron intermingled with the rubble of the side wall and apron that it shoved aside. The rest of the tree stretches northward above the gully onto the side of the hill (Figure 7). In essence, the tree acted as a lever that pried open the side of the dam.

Due to its poor condition, I was not able to measure Dam 1 as thoroughly as the other dams. The length of the main wall of Dam 1 across the top is 4.51 meters. The notch of the dam starts 1.55 meters from the south end, and steps down vertically 0.26 meters. The notch extends 3.6 meters before it steps back up vertically 0.26 meters. The dam then extends an additional 0.65 meters north before it ends abruptly due to the failure on the north side (Figure 8). The thickness of the top of the dam is 0.4 meters. The spillway notch is now 2.5 meters above and .82 meters south of the current gully floor.

It is still possible to measure the southern portion of the apron, which stretches close to 3.4 meters from the bottom of the spillway to the baffle wall at the end of the apron. The end of the apron is at least 0.55 meters thick. The baffle wall itself is also

Figure 7. Destruction of the north side of Dam 1. The collapse of this tree forced the north side of the Dam into the middle of the gully.

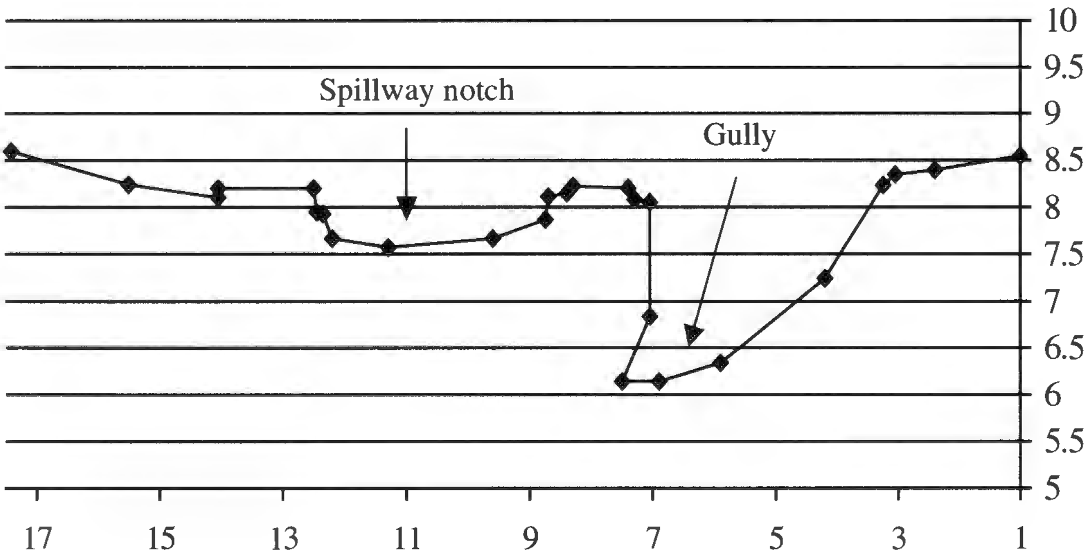

Figure 8. Cross section of Dam 1. North is to right. Horizontal and vertical units are meters.

still recognizable at the southern end of the apron. The baffle wall rises 0.45 meters above the apron pooling area.

The apron area is full of debris from the collapse of the tree. A great deal of the limestone 'rubble' was pushed up into a heap along the northern part of the old apron area by the tipping of the tree and the leverage of its roots. This limestone consists of the old side wall to the north and the northern part of the apron. This mixture of rubble and other debris is such that small trees have been able to take root in this area. The apron is no longer the main discharge area for water coming down the gully, as the active gully has shifted northward and bypasses the notch in the dam (Figure 9).

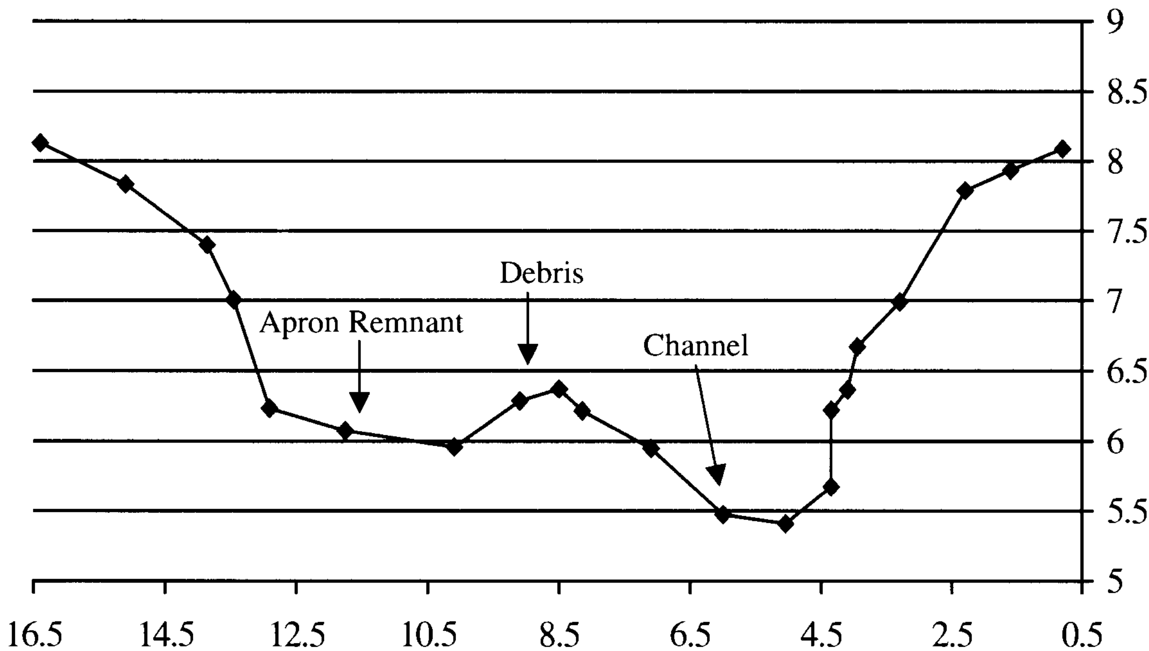

Figure 9. Cross section of Johnson Gully across the apron of Dam 1 downstream of the main wall. Debris has been pushed into the center of the old apron. The active gully has shifted to the right (north) side of Dam 1.

Because both the north end of the main wall and north side wall of Dam 1 have failed, the original north bank of the gully also has been laterally eroded by running water. This has led to the exposure of the portion of the dam base that was built in the trench along the gully's north bank. Currently, it projects into the air off of the current gully floor. This process has revealed the location of the pre-dam bank of the gully. A portion of the side wall that was built on the gully's north bank is still anchored into the main wall of the dam (Figure 10).

The portion of the north end of the dam that was built above the top lip of the gully and that was designed to funnel water toward the notch is now a long slab of limestone and concrete lying on the gully floor next to the dam wall. It fell into the gully after the dam failed.

The southern side wall of Dam 1 is still intact. It is anchored to the main wall of the dam and runs about 3.4 meters to the end of the apron. It is 1.15 meters tall and still lies upon the angled bank as it was constructed. It should be noted that a young tree has taken root in a crevice of the limestone 'rubble' that makes up this wall. If this tree continues to grow unchecked, it will eventually cause a great deal of damage as it pries the wall apart over time.

The Effect of the Failure of Dam 1 on Gully Morphology

When the tree collapsed and destroyed the north side wall of Dam 1 water started to pour through the newly created opening and erode alluvium upslope of the dam, including the historical sediments that had collected behind the dam. The dam now acts as a barrier that deflects running water toward the opening around the north end of the dam (Figure 11).

Figure 10. The north end of Dam 1. The location of the old gully bank from when the dam was built can be seen about three-quarters of the way down the center of the photo where the main wall starts to slant inward. The remnant of the extension of the side wall that fell down in the gully as it formed around the dam can be seen to the lower right of the photo.

Figure 11. View behind Dam 1 facing downstream (west). Water is being deflected by the dam to the right of the figure (north) were it has eroded around the dam. Remnant historical fill can be seen to the left of the figure (south) underneath the abandoned spillway notch (top left of figure).

The creation of the new opening around the north end of the dam has resulted in the removal of the historical alluvium that was stored behind the dam and the retreat of the gully headscarp 9.5 meters upslope of the location of Dam 1 (Figure 12). The width of the newly created gully upslope of Dam 1 varies from 1 meter wide near the gully headscarp to 4.9 meters wide near the dam. The depth of the gully upslope of the dam varies from .68 meters at the headscarp, to 1.54 meters deep in the remaining historical fill behind Dam 1. Thus, a great amount of sediment has been eroded away in response to the failure of this dam. The retreat of the gully headscarp upslope into the rill and swale up valley of the alluvium that has been stored behind the dam over the last 65 years will progress unabated as Dam 1 continues to be destroyed.

Figure 12. Extension of gully upslope of Dam 1. The headscarp of the gully is working its way upslope to the east (left). Dam 1 is just to the right of the photo.

The area directly up-valley of Dam 1 now consists of a low, convex-upward bulge that represents the surface of sediment that has been stored behind Dam 1 since it was built (Figure 13). This bulge is flanked on both sides by very shallow rills. The rill to the north of this bulge was used for the longitudinal profile. This rill also bulges upward quite a bit behind Dam 1. The western portion of sediment immediately behind the dam has been eroded away due to the failure of the dam and the subsequent movement of the gully's headscarp 9.5 meters into this sediment.

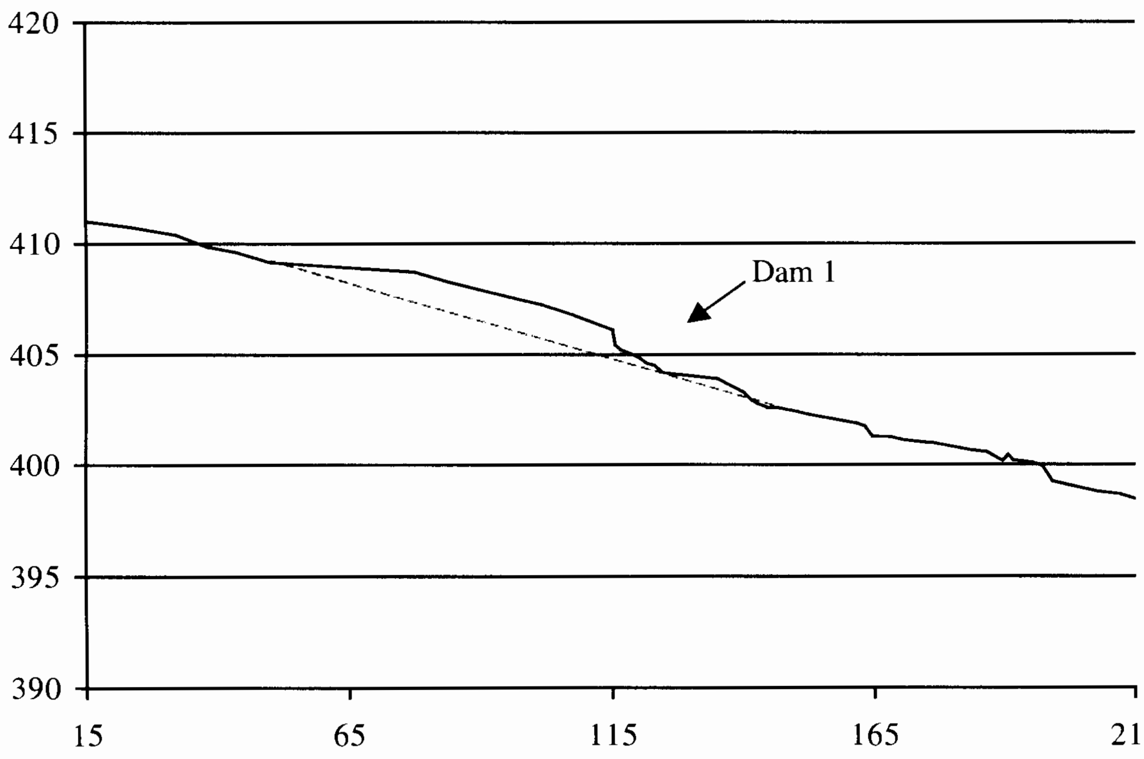

Figure 13. Longitudinal profile of the first 200 meters of Johnson Gully. A dashed line has been added that connects the rill upstream of the convex-upward bulge to the gully floor immediately below the remnants of Dam 1s apron. The gully is sloping to the west.

Since failure of Dam 1, the water that once drained over the dam through the spillway notch and pooled on the apron below now runs swiftly around the dam. The result of this has been incision of almost 1 meter (Figure 12 and Figure 14) to a distance of 9.5 meters behind the dam. Though the headscarp is currently stationary at the edge of a cow path (Figure 15), it will likely continue to retreat into the stored historical sediment.

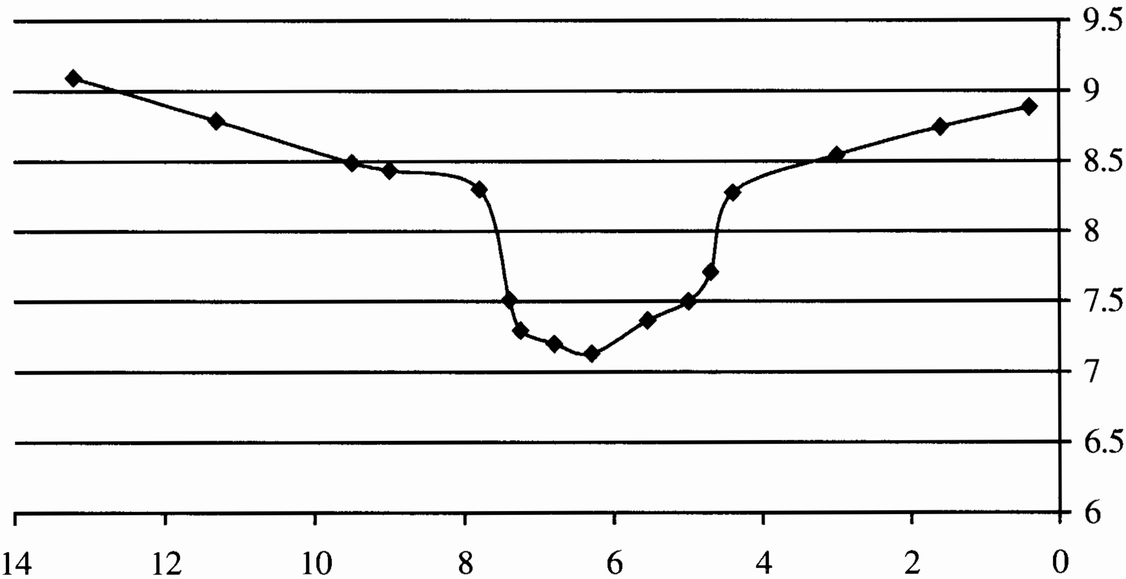

Figure 14. Cross section upstream of Dam 1. This channel has developed in the historical alluvium that was trapped behind Dam 1 before its failure. Horizontal and vertical units are in meters.

In summary, Dam 1 was built in 1934 to help keep the headscarp of Johnson Gully from retreating any further up the hill into the agricultural field. The failure of Dam 1 is estimated by the landowner to have occurred sometime within the last five years. The failure occurred when a tree collapsed and tore out the north side wall. The result has been erosion of the north side of the gully, and the retreat of the headscarp upslope. Thus, the failure of Dam 1 has altered the morphology of the gully in the vicinity of Dam 1. The failure of Dam 1 has resulted in the reactivation of the headscarp. Today the headscarp is slowly retreating up valley into the rill upslope of the dam.

Figure 15. Headscarp upstream of Dam 1.

Dam 2

Dam 2 is approximately 200 meters down-valley of Dam 1 (Figure 6). Dam 2 is in much better condition than Dam 1. The length of Dam 2 from north to south across the gully is 12.05 meters. The top of the main wall of the dam runs from the north for

2.55 meters to the south before it starts to taper down into the notch. At the beginning of the notch, it steps down through the layers of limestone that were stacked on top of each other 0.65 meters horizontally and 0.58 meters vertically into the spillway notch. The spillway notch then runs southward for 5.2 meters until it steps back up to the top of the dam 0.4 meters horizontally and 0.61 meters vertically. The top of the main wall of the dam then extends on for another 3.0 meters south (Figure 16).

The thickness of the of the main wall of the dam at the very top is about 0.35 meters, while the thickness of the dam at the spillway notch is 0.64 meters. The spillway of Dam 2 drops 2.2 meters from the lip of the spillway down to the apron. The apron is not the original apron that was built with the dam (Figure 17). It was replaced by a concrete apron in the mid 1980s (Scott Johnson, personal communication, March, 1999).

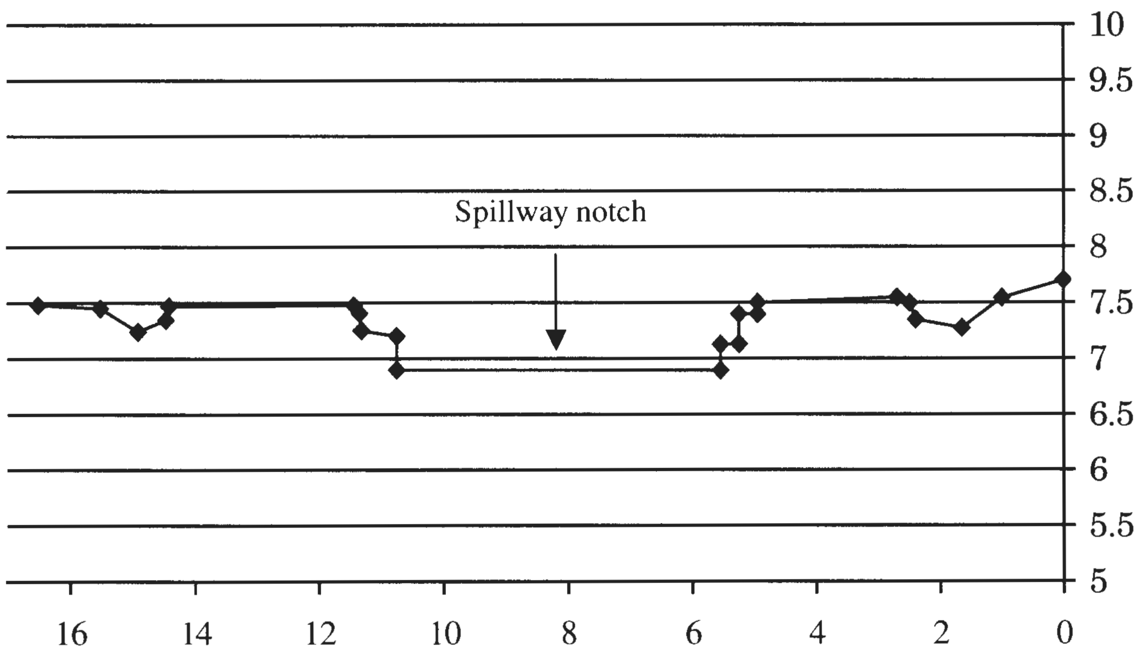

Figure 16. Cross section across the top of Dam 2. Horizontal and vertical units are in Meters.

Figure 17. Dam 2. Note the concrete apron that has replaced the original apron. View is upstream.

The reason this dam has been maintained is because a road runs across the historical alluvium fill in the gully just upstream of the dam, and the road is needed by the landowner to move heavy equipment from the farm to the fields (Figure 18). The concrete apron has helped keep the dam stable. Remnants of the old baffle wall that was a part of the end of the old apron are still visible in the gully not very far downstream of the new apron. The new apron does not have a baffle wall. Portions of the new apron are being undercut, as the water is not slowed as it runs across the concrete apron and flows over its end into the gully. The concrete apron extends downstream 4.65 meters from the bottom of the main wall of the dam. The downstream end of the apron is about 0.47 meters above the gully floor. The apron is 5.7 meters wide from side wall to side wall.

Figure 18. View from the north toward the southeast of Dam 2. This fill behind the dam is used to drive farm equipment over the gully to the field above.

The south side wall of the dam along the bank of the gully is in very good shape. The thickness of the side wall at the bottom of the apron floor 1.65 meters. It runs approximately 4.6 meters in length from where it is anchored into the main wall of the dam to its downstream end. On the outside of this south side wall there is a very small channel that has formed from water running around the south extension of the main wall. Water runs around the south extension of the main wall because it is able to spread out laterally across the historical fill behind Dam 2. This channel does not appear to threaten the stability of the southern side wall or the dam (Figure 19).

The condition of the northern side wall of the dam is not as good as that of the southern side wall. A small shallow channel has developed in the fill that has accumulated upstream of the dam. Water usually flows down the gully to the spillway notch via this small channel. A tributary gully enters Johnson gully alongside the northern part of the dam just a couple of meters upstream. The inflow of water from this tributary gully, along with the water that flows down Johnson gully, results in an overflow to the north of the gully around the main wall of the dam and the north side wall. This water has caused the north side wall to be partially undermined, and a significant channel has formed alongside the dam to the north. This bypass gully carries water around the dam into the gully downstream of the dam. The water that flows through this bypass channel actually runs alongside the outside of the remaining side wall (Figure 20).

Running water has eroded the outside of the northern side wall so that it is only 0.28 meters thick at its top and 0.45 meters at its end. The channel averages about 1.7 meters wide and is about 0.8 meters deep from the bottom of the channel to the top of the remaining concrete cap that makes up the top of the side wall of the dam. If preventive measures are not taken, the northern side wall will eventually fail, and the gully will continue to deepen and widen around Dam 2 as it has at Dam 1.

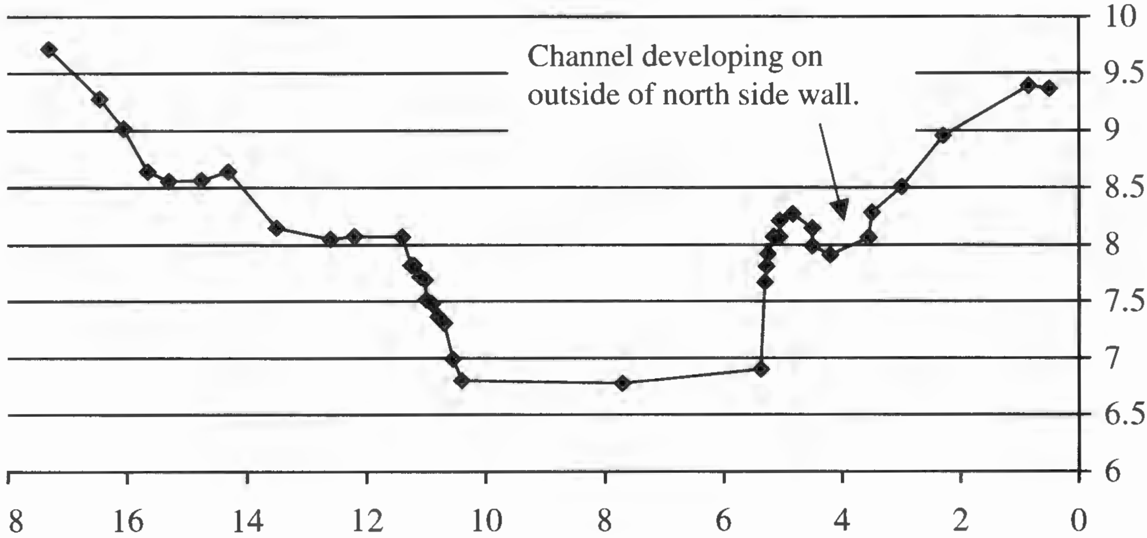

Figure 19. Cross section directly downstream of Dam2. This cross section runs from north (left) to south (right) over the side walls and apron of Dam 2. A channel has formed on the outside of the north side wall.

Figure 20. Dam 2 as viewed from the north. A small channel can be seen that flows around the northern side of the dam. A small tributary gully enters this area from the left.

<u>The Current Effect of Dam 2 on Gully Morphology</u>

The morphology of Johnson Gully changes just upstream of Dam 2. The side walls of the gully become much less steep and the gradient of the longitudinal profile decreases slightly. The gradient of the gully decreases on the historical sediment that has accumulated behind Dam 2 (Figure 21). Water velocities in the gully are reduced behind Dam 2 due to this reduction in slope caused by the accumulation of historic alluvium. Thus, Dam 2 is serving the purpose for which it was constructed.

The longitudinal profile near Dam 2 indicates that there is a slight convex-upward bulge immediately behind Dam 2 (Figure 21), although it is not nearly as dramatic as the one behind Dam 1. This convex-upward profile of the historical alluvium is deflecting water toward the north end of the dam. This, along with the entrance of water from a side gully, is allowing water to run around the north side wall of the dam. This redirection of the flow of water just upstream of Dam 2 is resulting in erosion of the north side wall of the dam from the outside in. If this side wall should fail in the future, the gully may bypass the dam as it has done at Dam 1. The result would be that the historical sediments behind Dam 2 would be eroded away, along with the road that runs over them, and the longitudinal profile of the gully will locally steepen. This will lead to an increase in the velocity of water which will, in turn, increase erosion.

The limited effect of check dams in gullies is demonstrated at Dam 2 in Johnson Gully. The dam initially rapidly changed the morphology of the gully by trapping sediments. The storage of alluvium behind Dam 2 is now leading to the demise of the dam by rerouting water around the dam. This will eventually lead to the reestablishment of the pre-dam morphology at this point in Johnson Gully.

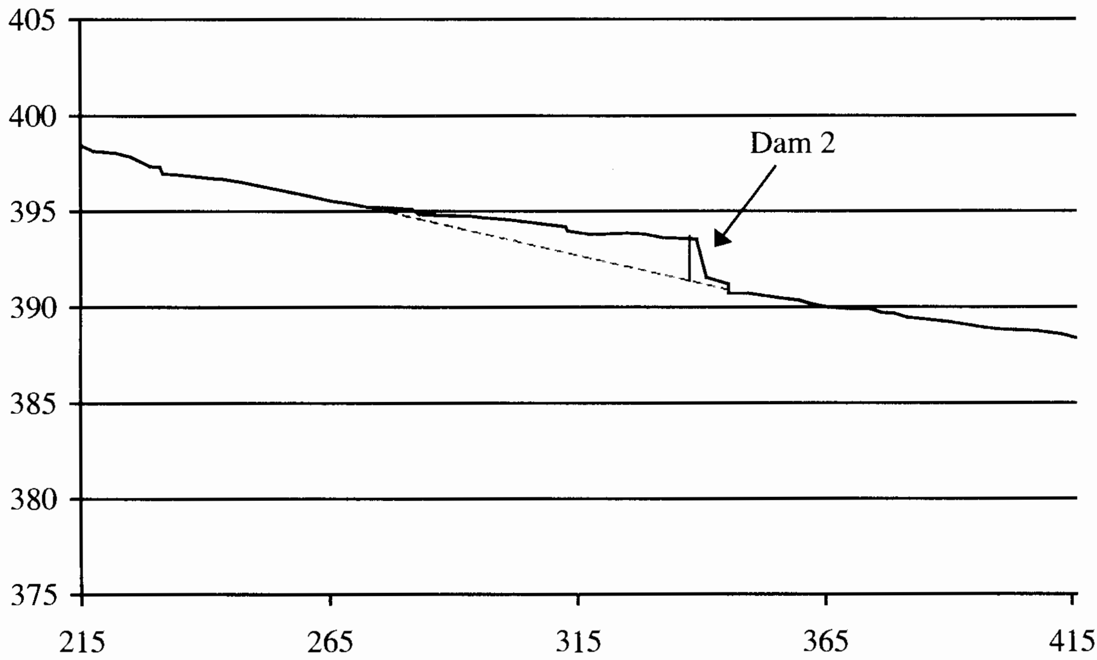

Figure 21. Longitudinal profile of Dam 2. A dashed line connects the gully floor from the start of the accumulated alluvium upstream of Dam 2 to the gully floor below the apron.

In summary, Dam 2 is still serving as a sediment trap and artificial knickpoint in the longitudinal profile of the gully. It is still in very good shape because of its value to the landowner; the historical sediments behind it serve as a bridge for farm machinery to travel to across. Therefore, the landowner has maintained the dam. In the mid 1980s the heavily-damaged original apron was replaced with one made of concrete. The lack of a baffle wall at the end of the new concrete apron, however, allows water to reenter the gully without its velocity being reduced. This increase in velocity has created renewed down-cutting just below Dam 2. While modification of the apron has helped to keep the dam operational, water flowing around the northern side wall of Dam 2 may eventually lead to its demise.

Dam 3

Dam 3 is about 686 meters downstream of Dam 2 (Figure 6). It was built in an area of much lower local relief than Dams 1 and 2. The main wall of Dam 3 is not as high as those of Dams 1 and 2, but is much longer than those of the other dams.

The length of the main wall of the dam is 15 meters. The spillway notch of the dam starts 3.85 meters from the north end, and steps down vertically 0.57 meters in a horizontal distance of 0.5 meters. The north side of the notch is filled with sandy alluvium to a depth of .13 meters. The bottom of the spillway notch extends for 7.15 meters before it steps back up vertically 0.62 meters in a horizontal distance of 0.41 meters. The dam then extends an additional 2.84 meters to its southern edge (Figure 22). The thickness of the dam wall at the notch is about 1 meter.

The distance from the top of the dam down to the apron was hard to determine because the apron area is covered with alluvial sand. The vertical distance downward from the top of the notch to the sand on the apron is 1.16 meters. This vertical drop is significantly smaller than those of Dams 1 and 2. The apron is virtually covered with alluvial sand because a tree that fell directly downstream of the apron has three very large branches growing upward that have collected woody debris. This woody debris has formed a small, natural dam at the end of the apron that is helping trap alluvium (Figure 23).

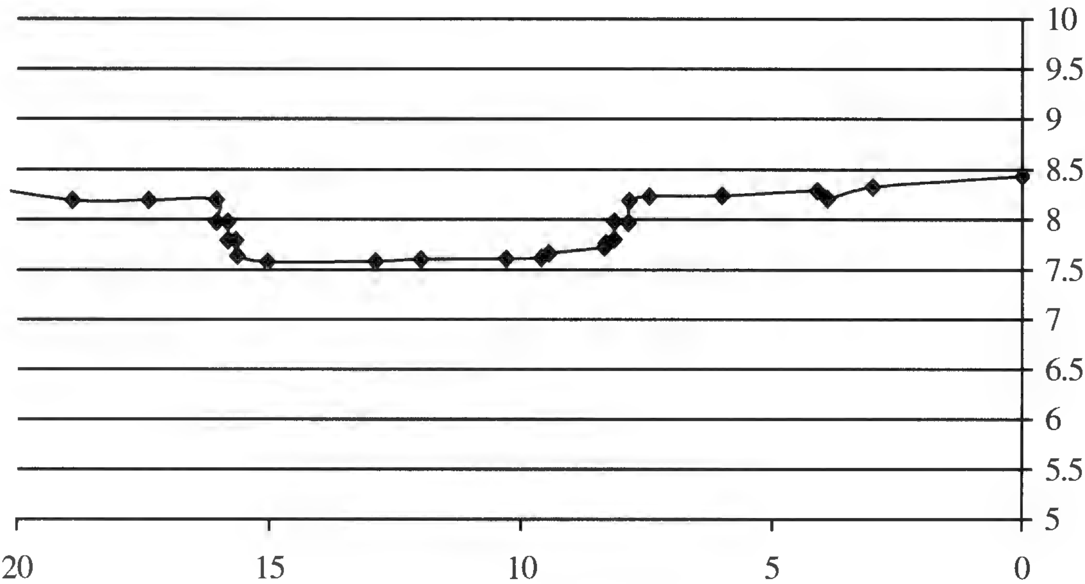

Figure 22. Cross section across the top of Dam 3. Horizontal and vertical units are in meters.

Figure 23. Debris on apron of Dam 3. Woody debris has formed a dam at the end of the apron that is trapping the large volumes of alluvial sand. View is from the southeast facing the northeast. Dam 3 is in the lower right portion of the figure.

The width of the apron is approximately 3.8 meters from side wall to side wall, although this is a rough estimate, as the north side wall has been severely disturbed by a number of trees that have grown upwards through the limestone. These trees have to pried apart the north wall into a large heap of rubble.

The southern side wall is still in very good shape. It is nearly 1.8 meters thick from its outer edge to the apron floor, and stretches from where it is anchored in the main wall of the dam to the baffle at the tip of the apron.

The baffle at the end of the apron is, for the most part, buried in alluvial sand. The baffle is still partially visible at its southern end. There it is 0.55 meters high and 0.22 meters thick.

A tunnel has developed in Dam 3 that is a result of the limestone rubble used in its construction. When disharge down the gully to the dam is low, the water runs down into a depression leading to a tunnel that has developed at the southern edge of the spillway notch behind the main wall of the dam. This tunnel extends downward through the alluvial sediments and into the dam wall to exit at an opening in the dam wall that is midway down the wall. The water that takes this route runs through thealluvial sand in the apron along the southern side wall. A channel has developed in the sand that is on the apron along this side wall from where the water spills out of the wall to the southern edge of the baffle wall (Figure 24). This part of the baffle wall is still visible because of this running water. As water continues to flow through this tunnel in Dam 3, it will continue to erode the limestone through solution, and may eventually undermine the main wall of the dam.

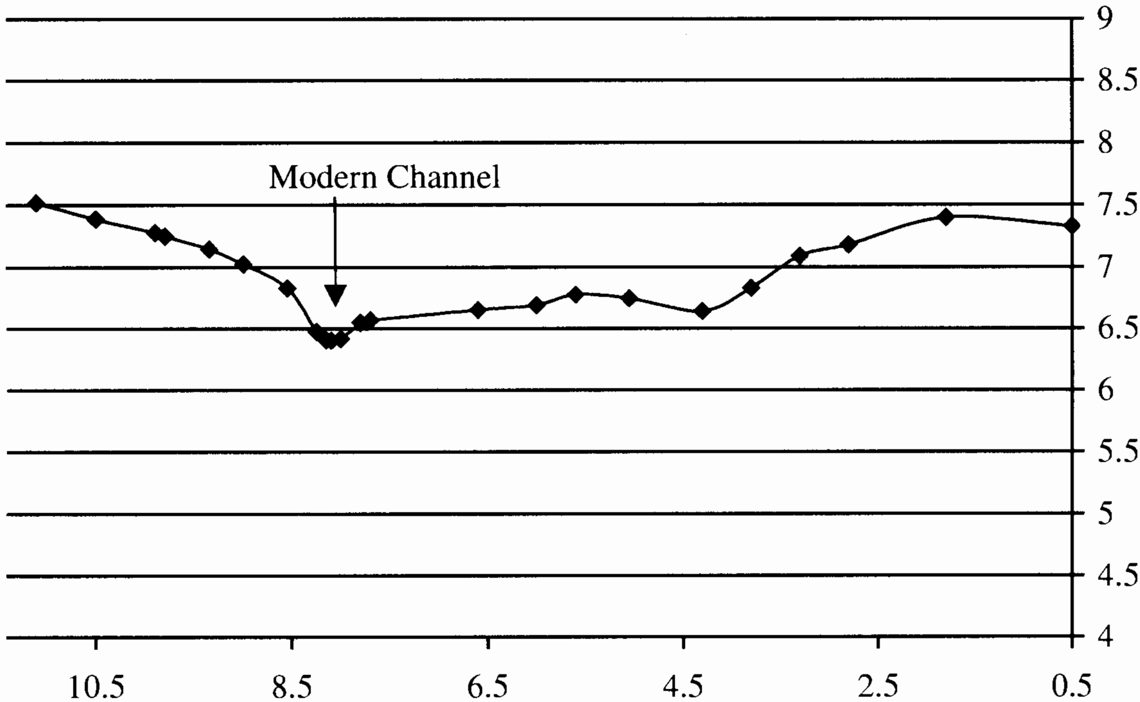

Figure 24. Cross section across apron of Dam 3. A small channel has developed in the sandy debris that covers the apron on the left (south) side. Water flows through a cavity in the main wall of Dam 3 and onto the apron at the location of this channel.

The Current Effect of Dam 3 on Gully Morphology

The influence of Dam 3 on Johnson Gully can be seen much further upstream than the effects of Dams 1 and 2. The historical sediment that has been trapped behind Dam 3 slows down water for a long distance upstream. The result has been the formation of a rather substantially sized alluvial fan consisting mostly of sand. The formation of this alluvial fan is due to the reduction in water velocity brought about by the development of the nearly flat historical alluvium behind Dam 3. The gully channel virtually disappears at the apex of the alluvial fan. There are very small, minor channels branching across this fan from the shifting water as it has spread across this area in the past. The fan has aggraded to such an extent that the cross-sectional measurement of the fan shows that the area to the north is actually lower in elevation than the channels on the fan (Figure 25). There is also a slight rise in the longitudinal profile due to the alluvial fan (Figure 26). During the surveying of Johnson Gully, it was observed that snow melt that reached the alluvial fan pooled in its shallow channels and slowly infiltrated into the ground. The characteristics of this sector of the gully are markedly different from the rest of the gully.

The gully channel reappears downstream of the alluvial fan, and then branches out into several channels as it approaches Dam 3 (Figure 27). This seems to be the result of the volume of historical sandy sediment that has accumulated behind Dam 3 and the flatter profile of the gully in this area. While there is also a convex-upward bulge in the surface of historical sediment directly behind Dam 3, it is not readily apparent in the longitudinal profile because the profile was measured through one of the main, deep channels that had developed in the sandy sediments behind the dam.

There is evidence that the large amount of sand being delivered to Dam 3 through Johnson Gully may eventually overwhelm and bury the dam in historical alluvium. This evidence includes: (a) the alluvial fan just upstream of Dam 3, (b) the large amount of sand immediately upstream of the dam, and (c) the amount of alluvial sand on the apron. However, it is also possible that if the tree at the end of the dam that is retaining so much of the alluvium were to be removed, then the apron of Dam 3 might be flushed clean during a peak discharge period.

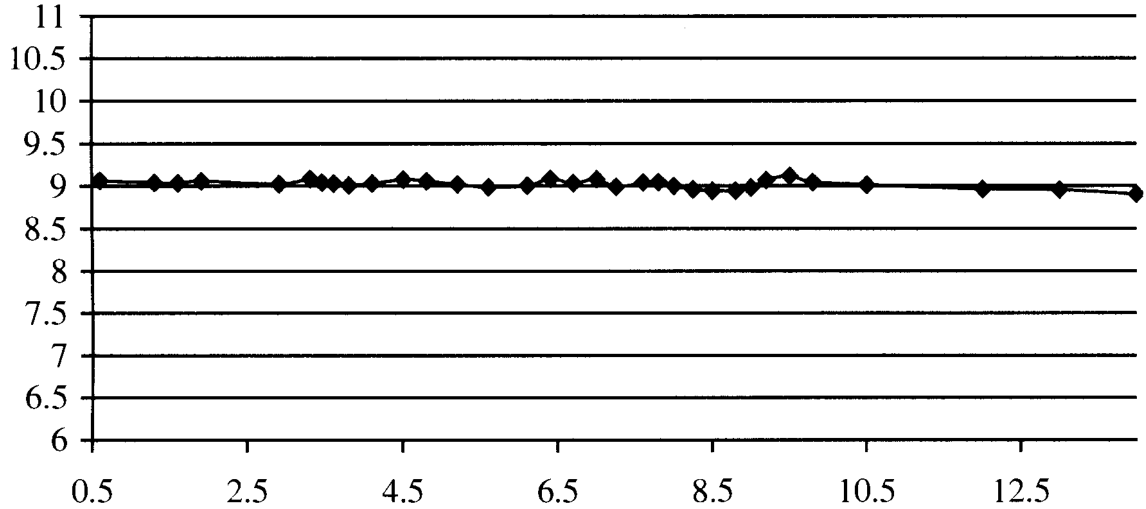

Figure 25. Alluvial fan cross section. Notice that the northern (right) edge is lower than the small channels in the fan. Horizontal and vertical units are meters.

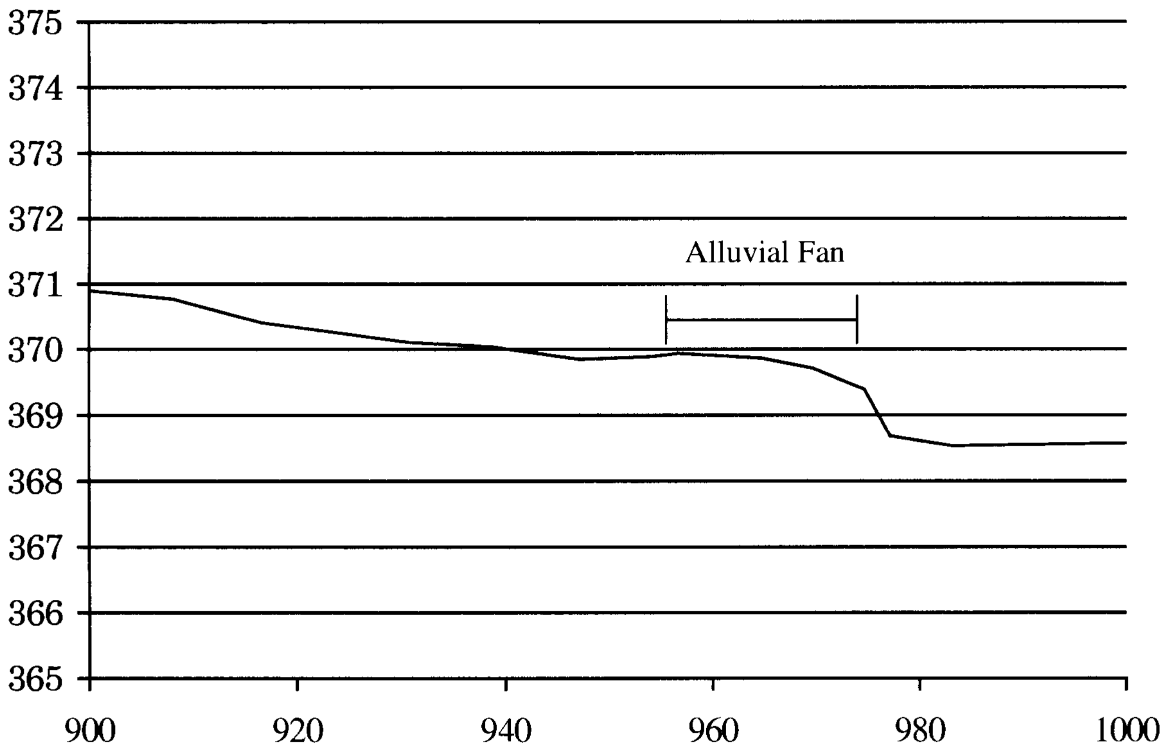

Figure 26. Longitudinal profile of the alluvial fan. In the depression (at approximately 945 meters) before the fan, water often sits and dissipates into the ground. Gully is sloping to the west (right). Horizontal and vertical units are meters.

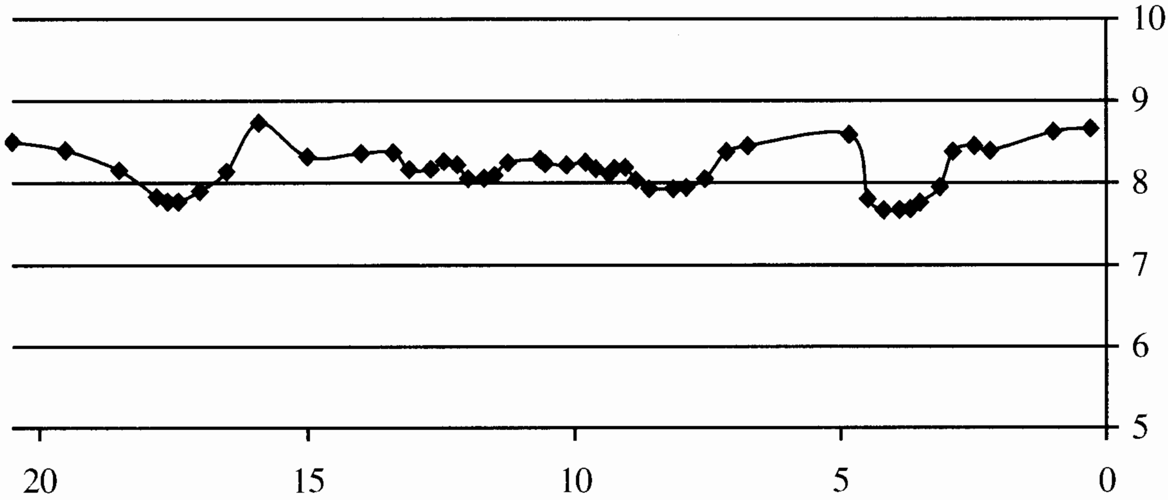

Figure 27. Cross section across the fill upstream of Dam 3. Braided channels have formed in this sandy historical fill. The main route of water is in the channel to the north (right). Horizontal and vertical units are meters.

Johnson Gully quickly flattens and shallows downstream of Dam 3. Within 40 meters of Dam 3 the channel of the gully disappears as a discrete, recognizable channel. The remainder of the distance from this point to the Upper Iowa River consists of the river's flood plain. Any water that makes it to this point will spread out and infiltrate down into the soil.

In summary, Dam 3 is serving as an effective sediment trap to such a degree that it may eventually be completely covered by historical alluvium. It continues to alter the morphology of Johnson Gully by retarding flow through the gully. While Dam 3 is effectively serving its purpose as a sediment trap, it is slowly loosing its integrity. Trees growing along its northern side wall have pried it apart, and the main wall of the dam is being eaten away by solution.

CHAPTER 5

DISCUSSION

The immediate impacts that the dams built on Johnson Gully had on the morphology of the gully were the accumulation of historical sediments behind each dam. This led to a reduction in the slope of the gully at each dam, and a reduction in the erosive velocity of the water traveling down the gully. The purpose of this thesis was to determine the current effectiveness of the dams built on Johnson Gully, the current morphology of the gully at the dams, and any modifications of the morphology of the gully due to the current and changing conditions of the dams.

An overall assessment of the current effectiveness of the three dams on Johnson Gully in controlling gully erosion and influencing the morphology of Johnson Gully can probably be best viewed by looking at where sediments have accumulated in the gully and how the longitudinal profile changes near the dams. As the original modification of the morphology of Johnson Gully was the creation of steps in the longitudinal profile as sediments accumulated behind the dams, any changes in this stepped appearance behind a dam should reflect the present condition of that dam.

Over time, sediment behind Dam 1 had accumulated to such a degree that a convex-upward bulge formed in the longitudinal profile upstream of Dam 1 in the area that had been an active channel prior to the construction of Dam 1. The accumulation of sediment behind Dam 1 indicates that a large amount of sediment was prevented from moving downstream. The reduced gradient of this stored sediment behind Dam 1 reduced the velocity of runoff above Dam 1. The reduction in velocity brought about by this sediment wedge that is buttressed by Dam 1 helped to slow down the rate of erosion from the field upslope of Dam 1.

Since the failure of Dam 1 within the last 5 years due to the collapse of a tree, the historical sediment plug behind Dam 1 has been eroding to such a degree that the headscarp of Johnson Gully has now moved 9.5 meters into the sediments up-valley of Dam 1. The renewed activity of the headscarp due to the failure of Dam 1 will result in the rapid loss of all of the accumulated historical alluvium behind the dam. The gully will revert back towards its earlier morphology upslope of Dam 1. While Dam 1 was an effective erosion-control structure for nearly 60 years, its failure makes it no longer viable as an erosion-control structure. Due to the destruction that has already occurred to Dam 1, it is unlikely that any remedial action will be able to salvage what is left of the dam.

Dam 2 is still serving as an effective erosion-control structure. Much historical alluvium has accumulated behind it, and there is also a small convex-upward bulge in the longitudinal profile upstream of it. Because Dam 2 is still in good shape structurally, the material behind it still acts to reduce the slope of the gully floor and helps to reduce the velocity of the water flowing down the gully. This reduction in velocity helps to slow erosion both upstream and downstream of Dam 2.

Dam 2 is still in good shape because of the work that has been done on its apron. The concrete that was used to replace the original apron has provided renewed protection for the dam. The new apron has prevented the dam from being undermined by water falling over the spillway notch. However, the new apron does not have a baffle wall at its end. Therefore, the water that flows off of it is not slowed down as it reenters the gully. This impedes the protection of the gully downslope of the dam due to the fact that the velocity of water is not slowed down as it was when the original apron was in place that had a functional baffle wall.

The present structural integrity of Dam 2 is directly related to the work that was done on its apron. Work was done on the apron because the accumulated sediment behind the dam is used as a roadway for fording equipment across the gully.

While Dam 2 is still in good enough shape to act as an effective erosion-control structure, it is not safe from failure. Water is currently flowing around its northern edge and eroding away the bank that flanks its northern side wall. In addition to this, a number of young trees that have taken root in the cracks of the limestone rubble comprising the dam are prying the dam apart. Also, the lack of a baffle wall at the end of the concrete apron has resulted in erosion of the material underneath the end of the apron by the water that flows over it into a plunge pool. This process will, over time, result in the destruction of the apron, and the eventual undermining of the main wall of the dam itself. The result of all of these processes will eventually be the failure of this dam. Because of the importance of the accumulated sediments behind Dam 2 as a roadway, it is probable that remedial action will be taken to keep it in working order. Its future failure will likely be due to the eventual disintegration of the limestone rubble by solution. When this failure does occur, most or all of the historical sediment that has accumulated behind Dam 2 will be eroded away. This section of the gully will then revert to its pre-dam morphology.

The setting of Dam 3 is quite different from that of Dams 1 and 2. The area of the gully immediately upstream of it is dominated by much lower relief, and Dam 3 is also responsible for a much larger drainage area than either of the dams upstream of it. Because of the larger drainage area, this dam is much longer than the other two dams.

Although the two dams upstream of Dam 3 have helped to contain eroding material in the past, and to a lesser degree in the present, and reduced the erosive velocity of the water in the gully, erosion has still occurred within the small watershed and in the gully. Runoff has carried vast quantities of alluvial sand down the gully and has deposited it along the lower reaches of the gully that are not as steep as those areas from which the sand was eroded. This accumulation of eroded sand has resulted in the large sandy alluvial fan that has developed upstream of Dam 3, as well as the large amounts of sand that make up the channel immediately upstream of Dam 3.

The reason that the alluvial fan has developed at this location is due to the fact that at this point the gradient of the gully is much less than at any point upslope and water coming down the gully is able to spread out laterally. When the water spreads out here, its velocity is reduced, and the alluvial sand is deposited. As sediment accumulated behind Dam 3 the velocity of the water behind Dam 3 was slowed down enough that it reached a threshold that was conducive for the deposition of the sand that it was carrying from the drainage area upstream.

There is a very large historical fill immediately behind Dam 3 that is similar to those that are seen upstream of the other two dams on Johnson Gully. In this case, the historical sediments behind Dam 3 have literally almost overwhelmed the dam. This fill extends upstream towards the alluvial fan, and the development of this fill may have slowed down the water sufficiently to aid the development of the alluvial fan.

Dam 3 has effectively served its purpose as a sediment trap to such a degree that it may eventually be covered over by alluvial sediments. While Dam 3 is still serving as a sediment trap, it is slowly loosing its integrity. Trees growing along its northern side wall have pried it apart, and the main wall is being eaten away by solution.

The future of Dam 3 is uncertain, because it is being overwhelmed by both alluvium and trees. While it is certain that the dam will eventually fail due to solution of the limestone rubble and the prying action of trees, the amount of material that has accumulated around it and the trees that have grown up around it may result in an amalgam of limestone lumps and flora that may keep the damming activities of this structure active for some time to come. It is highly unlikely that any remedial action will take place on Dam 3 due to its location far into the trees next to the flood plain of the Upper Iowa River. It is also far enough away from the agricultural fields that its failure will take a while to be noticed. When it does eventually fail and the velocity of the water is able to increase locally, it is likely that the channels upstream of the dam will disappear as the sand upstream of Dam 3 will be carried away. In the same respect, the alluvial fan of sand upslope of Dam 3 will also undergo a transformation. The increased velocity of the water due to the lowering of the base level will erode the fan away.

While these rubble and masonry dams that were comprised of limestone and cement were considered to be 'permanent,' their permanency is limited by the limestone rubble that was used to build them. Limestone was cheap and easy to quarry locally by company 1749 and it worked well for the construction of the dams. However, the permanency of these dams is limited, as the limestone that they are composed of is subject to solution and abrasion. After 65 years, the dams that were built by the CCC are starting to show their age.

CHAPTER 6

SUMMARY

The intent of this research was to determine the condition and effectiveness of the three rubble and masonry dams that were built on Johnson Gully by Company 1749 over 65 years ago. These questions led to investigating (a) the condition that each of the dams is in and whether or not the dams still serve their purpose as erosion-control sediment traps, and (b) the effects that the dams have had on the morphology of Johnson Gully as they deteriorate.

The steps involved in answering these questions included (a) developing a brief historical review of Company 1749, with an emphasis on their rubble and masonry dam building, (b) measuring and describing the dimensions and conditions of the three dams on Johnson Gully, and (c) creating multiple cross-sectional profiles and a longitudinal profile of Johnson Gully. While the historical review of Company 1749 was used to help determine the intended purposes of the dams, the field work was used to determine the condition and effectiveness of the dams, as well as the modern morphology of the gully.

The mission of Company 1749, as was the mission of many of the thousands of other CCC camps in the United States, was to control the widespread and severe soil erosion that was devastating the land. Their mission was accomplished through somewhat simple works, such as the construction of rubble and masonry dams.

Rubble and masonry dams were a favored method of erosion control by Company 1749 because of the steep landforms that are found in the area where they worked. Specifically, the Paleozoic Plateau with its high relief and highly erodable soils necessitated construction of many more permanent rubble and masonry dams than in most other places in Iowa. The high density of rubble and masonry dams in a relatively small geographic area was also a product of the easily accessible limestone.

In order to study the effects that the rubble and masonry dams have had in the area, Johnson Gully, near Kendallville, Iowa was selected for an in depth analysis. Dam 1 in Johnson Gully was built near the crest of the hill just below the headscarp of Johnson Gully. It acted to contain sediment to such a degree that the active gully upstream of it became filled in with historical sediment, and the headscarp became fixed at the dam site.

Dam 1 has failed within the last 5 years. This failure occurred because a tree collapsed along the north side wall of the dam. This collapsed tree thrust the side wall off of the bank and onto the apron of the dam. The result of this failure is that water has been able to erode around the north end of the dam into the bank of the gully. Since this failure, the headscarp of the gully has retreated 9.5 meters upslope through the sediment that had accumulated behind the dam. The removal of the stored sediment behind the dam and the reactivation of the gully since dam failure reveal how well this dam protected the swale upstream of it from erosion over the last 65 years.

Dam 2 was built approximately 200 meters downstream of Dam 1. The sediment fill behind it is used as a roadway for equipment to reach the field upslope. The importance of the fill as a roadway resulted in the dam being modified in the mid 1980s. At that time the original limestone and cement apron was replaced with concrete. The intention of this modification was to safeguard the main wall of the dam from being undermined. The modification of this dam has been successful in that the dam is still in very good structural shape.

Dam 2, like Dam 1, has a noticeable convex-upward bulge of sediment behind it that is visible in the longitudinal profile. This convex-upward bulge of alluvium immediately upstream of the dam has forced water flowing down the gully to flow around it towards the north of the spillway notch in the dam. The sediment that has accumulated behind Dam 2 forms a wedge of sediment that extends from the main wall of the dam upslope into the gully. In this manner, Dam 2 has worked effectively to control erosion by altering the gradient of the gully due to the accumulation of sediment behind it.

While Dam 2 is in still good structural condition, it is still prone to failure due to the erosive properties of the water that flows onto and around it, and the prying action of trees that are growing into the limestone rubble. There are, however, a number of appropriate actions that if taken soon enough will lengthen the functional life of this dam.

Dam 2 still serves very well as a sediment trap, and helps to control erosion by the way in which it has altered the morphology of the gully. This alteration is most strongly represented by the wedge of sediment behind the dam that extends upstream into the channel of the gully. This created a stair-step in the gradient that continues to slow down the velocity of the flowing water upstream of the dam, and to a lesser degree (due to the aprons lack of a baffle wall) below the dam. This modification of the original morphology of the gully also has served the landowner very well as a roadway for moving farm equipment across the gully.

Dam 3 is quite different from either of the other two dams because of its location along Johnson Gully. While Dams 1 and 2 are in the upper reaches of the gully along a steep gradient, Dam 3 is situated very near the flood plain of the Upper Iowa River near the mouth of the gully. Dam 3 is also responsible for a much larger drainage area than either of the other two dams on Johnson Gully. Therefore, there is a much larger accumulation of historical sediment behind it. This sediment, which is dominated by alluvial sand, forms a convex-upward bulge of alluvium behind the dam into which the flow of water has incised a number of braided channels leading to Dam 3.

Dam 3 is still in pretty good shape, although its northern side wall has been reduced to rubble due to a number of trees that have grown into it and pried it apart over the years. The trees have actually worked well in protecting the dam and channel from erosion, but this effect will not last forever. It is unlikely that any remedial action will be taken with this dam, as it is hidden from sight, and its benefits are not all that obvious without a very close inspection.

The large accumulation of historical alluvium behind Dam 3 has raised the elevation of the channel upstream of Dam 3 so much that the increase in base level behind the dam has led to the formation of a large alluvial fan of sand above the dammed sediment. As sediment accumulated behind Dam 3 over the years, the channel upstream filled with sand. As the channel continued to fill, water was eventually able to spread outside of the banks of the former channel. When this happened, the spreading water was slowed, and even more alluvial sand was deposited over the area in which the water had spread.

The result of this has been the development of the large, extended, sandy alluvial fan, which has choked up the channel. This alluvial fan is so large that the area alongside its northern border is actually lower in elevation than any of the very small channels which work their way across the fan. A great deal of the water that reaches this point along the gully at low flow is slowed down, becomes trapped in the very small channels on the fan, and then slowly infiltrates into the fan.

Dam 3 has worked so well as a sediment trap that it is in danger of literally being buried by sediment. The accumulated historical alluvium behind it is actually much higher than the dam itself, and its apron is overflowing with sand. It is possible that water encountering the alluvial fan may eventually form a channel to the north that bypasses all of this sediment. This could be a problem, as this channel adjustment would direct the flow of water towards an agricultural field to the north of Dam 3.

The primary influences that the dams built on Johnson gully have had on the gully is that of the modification of the longitudinal profile of the gully. The dams have trapped sediment and created a staircase in the longitudinal profile. This staircase has reduced the erosive velocities of the water traveling through the fluvial system. The pooling effect that was caused by the baffle walls at the end of each apron below each dam also reduced runoff velocities. These are the primary morphological effects that the dams have had on Johnson Gully. Dams 2 and 3 are still acting as sediment traps. Dam 1, however, is no longer acting as a sediment trap.

These dams were built over 65 years ago, and are in varying stages of decay. The result of this decay is the tendency for the morphology of the gully to revert back towards the morphology of the gully prior to dam construction as the historical sediments retained by the dams are eroded away. If action is not taken to extend their effective life span, their fate will be total destruction, and erosion protection that has been provided by these erosion-control structures built in 1934 by Company 1749 will be lost.

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