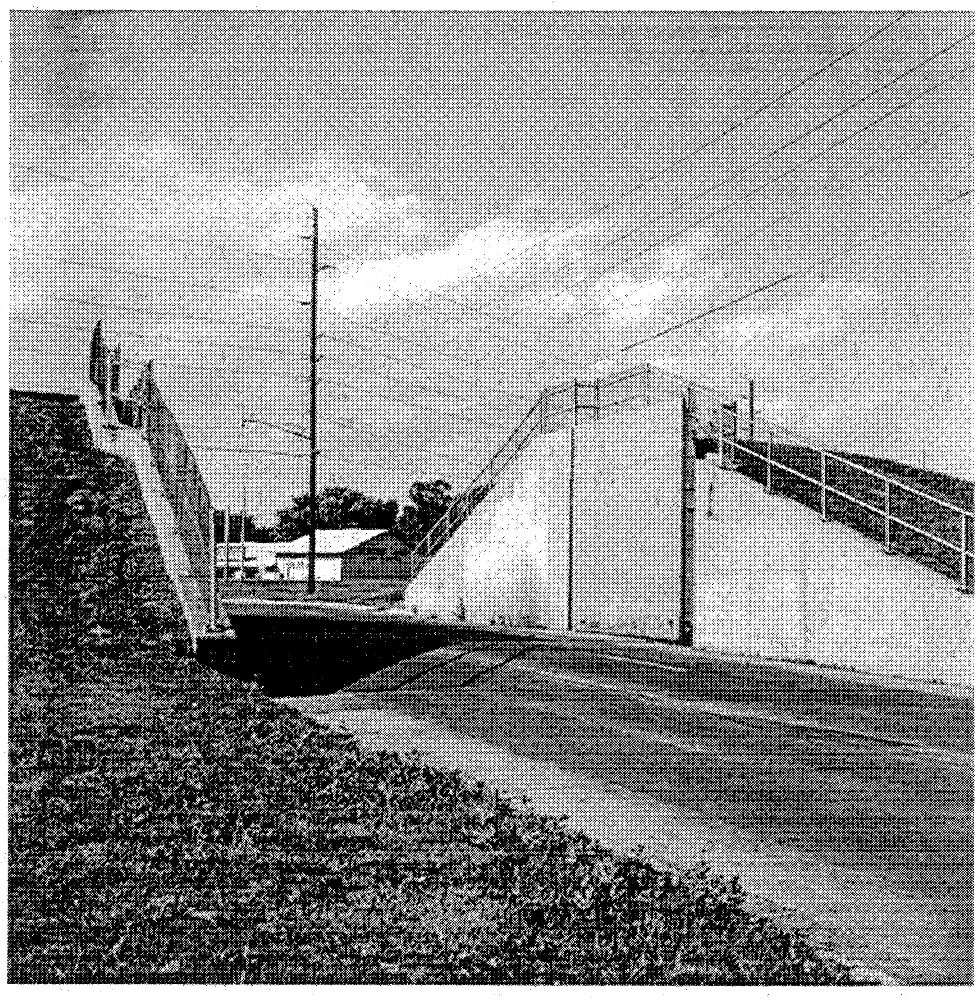
GENERAL AND ENVIRONMENTAL GEOLOGY OF CEDAR FALLS/WATERLOO AND SURROUNDING AREA, NORTHEAST IOWA

Geological Survey Bureau
Guidebook Series No. 22



Iowa Department of Natural Resources
Larry J. Wilson, Director
October 1996

Landscape—Iowa

No one who lives here
knows how to tell the stranger
what it's like, the land I mean,
farms all gently rolling,
squared off by roads and fences,
creased by streams, stubbled with groves,
a land not known by mountain's height
or tides of either ocean,
a land in its working clothes
sweaty with dew, thick-skinned loam,
a match for the men who work it,
breathes dust and pollen, wears furrows
and meadows, endures drought and flood.
Muscles swell and bulge in horizons
of corn, lakes of purple alfalfa,
a land drunk on spring promises,
half-crazed with growth - I can no more
tell the secrets of its dark depth
than I can count the banners in a
farmer's eye at spring planting.

James Hearst (1900-1983)

Born on a farm southwest of Cedar Falls, James Hearst was a farmer, teacher, poet and writer. He taught at UNI from 1941 to 1975.

Cover: The cover photograph shows one of two control gates on Fletcher Avenue (Waterloo, Iowa) where levees cross that street. The levees were built in the mid-1970's to protect this part of the city from flooding arising mostly from Black Hawk Creek, a stream passing through waterloo before joining the Cedar River. The gates have been closed several times since their construction, most recently in the large floods of 1993.

Photo by Lynn Brant.

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GENERAL AND ENVIRONMENTAL GEOLOGY OF CEDAR FALLS/WATERLOO AND SURROUNDING AREA, NORTHEAST IOWA

Geological Survey Bureau
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Prepared by

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University of Northern Iowa

and

Geological Society of Iowa

59th Tri-State Geological Field Conference
University of Northern Iowa

October 4-6, 1996

Iowa Department of Natural Resources
Larry J. Wilson, Director

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Many individuals were instrumental in the preparation of this guidebook and we extend to them our sincere thanks and appreciation. Guidebook contributors are listed in the table of contents and in the sections they authored. The Iowa Geological Survey Bureau accepted the responsibility of preparing the guidebook for publication.

The students in last spring's Environmental Geology course at the University of Northern (UNI) Iowa investigated environmental concerns in the Cedar Falls/Waterloo area, and some of their work appears in this guidebook. Author's names appear with the sections they wrote, and a complete listing of all participants in the course follows: Donald Bardole, Jim Rugarber, Allyson K. Anderson, Nanette R. Brcka, Kari Lundeen, Phath Baccam, Chad Pietig, Craig Smith, Charlene Sundermann, Jenny Kanter, Jason Martin, Mike Powelka, Jon Teslow, Sabrina Wente, Robert Sullivan, Mary Beck, Melissa Harbaugh-Adams, Ben Newton, Jon Yetley, Jeff Brandt, Troy Dooley, Jeremy Linsenmeyer, Steph Morris, Pete Stavlund, Randy Read, Bridget Brown, Brock Emmert, and Lynne Jondall.

Field trip route maps were developed with the assistance of the Iowa Northland Regional Council of Governments. In particular, we thank Kevin Blanshan, Senior Director of Transportation, and Greg Smith, Information Specialist. Permission to visit the Tripoli Quarry was provided by Paul Nieman Construction Company, while Basic Materials Corporation allowed access to the Peske Quarry. Gary Wilcox, Black Hawk County Solid Waste Commissioner, opened the County Landfill on Sunday and provided a tour of the facility. Kari Lundeen, Amy Frieberg, Nancy Howland, and Allyson Anderson typed revised sections of the guidebook.

Thanks is also expressed to Kenneth J. De Nault, our Saturday evening banquet speaker. The support of student assistants and the UNI Office of Continuing Education for assisting with many of the logistical aspects of the field conference is also greatly appreciated.

Jim Walters
1996 Tri-State Coordinator

INTRODUCTION

After an absence of one year, the Tri-State Geological Field Conference returns this fall as a combined event with the Geological Society of Iowa Fall Field Trip. The Department of Earth Science at the University of Northern Iowa is pleased to be able to serve as host for the 1996 Tri-State, and we gratefully acknowledge the assistance of the Geological Survey Bureau of the Iowa Department of Natural Resources, the Geological Society of Iowa, and the Central Section of the National Association of Geoscience Teachers. Our theme for this year's field trip centers on the general geology of the Cedar Falls/Waterloo area, with special focus on environmental geology.

It is doubly appropriate to conduct the Tri-State field conference in Iowa this year at the University of Northern Iowa. This is because 1996 marks the State's 150th anniversary, and this year is also the 120th birthday of the University. We are looking forward to showing participants some of the local geology in addition to some of our University facilities.

The geology in this part of the state is not spectacular; it does not knock a person off his feet; it is subtle, and it is secretive, but it is there—in the gently undulating glacial topography, the broad river valleys of the major streams, the eolian sand sheets and dunal features superimposed on glacial and fluvial sediments, the limestone bedrock exposed naturally only occasionally in stream cuts and exposed artificially in quarry operations. It takes some looking to get a feel for this kind of geology, but this is the type of geology much of the Midwest has to offer. Beginning geology students are often frustrated and perplexed when they seek to find a topic for their undergraduate research and there is nothing that seems conspicuous or interesting to them. "There's no interesting geology around here" is a frequently heard comment. In fact, there is a lot of interesting geology around here, and we hope to present some aspects and get a feel for the variety of this interesting geology during this Tri-State/ Geological Society of Iowa Field Trip. With this in mind, this guidebook is oriented to the student, although, of course, we are really all students, whether beginning or advanced.

Portions of this trip will be led by our students. As a part of the course requirements in Environmental Geology last spring at UNI, Lynn Brant had his students report on and develop a field trip guidebook dealing with the environmental aspects of the Cedar Falls/Waterloo area. We have adapted some of their work into the present guidebook, and we will hear their commentary at several sites.

THE TRI-STATE GEOLOGICAL FIELD CONFERENCE: ITS' PAST AND FUTURE

Wayne I. Anderson
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INTRODUCTION

Initiated in the fall of 1933, the Tri-State Geological Field Conference still provides significant educational opportunities for geologists and geology students in Illinois, Iowa, Wisconsin, and surrounding states. After a hiatus of one year the Tri-State is back! The University of Northern Iowa is pleased to host its' third Tri-State field conference. Our Tri-State ventures in 1972 and 1984 were successful, and our field stops for 1996 promise to be varied and stimulating.

Illinois State University invites your participation at next year's conference in Illinois, and the Illinois State Geological Survey (ISGS) is on deck for the year 2000. In Iowa, the standard Tri-State rotation since 1972 has been in the following order: U. N. I., University of Iowa, Iowa Geological Survey Bureau, and Iowa State University. Assuming that this sequence continues, the next Tri-State in Iowa will be hosted by the University of Iowa in 1999. Given that the conference was not held in Wisconsin last year, it is important to identify hosts in Wisconsin for 1998 and future years. Any suggestions or volunteers?

THE TRI-STATE GEOLOGICAL FIELD CONFERENCE

The Tri-State Geological Field Conference was an outgrowth of a series of annual field trips sponsored by the Illinois State Geological Survey. In response to a suggestion from W. H. Twenhofel of the University of Wisconsin, Morris M. Leighton, Chief of the ISGS, invited geologists from the states of Iowa and Wisconsin to participate in the fall field trip of the ISGS in October of 1933. This gathering in the LaSalle area of Illinois constituted the first Tri-State Geological Field Conference. Attendance at the first field conference included 52 geologists from the universities of Chicago, Illinois, Iowa, and Wisconsin, Northwestern University, the Illinois State Geological Survey, and Northern and Western State Teachers colleges.

An executive committee was selected to plan for future Tri-States. W. H. Twenhofel volunteered to host the second Tri-State in Wisconsin in 1934, and A. C. Trowbridge took responsibility for the meeting in Iowa in 1935. Thus, the basic pattern of rotation of Tri-State field conferences began. Attendance at the second and third conferences totaled 124 for each gathering. The highlights of the early Tri-State conferences were published in the journal, *Science*. It is interesting to note that A. C. Trowbridge arranged for overnight lodging at the Canfield Hotel in Dubuque for Tri-State participants at the third conference in 1935 at the flat fee of 75 cents each.

Table 1 lists the hosts for Tri-State conferences, 1933-1996. In the early years of the field conference, the state geological surveys and the major research universities provided the principal leadership for the annual field gathering. Since 1962, a variety of institutions, including regional state universities and liberal arts colleges, have sponsored Tri-States and contributed to the success of the conference.

Anderson (1980a) prepared a history of the Tri-State Geological Field Conference and detailed the state of Iowa's involvement in Tri-State meetings (Anderson, 1980b). M. E. Ostrom (1986) updated Anderson's work in a contribution published in the Guidebook of the 50th Annual Tri-State Geological Field Conference. Ostrom's article provides a summary of the first 50 Tri-State conferences and includes a listing of locations, themes, and names of trip leaders. Following Ostrom's format, Table 2 summarizes subsequent Tri-State conferences (1987-1996).

THE TRI-STATE GEOLOGICAL FIELD CONFERENCE AND THE NATIONAL ASSOCIATION OF GEOSCIENCE TEACHERS

The 1996 Tri-State conference is cosponsored by the Central Section of the National Association of Geoscience Teachers. This is altogether appropriate in that the beginnings of NAGT trace to discussions held by five college geology teachers in a quarry in Wauwatosa, Wisconsin at the final field stop of the fifth Tri-State conference in 1937.

The five college teachers were David M. Delo, Knox College, Galesburg, Illinois; Fritiof M. Fryxell, Augustana College, Rock Island, Illinois; Neil A. Miner, Cornell College, Mt. Vernon, Iowa; Leonard R. Wilson, Coe College, Cedar Rapids, Iowa; and Monta E. Wing, Beloit College, Beloit, Wisconsin. The five teachers met at Augustana College on April 13 and 14, 1938 and organized The Association of College Geology Teachers, the forerunner of today's NAGT. Also attending the initial meeting of the ACGT were Edward L. Clark of Drury College, Springfield, Missouri and Rudolph W. Edmund, University of Iowa, Iowa City. According to Martha Wing (Mrs. Monta Wing), the five founders of ACGT thoroughly enjoyed each others' company and the chance to interact at the Tri-State field conferences and on other occasions. They exchanged ideas on teaching methods and discussed common problems; the five had much in common in that they were all from "one-man" geology departments (Wing, 1988).

Rudy Edmund, then a graduate student at the University of Iowa, was present at the first meeting of the ACGT in 1938. He had this to say about the five early Tri-Staters, who were founders of ACGT (the organization that evolved into today's NAGT):

"At a quarry in southeast Wisconsin, the last stop on the Fifth Tri-State Field Conference in October 1937, five college teachers were preparing to leave the outcrop and start the long trip back home to their respective one-man geology departments. The field exposure to new outcrops and the professional exchanges with a host of geologists had made the field conference a rewarding experience and there was a feeling of reluctance to say "good-by" for another year."

May your 1996 Tri-State experience be filled with similar stimulating outcrops, professional exchanges, and rewarding experiences. Thanks for coming and participating in the 59th ("nearly annual") Tri-State Geological Field Conference.

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Edmund, Rudolph W. 1988. "Recollections of the Early Days of NAGT." A Paper Presented at the Central Section Meeting of NAGT, April 8, 1988, Augustana College, Rock Island, Illinois.

Ostrom, M. E. 1986. "Preface." In Alpha and Omega (Precambrian and Quaternary) in Central Wisconsin, Volume 1: Papers. Guidebook for the 50th Annual Tri-State Geological Field Conference, p. v-x.

Wing, Martha. 1988. "Some Recollections of Monta Wing's Beloit Years." Remarks Distributed at the 50th Anniversary Meeting of NAGT, Central Section Meeting of NAGT, April 8-9, 1988, Augustana College, Rock Island, Illinois.

Table 1. Host institutions for Tri-State Geological Field Conferences, 1933-1996. No conference was held in 1995 and during World War II, 1942-45. Number indicates the number of conferences hosted. Conferences with co-hosts indicated with an *. Hosting credited to the principal host unless responsibilities were shared equally.

HOST INSTITUTION	NUMBER	YEAR(S)
Univ. of Wisconsin-Madison	6.5	1934, 1937, 1940*, 1947, 1950, 1953, 1959
Iowa State University	6	1938, 1951, 1960, 1969, 1981, 1993
Iowa Geological Survey (IGSB)	6	1941, 1948, 1957, 1966, 1978, 1990
Illinois Geological Survey	5	1933, 1939, 1952, 1964, 1979
University Of Iowa	5	1935, 1954, 1963, 1975, 1987
Wisc. Geol. & Nat. Hist. Surv.	3.5	1940*, 1956*, 1965, 1983
University of Northern Iowa	3	1972, 1984, 1996*
Augustana College	2	1967, 1982
Northern Illinois University	2	1970, 1994
Northwestern University	2	1949, 1958
Southern Illinois University	2	1961, 1973
University of Illinois	2	1936, 1955
Univ. Wisc.-Oshkosh	2	1968*, 1986*
Eastern Illinois University	1	1991
Illinois State University	1	1988
University of Chicago	1	1946
Univ. Ill.- Chicago	1	1985
Western Illinois University	1	1976
Lawrence College	1	1962
Univ. Wisc.- Eau Claire	1	1974
Univ. Wisc.- Green Bay	1	1980
Univ. Wisc.- Milwaukee	1	1977
Univ. Wisc.- River Falls	1	1989
Univ. Wisc.- Superior	1	1971
Univ. Wisc.- Whitewater	1	1992
U.S.G.S. (Wisc.)	CO-HOST	1956*
Univ. Wisc.- Fox Valley	CO-HOST	1968*
Univ. Wisc.- Marathon Center	CO-HOST	1986*
Central Section NAGT	CO-HOST	1996*

Table 2. A Summary of Tri-State Geological Field Conferences, 1987-1996.

Conference/Year	Location (Host)	Themes	Leaders
51/1987	SE & S-Central Iowa (**University of Iowa**)	Environment of Deposition of the Carbonif. System & Strip-Mine Reclamation	G. R. McCormick (ed.), assisted by L. Johnson; E. A. Bettis, L. Drake, B. Glenister, G. Ludvigson, R. Neimann, and K. Swett
52/1988	LaSalle-Peru Area, Illinois (**Illinois State Univ**.)	The LaSalle Anticline and Its Influence on Penn. Sedimentation in the LaSalle-Peru Area	Guidebook by: R. S. Nelson, J. G. Kirchner, and T. K. Searight; Leaders: Kirchner, Nelson, Searight, J. Ernst, T. Hudson, and S. Kelly
53/1989	St. Croix River Valley, Wisc. (**Univ. of Wisc.-River Falls**)	Paleogeography and Structure of the St. Croix River Valley, Wisc.	Ian S. Williams (ed.); Leaders: R. Baker, W. Cordua, M. Middleton, and I. Williams
54/1990	Keokuk and Washington Counties, SE Iowa (**IGSB**)	Stratigraphy and Paleoenvironments of Mississippian Strata in Keokuk and Washington Counties, SE Iowa.	B. J. Witzke, R. M. McKay, B. J. Bunker, and F. J. Woodson
55/1991	East-Central Illinois (**Eastern Illinois Univ.**)	The General, Environmental and Economic Geology and Stratigraphy of East-Central Illinois	Robert Jorstad (ed. and coordinator); leaders: V. Gutowski, R. Jorstad, R. Pheifer, T. Phillips, J. Stratton, and G. Wallace
56/1992	Whitewater, Wisc. (**Univ. of Wisc.-Whitewater**)	Glacial Features, Precambrian, Cambrian, and Silurian	Jack W. Travis (editor and coordinator); F. Luther, J. Kluessendorf, D. Mikulic
57/1993	Central Iowa (**Iowa State Univ**.)	Water, Water, Everywhere..	W. W. Simpkins (ed. and coordinator); A. Ariffin, J. Eldem, W. Gibbons, B. Johnson, Z. Qui, M. Weis, G. Caron, R. Anderson, E. Bettis, G. Hallberg, M. Howes, T. Kemmis, J. Littke, D. Quade, D. Bruner, M. Burkhart, T. Parkin, and K. Loreth
58/1994	Northern Illinois (**Northern Illinois Univ**.)	Pleistocene Stratigraphy & Structure and Stratigraphy of the Lower Paleozoic of Northern Illinois	J. Stravers, R. Powell, B. Curry, C. Casella, and R. Nelson
/1995	Wisconsin	No Host Identified	No Tri-State Geological Field Conf.
59/1996	Black Hawk and Bremer Counties, Iowa (**University of Northern Iowa**)	General and Environmental Geology in Black Hawk and Bremer Counties	James C. Walters (conference coordinator); W. Anderson, L. Brant, M. Iqbal, S. Lundy, G. Wilcox, A. Bettis, B. Bunker, and B. Witzke

GENERAL AND ENVIRONMENTAL GEOLOGY OF THE CEDAR FALLS/WATERLOO AREA

THE IOWAN SURFACE

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The Cedar Falls/Waterloo area is located in the heart of one of the State's major topographic regions, the Iowan Surface (Figs. 1 and 2). Characterized by a gently rolling landscape and broad open vistas, the Iowan Surface was thought by early workers to represent a surface covered by an "Iowan Glacier" which existed between the Illinoian and Wisconsinan glacial periods. Later the "Iowan" was assigned to the earliest substage of the Wisconsinan. Over the years, controversy surrounded the glacial deposits of northeast Iowa, and because of the lack of many exposures in the area, the age and origin of this drift could not be resolved until detailed studies involving drilling and radiocarbon dating were undertaken. This was done by Robert Ruhe and colleagues in the 1960s. Their work showed that the so-called Iowan drift did not exist; there had been no Iowan glacier. Rather, this landscape region consisted of a widespread erosion surface complex cut into Pre-Illinoian age glacial deposits. The Iowan Surface problem was examined during the 42nd Tri-State Geological Field Conference in 1978 (Hallberg et al., 1978) and the reader is referred to that publication for detailed information.

Today the Iowan Surface is described as a multi-leveled erosion surface with stepped topography. The stepped surfaces occur in a gradual and subdued fashion from upland drainage divides down to the major streams. These surfaces were cut into the Pre-Illinoian age glacial deposits of the region during periods of accelerated erosion involving stream action, slope wash, and wind deflation. It is now known that an especially severe period of erosional development occurred between 21,000 and 16,500 years ago during the coldest part of the Wisconsinan. Integrated studies involving analyses of fossil pollen, plant macrofossils, small mammals, insects, and molluscs at sites in Iowa and adjacent states indicate that this region had a cold climate with open tundra conditions during this period of time (Baker et al., 1986, 1989, 1991).

A periglacial environment existed in northeast Iowa and intensive freeze-thaw activity, solifluction, strong winds, and other periglacial processes were active. The result was the formation of an erosional surface on the Pre-Illinoian glacial deposits and the development of a residual lag deposit or *stone line* (Iowan pebble band). Scattered uneroded remnants of higher ground persisted along drainage divides above the stepped surfaces. These elongate ridges and isolated elliptical hills exist as erosional remnants of the once higher and older land surface and are known as *paha*. Permafrost was present and severely cold temperatures resulted in the formation of ice-wedge polygons in the frozen sediments. These features are observable today as *ice-wedge casts*.

In summary, in addition to the characteristic gently undulating terrain with long slopes, low relief, and open valleys, the landform region known as the Iowan Surface contains an interesting variety of geological features including: 1. prominent elongate ridges and isolated elliptical hills called paha, 2. scattered areas of large glacial erratics, 3. a stone line or pebble band, and 4. ice-wedge casts. Figure 3 presents an oblique cross-sectional view of the Iowan Surface showing the features which characterize this intriguing landform region.

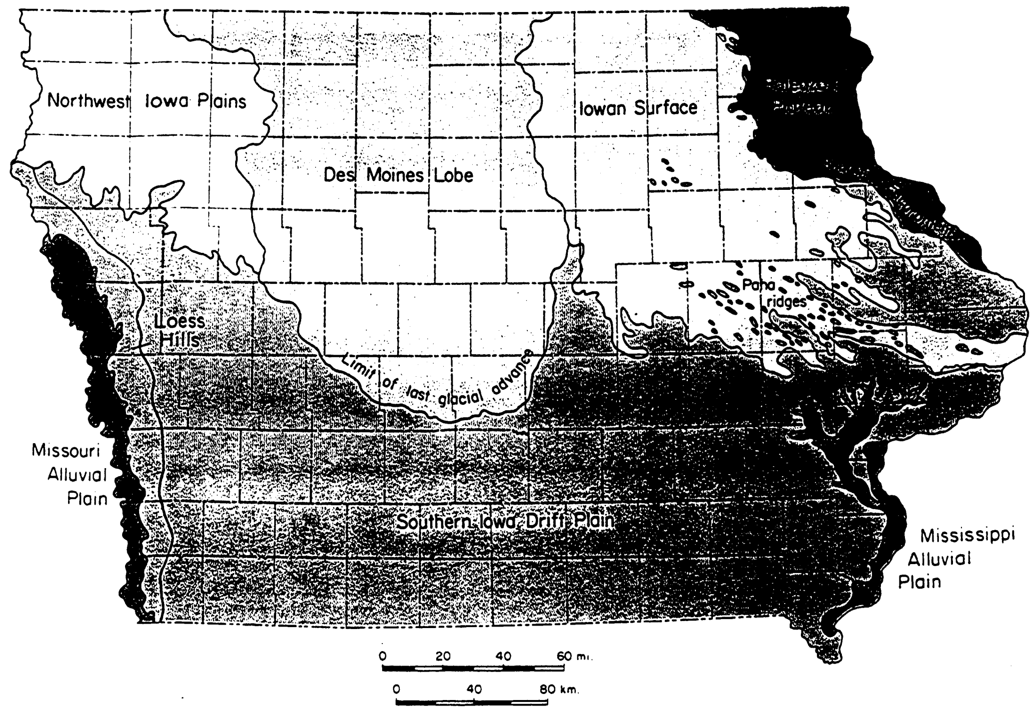

Figure 1. Landform regions of Iowa (from Prior, 1991, p. 31)

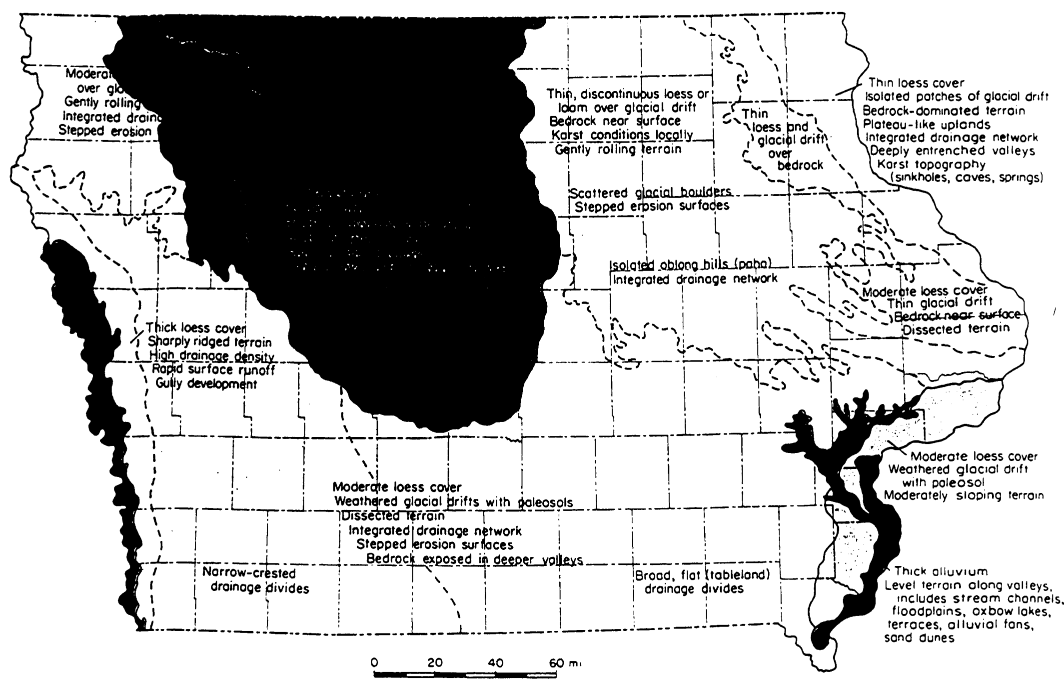

Figure 2. Landform materials and terrain characteristics of Iowa (from Prior, 1991, p. 34).

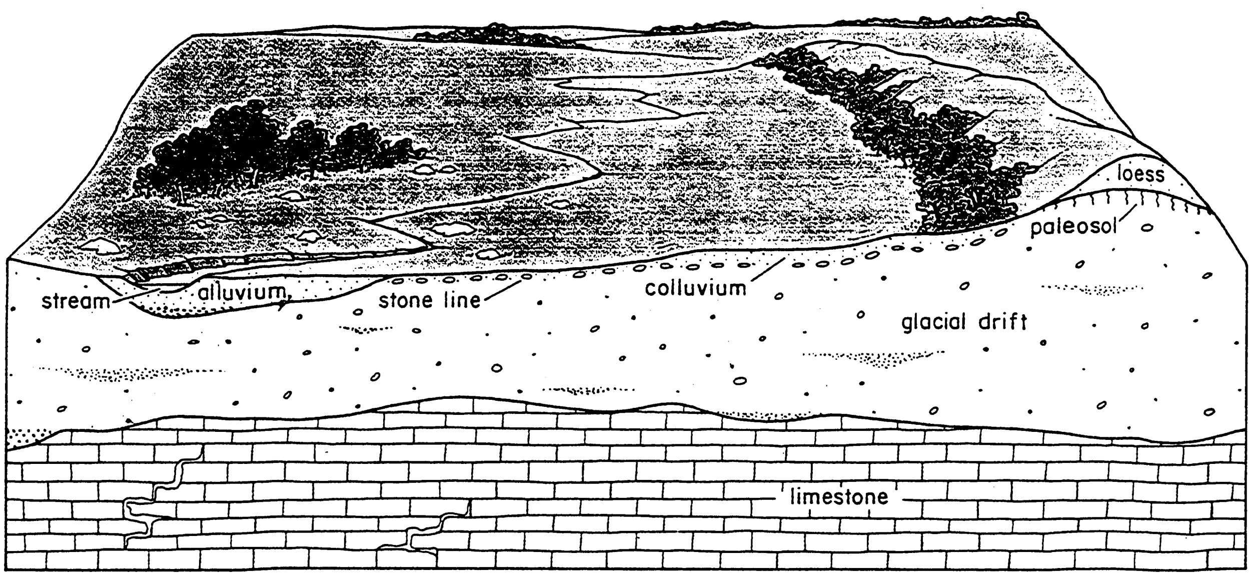

Figure 3. Characteristics and typical features associated with the Iowan Surface (modified from Prior, 1991, p. 69).

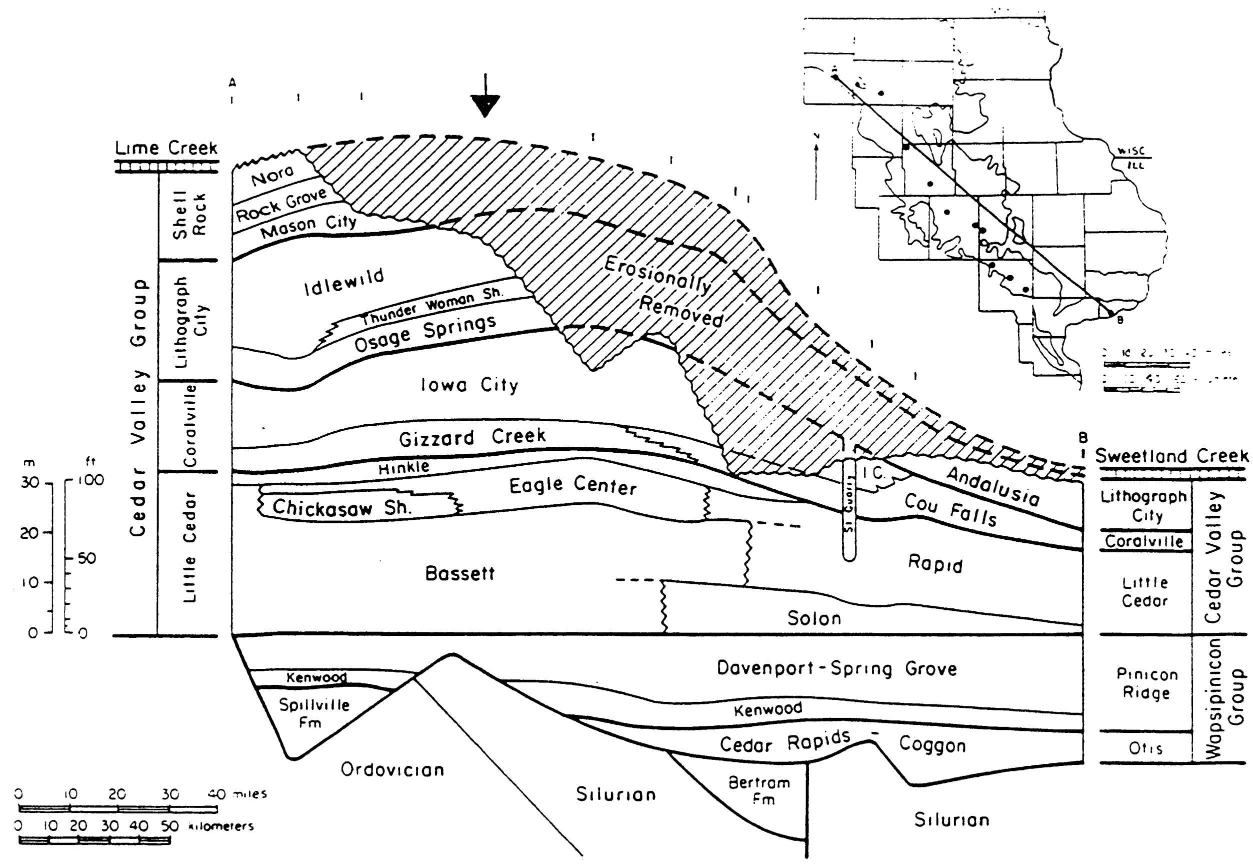

Figure 4. Generalized stratigraphic cross-section from north-central to extreme east-central Iowa, showing interpreted stratigraphic relationships of the various units of the Wapsipinicon and Cedar Valley groups. Arrow points to location of border between Black Hawk and Bremer counties (from Witzke et al., 1988).

BEDROCK GEOLOGY

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A brief overview of the bedrock geology of Black Hawk and Bremer counties, the two counties visited on the present field trip, was provided by Wayne Anderson for the 1992 Geological Society of Iowa/Iowa Natural History Association field trip (Anderson, 1992). That information is presented here with the author's permission.

Exposed bedrock in Black Hawk and Bremer counties consists of rocks of Silurian and Devonian ages. A generalized cross section (Fig. 4) from Witzke et al. (1988) shows the interpreted stratigraphic relationships of Devonian strata from north central to east central Iowa.

Devonian rocks in Black Hawk and Bremer counties are assigned to the Cedar Valley and Wapsipinicon groups. Witzke et al. (1988) include four formations within the Cedar Valley Group. In ascending order, the formations are Little Cedar, Coralville, Lithograph City, and Shell Rock. All except the Shell Rock Formation are well exposed in quarries in the field trip area. Each formation corresponds to a major transgressive-regressive cycle of deposition, and each formation is separated from adjacent formations by an erosional surface (Witzke et al., 1988). The Cedar Valley

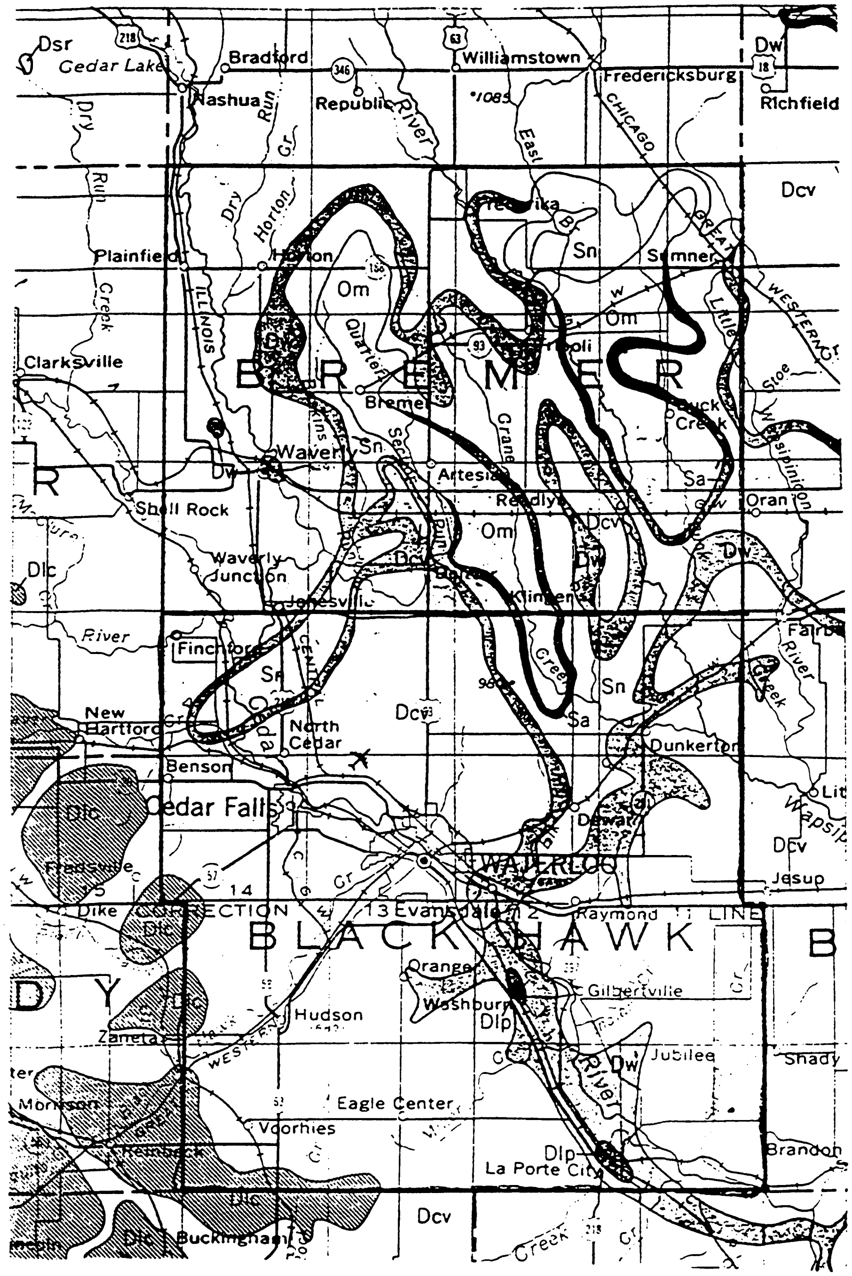

Figure 5. Bedrock map of Black Hawk and Bremer counties. Note southwest to northeast trending pattern of Silurian strata (Niagaran, Sn) in northwest Black Hawk County and southwest Bremer County (from Geologic Map of Iowa; Hershey, 1969).

Group lies unconformably on the Wapsipinicon Group. The Wapsipinicon Group is represented by the Otis (lower) and Pinicon Ridge (upper) formations. Rocks of the Cedar Valley and Wapsipinicon formations reflect deposition under extensive shallow-marine, restricted marine, tidal flat, and evaporative settings (Plocher and Bunker, 1989).

The Geologic Map of Iowa (Hershey, 1969) shows Ordovician, Silurian, and Devonian bedrock in Black Hawk and Bremer counties (Fig. 5). A pattern of older rocks (Ordovician or Silurian) surrounded by younger Devonian strata suggests the presence of anticlinal structures in the area. As noted by Prior (1986), Bremer County is criss-crossed with pre-glacial bedrock valleys. This also affords an explanation for the appearance of older bedrock on the geologic map.

GROUNDWATER

Brock Emmert, Randy Read, Lynne Jondall, and Bridget Brown
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Silurian-Devonian Aquifer

Nearly all of the water supply for northeast Iowa communities, industries, farms, and rural residences is obtained from groundwater sources. There are three recognizable surficial-aquifer types and three principal bedrock aquifers that supply water to northeast Iowa. Of these, the Silurian-Devonian aquifer underlies approximately 89 percent of the state and is the uppermost bedrock for nearly 21 percent of the state (Horick, 1984). Figure 6 is an east-west hydrogeologic cross-section extending from southern Black Hawk to western Delaware counties (A-A'). The figure shows the positions and relationships of the various aquifers.

The Silurian-Devonian aquifer of Iowa consists of a thick (average 200 to 350 feet) succession of carbonate rock (limestones and dolostones). The primary pathways for the water movement in the aquifer are the secondary openings in the rock. The permeability of these rocks is predominantly secondary and related to dissolution and fracturing that has formed pores, small voids, cavities and shrinkage cracks, fissures, and other solutional channels.

Groundwater Availability

Aquifer performance can be measured by two hydraulic parameters: transmissivity (T) and storativity (S). Transmissivity indicates the rate at which water will move through the vertical strip of the aquifer formations, with a unit width, expressed in square feet per day (sq. ft./day). Storativity indicates the storage capacity of an aquifer, expressed as the volume of water released through the unit cross sectional area of the aquifer due to a unit decline in the hydraulic head. In other words, it indicates how much water can be removed from storage in the aquifer for each foot the water level will drop. Although values vary greatly with the local topography, the range of T and S are 5000-15000 gpd/ft. and 0.0003 respectively (Horick, 1984). The largest capacity bedrock wells of the Waterloo-Cedar Falls area are found in or near river valleys. T and S values are increased in these areas due to solution enlargement of voids and fractures. This allows more water to be removed from the aquifer without greatly lowering the water table.

Quantity and Recharge

The quantity of groundwater in Iowa aquifers is estimated at a minimum of 30 million acre feet and could be as high as 60 million acre feet. About one-third of the high estimate or 20 million acre feet of water is considered to be good quality water, using present standards (Horick, 1984).

Groundwater levels in the Silurian-Devonian aquifer are related to the availability and rate of recharge, the permeability of the aquifer, the quantity of withdrawals, and whether the aquifer is confined or unconfined. Variations occur by locality and time. The largest variations are noticeable in areas with large withdrawal and low permeability. In addition to the Silurian-Devonian bedrock aquifer, important sources of groundwater are found in sand and gravel deposits associated with major river valleys. These resources are referred to as alluvial aquifers. Alluvial aquifers are thickest and most extensive beneath the floodplains of the larger rivers such as the Cedar and the Wapsipinicon in northeast Iowa (Fig. 7). Large quantities of water can be stored in alluvial deposits because of their high porosity. Alluvial aquifers are readily recharged directly by precipitation and/or from rivers and bedrock aquifers.

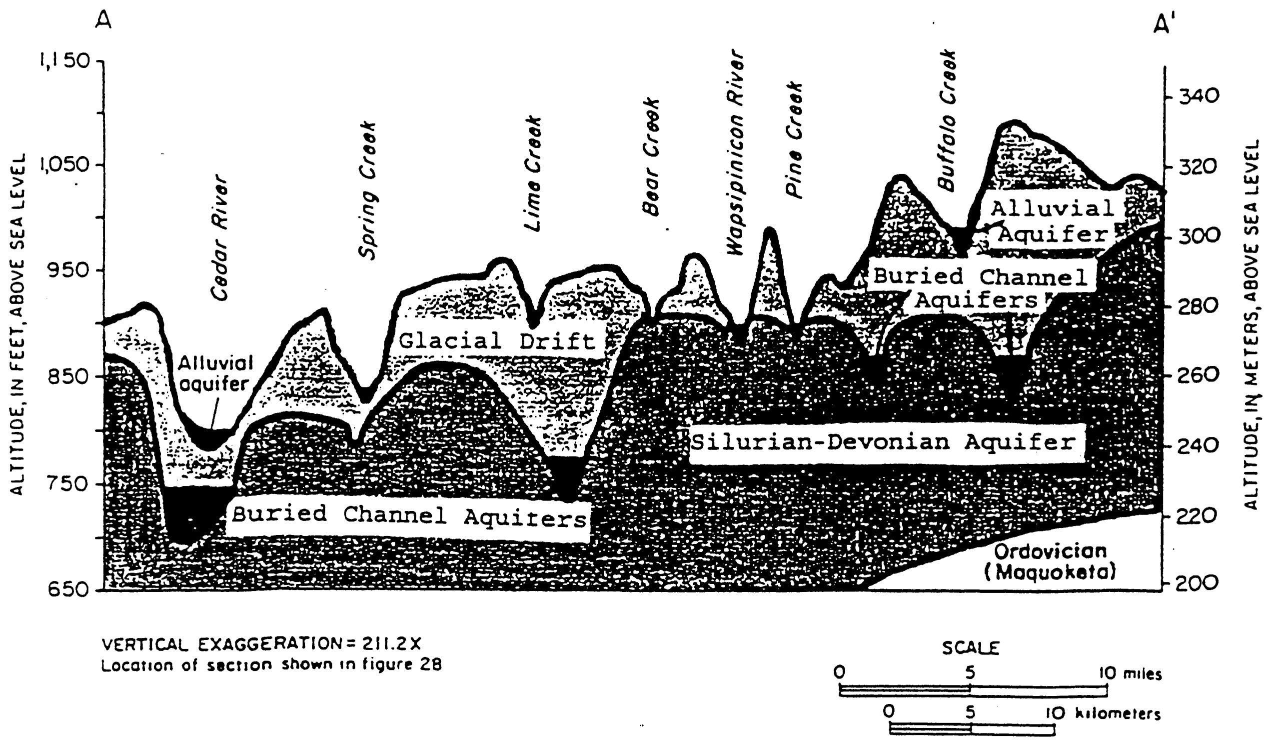

Figure 6. Hydrogeologic cross section of surficial aquifers and upper bedrock units (from Horick, 1984).

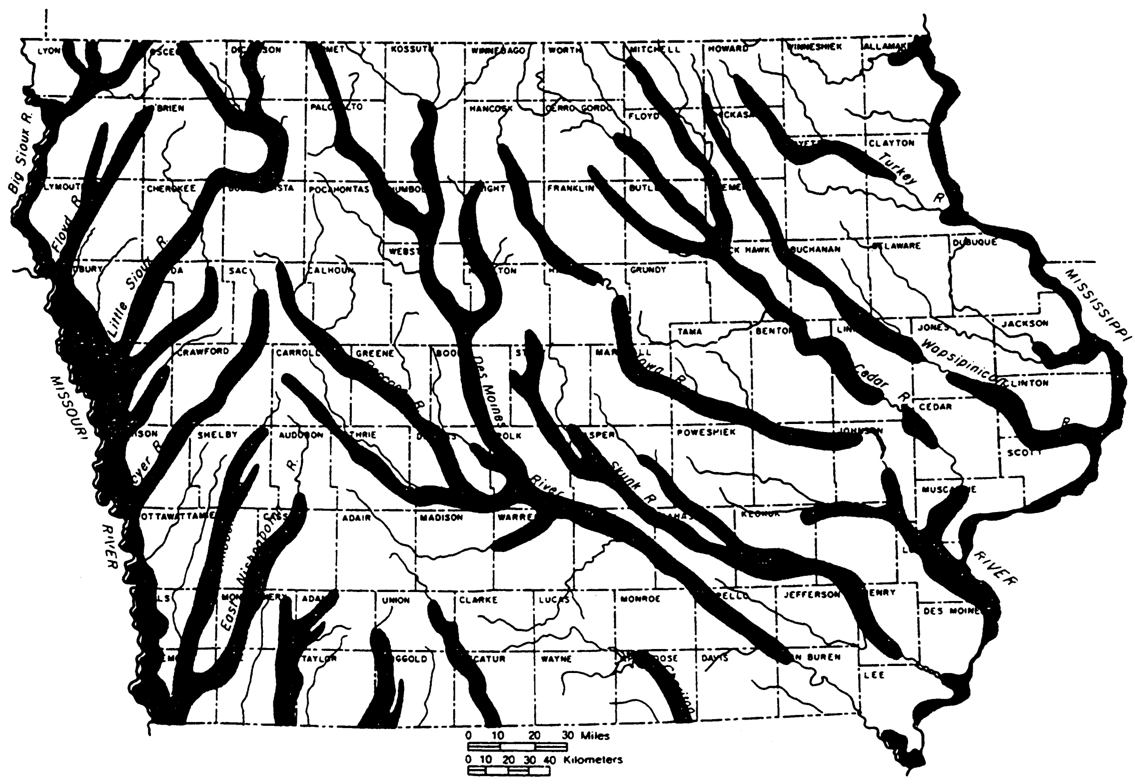

Figure 7. Principal alluvial aquifers of Iowa. Note those associated with the Cedar and Wapsipinicon rivers in Black Hawk and Bremer counties (after Steinhilber and Horick, 1970).

Usage

The Silurian-Devonian aquifer serves the people of Black Hawk County as its principal water supply. The quantity of water withdrawn from the Silurian-Devonian aquifer in Iowa is estimated at 27.75 billion gallons a year, in four main categories (Horick, 1984);

1.	Municipal	12.25 billion gal/yr
2.	Domestic (rural)	10.0 billion gal/yr
3.	Industrial	3.5 billion gal/yr
4.	Irrigation	2.0 billion gal/yr

Black Hawk County draws approximately 5,361,485,000 gallons of water per year from the aquifer. Overall, the groundwater movement in the area is to the southeast. Figure 8 shows the general direction of this flow (Horick, 1984).

Contamination

Groundwater generally contains many dissolved minerals. The mineral content is influenced by many factors, such as: water temperature, pH, groundwater residence time, and chemical composition of the aquifer. Overall, the quality of the groundwater is inversely proportional to the amount of the dissolved substances.

In much of northeast Iowa, the unconsolidated materials overlying the Silurian-Devonian aquifer are less than 50 feet thick (Horick, 1984). The proximity of the aquifer to the land surface makes it vulnerable to contamination by surface-derived chemicals..

Floyd County, 30 miles north Waterloo, is the site of numerous agricultural drainage wells (ADWs). The ADWs were designed to drain excess water from cropped agricultural fields and “inject” this water into the underlying aquifers (Libra et al., 1994). Floyd and adjoining Mitchell County are also the sites of numerous sinkholes. Figure 9 shows the location of these sinkholes and the ADWs. The figure also shows detail of the vulnerability of groundwater regions in the area.

Generally, water quality of the Silurian-Devonian aquifer is good, with total dissolved solids (TDS) under 500 mg/L (Iqbal, 1995). Figure 10 shows the result of recent testing done at sites in Black Hawk and Bremer counties by Iqbal (1995). Several locations tested exceeded or were dangerously close to the maximum contaminant level (MCL) of nitrates (NO_3) for drinking water. Combining the flow of the aquifer with the location of the ADWs and sinkholes, it is possible that the ADWs and sinkholes may contribute to the increased nitrates in area waters. Concentrations of other inorganic ions are below the recommended MCLs (Iqbal, 1995).

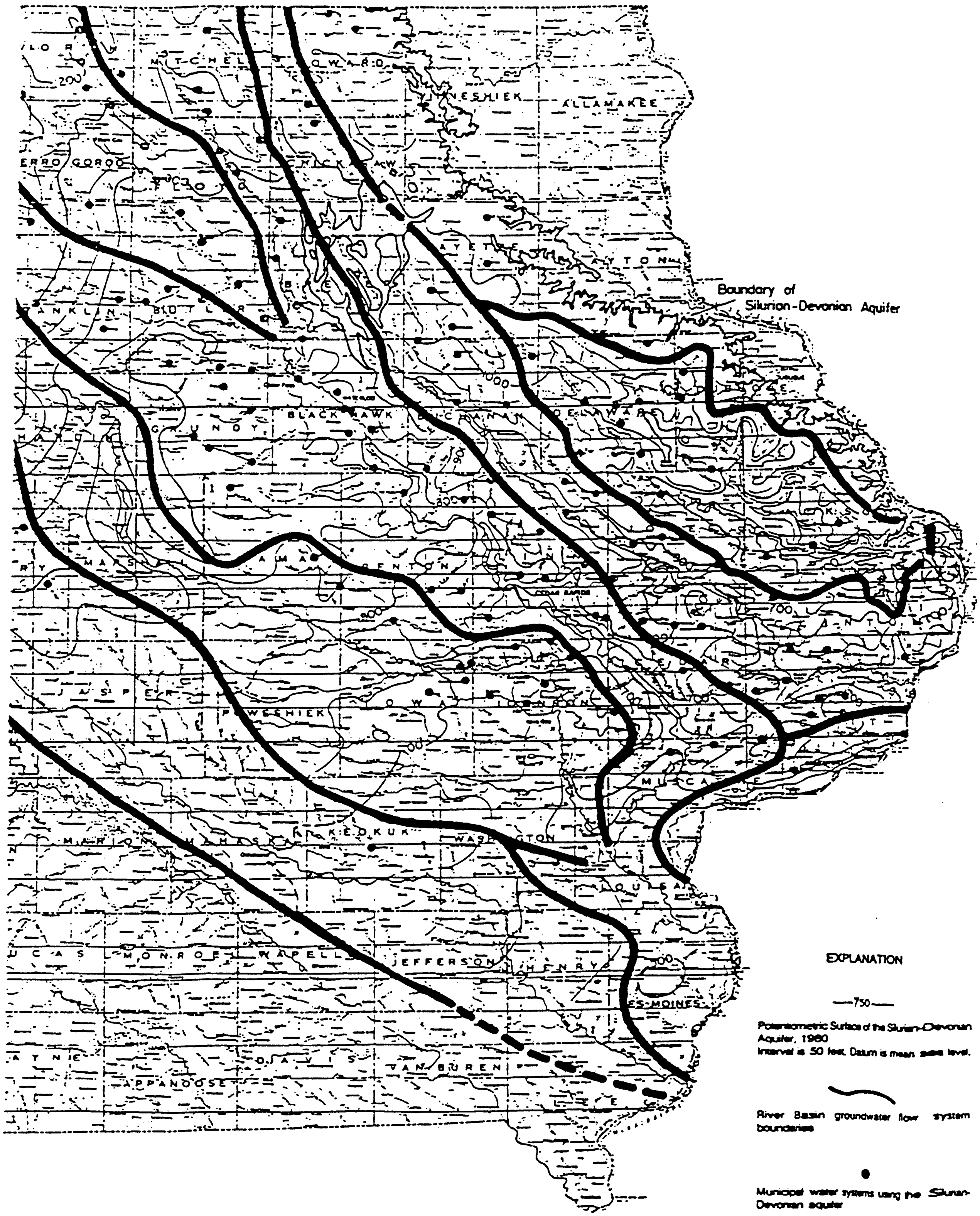

Figure 8. The flow systems and municipal water systems of the Silurian-Devonian aquifer in eastern Iowa (from Horick, 1984).

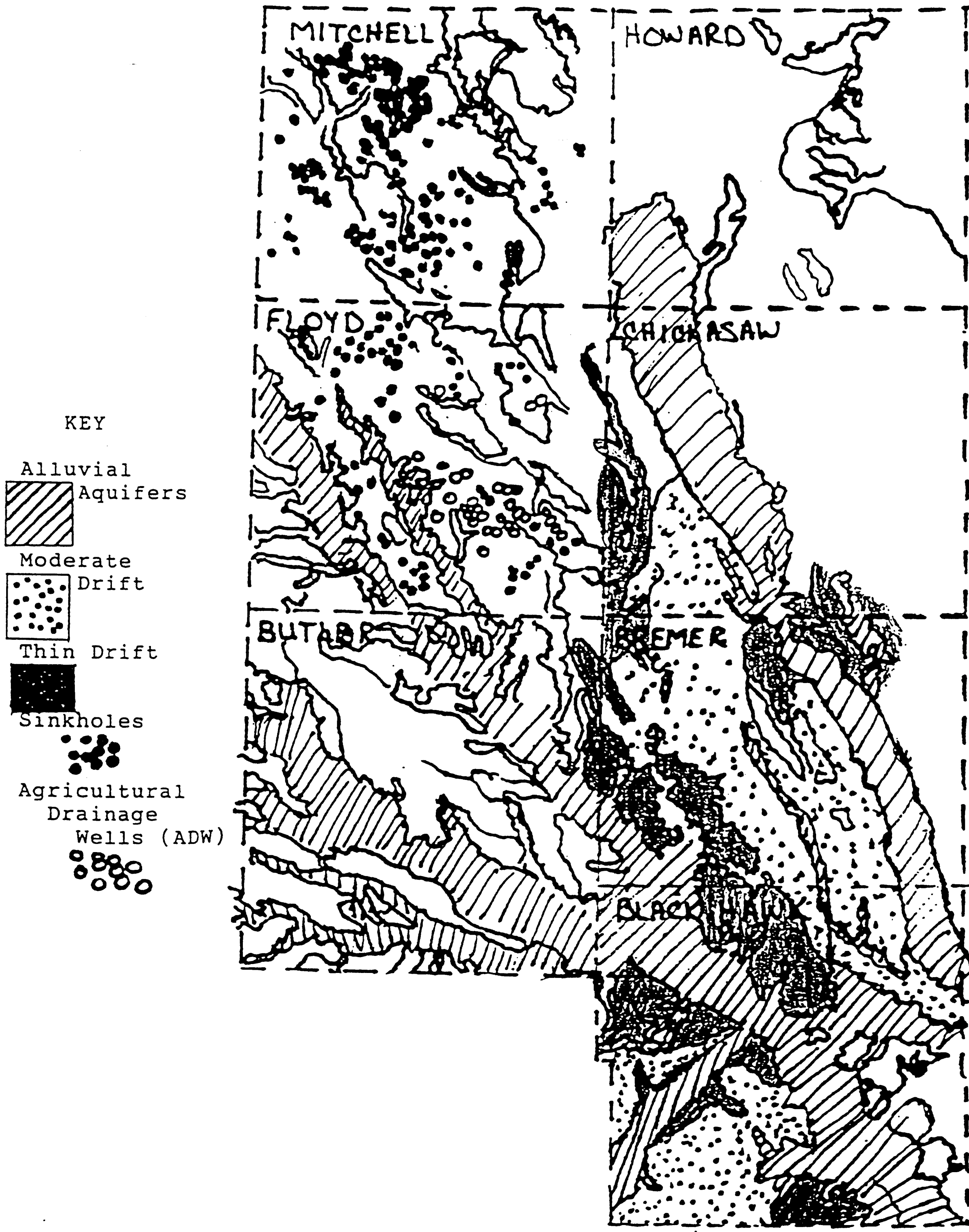

Figure 9. A recreated portion of the groundwater vulnerability regions of northeast Iowa (after Libra et al., 1994).

			MCL 500 Mg/L		MCL 45 Mg/l	MCL 250 Mg/L		
WELL ID	DATE	TEMP.(C)	TDS (mg/1)	pH	NO_3 (ppm)	SO_4 (ppm)	Ca+ (ppm)	Mg+ (ppm)
A1	5/12/95	17.2	317	7.82	40.847	17.27	64.853	16.716
B2	5/12/95	12.2	263	7.63	3.657	11.81	54.918	15.281
C3	5/12/95	12.4	487	7.49	43.087	20.70	93.678	26.624
D4	5/12/95	12.9	278	7.69	ND	10.88	57.997	17.005
E5	5/12/95	17.1	410	7.49	55.735	16.62	76.586	21.420
F6	5/12/95	15.0	411	7.56	68.213	16.07	90.436	16.792
G7	5/12/95	12.7	375	7.69	83.298	15.80	83.020	13.874
H8	5/18/95	11.6	368	7.66	38.791	23.75	70.602	23.460
I9	5/18/95	12.0	419	7.40	59.327	17.25	85.735	21.829
J10	5/12/95	15.2	366	7.76	45.252	18.04	72.781	21.165
K11	5/12/95	13.9	533	7.32	70.255	23.60	107.000	25.210
L12	5/12/95	16.8	364	7.69	79.335	17.00	79.730	14.596
M13	5/12/95	12.8	417	7.42	19.953	20.38	95.052	19.852
N14	5/12/95	10.3	448	7.48	29.630	25.19	90.995	30.134
O15	5/12/95	19.6	526	7.47	89.248	29.33	4.398	1.183
P16	5/12/95	18.2	402	7.58	37.204	25.88	76.955	24.263
Q17	5/12/95	14.5	434	6.97	18.823	22.96	88.954	25.281
R18	5/12/95	12.8	280	7.61	ND	21.18	9.254	2.531
S19	5/18/95	19.4	391	7.82	57.603	19.61	72.952	23.398
T20	5/12/95	10.8	346	7.61	17.703	32.28	69.350	20.484
RM13	5/12/95	16.4	363	8.75	33.156	25.76	22.612	17.339
RJ10	5/18/95	16.0	351	8.36	40.030	24.64	68.367	19.866

Figure 10. Results of chemical analysis of 20 groundwater samples and 2 river water samples (RM13 and RJ10) in Black Hawk and Bremer counties by Iqbal (1995).

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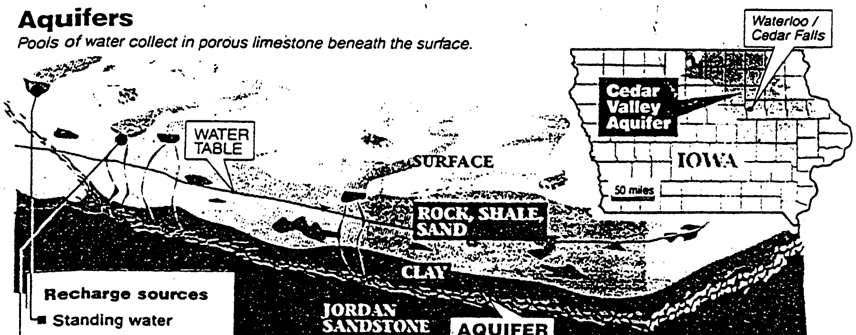
Courier
WATERLOO ◆ CEDAR FALLS
Sunday, March 12, 1995

A giant limestone 'sponge' beneath our feet gives us a pure, nearly inexhaustible resource

WATERRICH

Aquifers

Pools of water collect in porous limestone beneath the surface.



Recharge sources

- **Standing water** — *At its northern end the aquifer breaks the surface and collects water. Ponds, creeks also fill the aquifer.*
- **Porous earth** — *Sandy creek and river beds and soft soil allow water to seep into the aquifer.*

The Cedar Valley Aquifer

- Water drawn from the aquifer is a constant 55 degrees.
- The aquifer is 400 feet below the surface in some places; at others it breaks the surface in the form of a rocky outcropping.
- In 1994, Waterloo used 5.04 billion gallons of water; Cedar Falls 1.42 billion gallons.
- Cedar Falls began adding flouride to drinking water (to help prevent tooth decay) in 1958; Waterloo started adding it in 1966.

Sources: Iowa Geological Survey Bureau; Cedar Falls Utilities; Waterloo Water Works

RANDY MISHLER / Courier Art Director and JENNIFER JACOBS / Courier Staff Writer

By JENNIFER JACOBS
Courier Staff Writer

The facts don't indicate a roaring river gorge, tunneling caves or a quiet, glassy ocean.

No human eye has actually seen the massive pools of water floating so closely beneath the streets of Waterloo and Cedar Falls, yet experts know the slightly mysterious supply is virtually inexhaustible.

It's called the Cedar Valley Aquifer, and it has sparked awe in everyone who has investigated its rocky depths since it was discovered in the 1920s.

"We are blessed with one of the best aquifers in certainly the U.S. and maybe in the world," said Waterloo Water Works General Manager Reed Craft.

With hardly a thought about their water source, metro residents can draw a cool and tasty drink, spray lawns, wash cars and fill swimming pools — even in the midst of drought.

METRO AREA RESIDENTS USE 80 GALLONS PER PERSON OF AQUIFER WATER A DAY.

This aquifer allows the Water Works to deliver a ton of fresh water citywide every 30 hours for the cost of two dime store gumballs.

Waterloo has the lowest water rates of any city in Iowa — and Cedar Falls is not far behind — because the easily reached fountain of water keeps pumping costs at rock bottom.

The aquifer has tremendous capacity. Metro residents sucked out 6.46 billion gallons of crystal clear water in 1994 — and the aquifer's water level did not budge.

The Cedar Valley Aquifer, actually scientifically named the Silurian-Devonian Aquifer, is a 400-million-year-old bedrock formation. Its limestone is cracked for storing water and is so permeable that it readily yields water to wells.

See WATER / page A4

GREG BROWN / Courier Staff Photographer

Nine Waterloo high pressure wells, like this one behind Waterloo Water Works Assistant General Manager Jerry Stevens, truck water straight from the aquifer.

Aquifer a dependable resource for future

Continued from page A1

The water is hard, meaning it contains calcium bicarbonate, but it's not carcinogenic.

In fact, it's about as pure as earthly possible.

Metro water utility workers regularly test the aquifer water for an extensive list of naturally occurring and manufactured chemicals — such as nitrates, arsenic and lead — and rarely find a trace.

The water companies need to add only one part per million of chlorine (a precaution against bacteria) to the water, and a dash of fluoride to prevent tooth decay.

The aquifer rock — which is a wide belt ranging in depth from zero feet along the Iowa/Minnesota border to 400 feet deep at La Porte City — acts like a big coffee filter, cleansing away dirt as it percolates water through its tiny pores.

Feather-like fractures constantly transmit water from "recharge" sources, which include the Cedar River, creeks and streams north of here, and Minnesota rainfall.

This continual hydrologic cycle has kept the aquifer full for as long as people have been tapping into it.

And because water entering the aquifer in northern Iowa moves just centimeters a day, said Dr. Jim Walters, professor of geology at the University of Northern Iowa, some of the metro water pumped up has been carbon-dated at over 2,000 years old.

Bucket brigades

In 1905, Waterloo began to search for an alternate to its Cedar River water source.

The first deep well was drilled into the Jordan Sandstone Aquifer 1,200 feet below the corner of First and Sycamore streets, nearly 100 feet below sea level. That well and four additional Jordan wells, which provided 72-degree water, began to fail by the late 1920s.

When a test well punctured the Cedar Valley Aquifer, it was like striking oil.

Today the aquifer supplies Waterloo's 15 operational pump wells, 351 miles of pipe, three, 1 million-gallon capacity elevated water towers, 3,000 hydrants and 24,000 metered customers.

The city pumps an average of 13 million gallons daily. In one peak 24-hour period in 1980, the city pumped 28 million gallons.

If necessary, the aquifer can provide Waterloo with 53 million gallons in one day.

Cedar Falls in the 1860s drew drinking water from Dry Run Creek and formed bucket brigades to fight fires.

At the turn of the century, a new system pumped spring water to a cistern at the early settlement's $40,000 water plant on East 12th Street, then on to main streets for distribution via wooden conduits.

But that method was discarded in 1912 under threat of a typhoid epidemic, and three wells were drilled to a depth of about 110 feet. The wells' 3.5 million-gallon daily capacity exceeded the needs of the city five or six times over.

Cedar Falls' nine existing wells today still have that "amazing capacity" said Jerry Shoff, Cedar Falls Utilities water supervisor. Only two or three run at any one time, and that's plenty for the town of 37,000.

Predicting the future

It's lucky Cedar Falls and Waterloo city founders chose this exact spot to settle one of the largest metropolitan areas in Northeast Iowa.

Nearly all of the water for Northeast Iowa towns, farms and industries comes from groundwater, and dozens of municipalities rely on the Cedar Valley Aquifer.

But quantity and quality drop significantly outside Black Hawk County, Gordon said. Elsewhere, the aquifer's limestone is not nearly as fractured and pourous, and the water is often high in undesirable iron, calcium, and magnesium.

Other cities in the state are forced to struggle with river water purification systems.

Many Iowa City residents drink bottled water, and the city is trying to its abandon river water system but has few other options. Two summers ago, Des Moines went without city drinking water for 19 days after flood waters breached the treatment plant.

Runoff and silt can also hamper the water quality. Cities that use lake water must deal with algae and other variables.

Aquifers remain protected from those problems, but they are not perfect. The Ogallala Aquifer, which stretches from South Dakota to Texas, is a reminder that some water supplies are not endless. In the 1980s officials in the states where the Ogallala supplied water found the aquifer was being depleted at a rapid pace. Water conservation measures have since allowed the water supply to replenish.

No one has any idea how much water is really in the Cedar Valley Aquifer. Or how long it will last.

Craft pointed out, "Because it has not dropped in decades we can predict that it will not drop in future years."

Shoff said crews can dig a well anywhere in town and water will gush at more than 2,000 gallons a minute.

"That's a lot of water," said Don Gordon, supervisor of the hydrology for the Iowa Geological Survey Bureau. "I don't think you're ever going to run out of water."

Cedar Falls Utility General Manager Dean Crowe said, "I've been fascinated with it for years. Even during (dry spells) we've continued pumping at the same level and it just didn't go down."

Potential dangers

Still, city water managers know they can't consider the aquifer an infinite gold mine.

The occasional hint of a contaminant in test samples proves that chemical runoff is indeed penetrating the aquifer.

"Once it's polluted, it will stay polluted," Craft said. "I hope and trust that farm operations will use no more chemicals than is absolutely essential and that industrial operations will properly dispose of the by-products and chemicals they use."

Sinkholes, caused when a fracture in underground limestone causes a chunk of land to sink several feet, are another way for contaminants to enter groundwater. The closest sinkhole to the Waterloo/Cedar Falls is in Janesville. They're more of a problem in counties north of here.

The Cedar Falls Recreation Center and about 30 buildings on the University of Northern Iowa draw aquifer water for heating and cooling purposes, then drain the water into storm sewers.

That could be a cause of future depletion, water experts said, if more area residents use the aquifer for heating and cooling buildings, or for irrigation.

FLOODING

Kari Lundeen
Department of Earth Science
University of Northern Iowa

In the Spring of 1993, the yearly snow melt had already saturated the floodplains of the Midwest, making them incapable of holding the exceptionally heavy precipitation that followed. During the months of January through July of 1993, record amounts of precipitation were received in the Upper Midwest. This combination caused the high water levels which were more than the rivers—and their more than 7,000 miles of levees—could handle.

Investigation of the effects of the Flood of '93 led to a better understanding of the factors that contributed to the severity of the flooding. This will aid in developing better flood-control measures in the future. Prevention of the overall direct and indirect damage suffered is in the best interest of everyone.

One of the immediate concerns of the Flood of '93 that grabbed media attention was the perceived failure of flood-control measures, particularly levees (Tobin, 1994). With the continued threats of flooding, people expended considerable effort attempting to protect their property by filling sandbags and stacking them on levees.

The fact that is often forgotten is that levees are effective in controlling flood waters only up to their design standards. For years, these structures have successfully protected urban and rural communities until they were compromised by extraordinarily high water levels. Since many people depended upon the levees for protection, they watched in horror as many were overtopped, eroded away, or broken by the immense pressure of the raging river. Of the 1,576 levees in the Midwest drainage basin, 70% failed. Of those that did fail, only 20% were federally funded while nearly 80% were privately owned (Tobin, 1994).

The flood waters swept through homes and businesses leaving property damage estimated at $10-20 billion (Tobin, 1994). Agricultural damage was extensive, with thousands of acres of corn, soy beans, and other crops completely destroyed. Highways were damaged, roads and bridges lost, airports closed, railroads washed out, and navigation on the Mississippi brought to a halt. Des Moines, Iowa, went without drinking water for 12 days during July due to flood caused contamination (Newsweek, 1993). Other indirect losses include wages, production, and health care costs.

Since flooding is a recurring process, and floods with magnitudes comparable to 1993 can be expected in the future, adjustments in flood control procedures, both structural and non-structural, are needed (Fig. 11). Some difficult decisions will have to be made regarding the levee system; should levees be rebuilt, redesigned, removed, or repaired using non-structural methods? Appropriate land use management will be necessary to minimize flood losses, and will take several forms; returning the floodplain to the river by relocation of communities, buying out houses in flood prone areas, and minimizing development on wetlands. Individuals can also take action to protect themselves from future damages by floodproofing their houses and buying flood insurance. The Cedar Falls/Waterloo area has also taken flood control measures that have been successful, but there is always room for improvement.

Affects of the Flood of 1993 in the Cedar Falls/Waterloo Area

The Cedar River has a drainage area of 4,743 square miles upstream from Old Highway 20 (Highway D-22) in Cedar Falls. Its headwaters are in Dodge County in southern Minnesota. The Cedar River Basin consists mainly of prairie-derived soils. The river valley is characterized as being mature, with surficial glacial till deposited over the entire basin. This basin is used primarily for farm land. The primary flood season for the Cedar River is in the Spring and early Summer. Most of the largest floods in the area have resulted from snow melt (or snow melt in combination with heavy Spring rains). Severe thunderstorms also sometimes create flood conditions. The gauging stations are located at the Highway 20 bridge in Cedar Falls and on the left bank of the Cedar River at the foot of East Seventh

A. Mitigation Options, by Type of Action

ADJUSTMENT Action on Floodplain	ABATEMENT Action in Catchment	PROTECTION Action along Channel
NONE	*AFFORESTATION*	*LEVEES*
EMERGENCY ACTION	*AGRICULTURAL METHODS*	*FLOODWALLS*
FLOOD-PROOFING	*URBAN AREAS*	*DIVERSION SCHEMES*
LAND USE REGULATION	*WETLAND PROTECTION*	*DAMS*
FINANCIAL		

B. Mitigation Options, by Approach

STRUCTURAL	NONSTRUCTURAL
LEVEES	*FLOOD WARNING*
FLOODWALLS	*EVACUATION SYSTEMS*
DIVERSION SCHEMES	*LAND-USE MANAGEMENT*
DAMS	*FLOOD-PROOFING*
	FLOOD INSURANCE

C. Mitigation Options, by Ability to Choose

INDIVIDUAL	GROUP
FLOOD-PROOFING	*FLOODWALLS*
FLOOD INSURANCE	*DAMS*
RELOCATION	*FLOOD WARNING and*
EVACUATION	*EVACUATION SYSTEMS*
	FLOOD INSURANCE PROGRAM

Figure 11. Range of adjustments to the flood hazard (Tobin, 1994).

Street in Waterloo. Data has been monitored in Cedar Falls from 1975 to the present and in Waterloo from 1940 to the present.

The 1993 water year began in October, 1992, and ended in September, 1993. Looking at the record for the entire year gives a better understanding of why such dramatic flooding took place, specifically, how the flood of 1993 affected the local Cedar Falls/Waterloo area. Most of these data are from the United States Geological Water Resource Data Book of 1993.

The 1993 water year was considered to be the wettest in 121 years of record for the State of Iowa. It was also the fourteenth coldest. Precipitation for October at the start of the 1993 water year was at 66% of normal. The Cedar River was at normal discharge. November was wet, and precipitation jumped to 251% of the normal for the month. This resulted from statewide precipitation in the form of rain and snow towards the end of the month. The discharge of the Cedar River was considered to be in the excessive range. December precipitation was at 144% of normal, but it was mostly in the form of snow, and there was little discharge fluctuation. January and February were similar, around 130% of normal precipitation; discharge was excessive. In March, stream flow increased due to the runoff of melting snow along with precipitation. Statewide precipitation was 126% of normal and the discharge of the Cedar River was once again in the excessive range. During April, with the ground still frozen or saturated ground, a high rate of precipitation resulted in major flooding on the Cedar River. The Des Moines River flowed over the dam and through the emergency spillway twice at the Saylorville Reservoir north of Des Moines, and the Iowa River flowed over the Coralville Dam and through the emergency spillway at the Coralville Reservoir near Iowa City. A new maximum monthly discharge record was set at Cedar Rapids on the Cedar River at 35,320 cfs. In Waterloo the mean discharge for April was 24,940 cfs. May also set a new record for mean monthly discharge on the Cedar River at Cedar Rapids reaching 18,270 cfs. Again, this was a result of intense rains falling on the already saturated grounds across the State of Iowa. June precipitation was 183% of normal. This was the third wettest June in 121 years of record. The months of July and August were also the wettest in 121 years of record with August at 204% of normal. Statewide, the average August precipitation was 254% of normal. August discharges increased as a result of heavy rains, creating another new average discharge record for the Cedar River at 28,700 cfs. September ended the water year with the first month since the previous October to receive below average precipitation.

Flooding Hazards Due to Highway Construction

Two highways were recently constructed in the Cedar River floodplain in Cedar Falls. These are Highway 218, which runs from Cedar Falls to Waverly and Highway 58, which connects to Highway 218 and runs south from the intersection of Highway 57 to Highway 20. The conjunction of these three highways has altered the hydrologic characteristics of the floodplain, producing an increase of water level during flooding in the main channel and especially in the diversion channel.

The floods of April, 1993, and August, 1993, were used to evaluate the U.S. Army Corps. of Engineers HEC-2 water surface profile model, created to evaluate hydraulic effects of development on the floodplain. Earlier models had experienced difficulty evaluating this area due to the split flow of the river. The HEC-2 model was an update of a 1984 model, produced by the Flood Insurance Study, which had been used to identify a floodway through the Cedar Falls area where no development could occur. The development level was established at 1 foot above the 100 year flood level, consistent with the federal standard.

The floods of 1993, although very destructive and costly, provided valuable information for updating and improving the accuracy of the existing hydraulic model. The model was adjusted, using actual levels and discharges from the flood records with the highway structures in place. These highway structures were then "taken out" of the model to see what water levels would be without the structures (Fig. 12).

For the 100-year flood, the water level was increased from 0.5 to 1.3 feet in the main channel due to the highway structures. A 0.5 foot rise was produced by Highway 218 in Waterloo near East George Wyth State Park. The river level increased by 1.3 feet downstream from Highways 58 and 218. Backwater level was lowered upstream from Highway 57, to 0.7 feet by the Center Street Bridge. In the diversion channel, backwater levels increased by 1.4 feet on the downstream side of Highway 218, and increased by 1.9 feet at Lincoln Street. The backwater profile is 1.7 feet higher downstream of the Illinois Central Gulf Railroad and 1.0 feet higher upstream of the railroad bridge. The increase in the profile goes down to 0.7 feet at Big Woods Road. The Cedar City area would be effected by these rises of the water level in the diversion channel.

The higher rises in the diversion channel can be attributed to three factors: 1) backwater created by

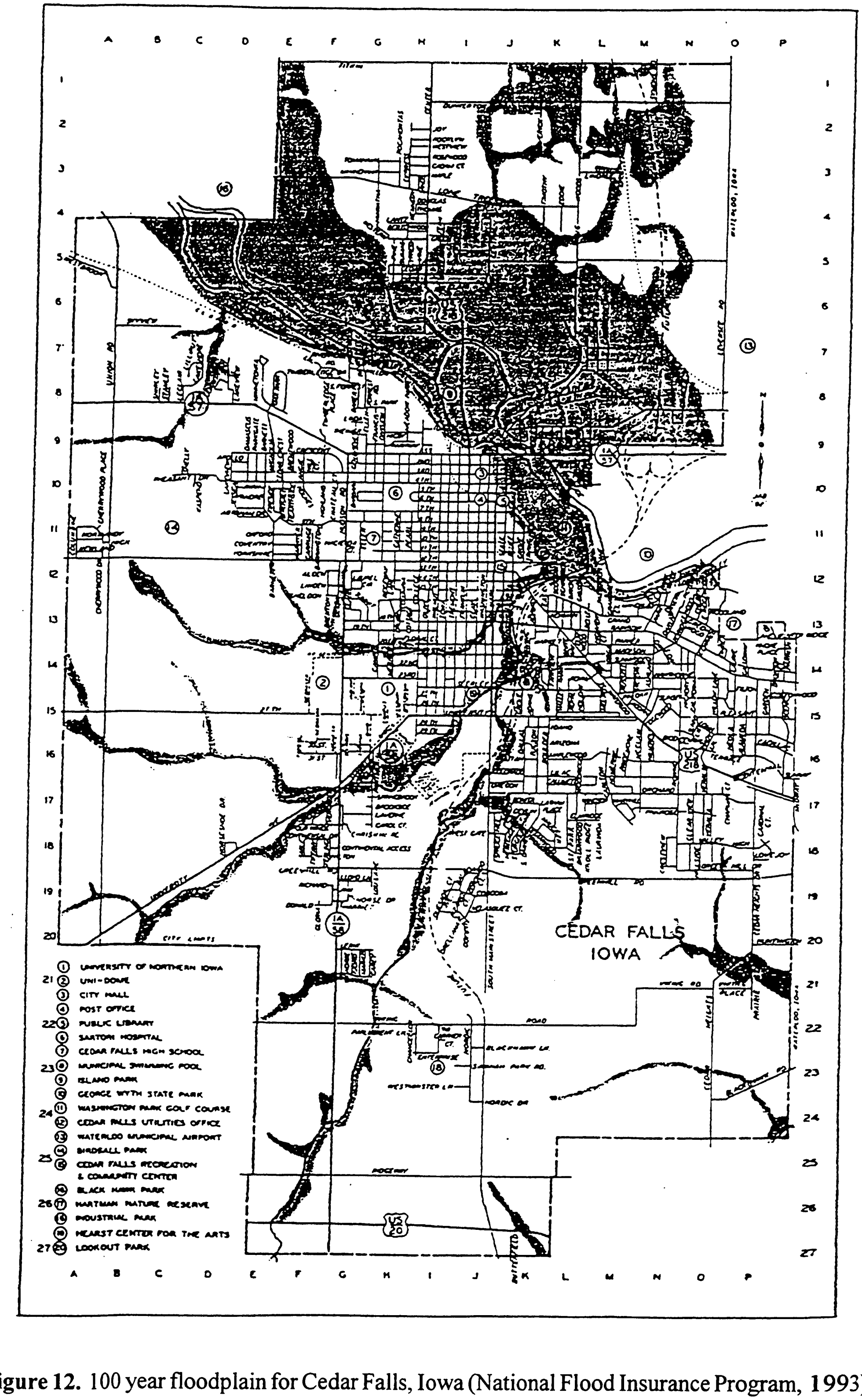


Figure 12. 100 year floodplain for Cedar Falls, Iowa (National Flood Insurance Program, 1993).

the Highway 218 bridge, 2) bridges on the main channel create backwater which raises water elevation levels upstream, increasing the discharge through the diversion channel, and 3),the construction of West Lake removed a portion of Big Woods Road south of Lake Street creating a less resistant flow path for water to enter the diversion channel. Consequently, it was determined that the recent highway construction projects had increased the discharge in the diversion channel by 13%.

Flooding in North Cedar and Cedar City Area

Cedar Falls can be geographically divided into three areas; Cedar City, North Cedar, and the main city of Cedar Falls. Cedar City is northeast of downtown Cedar Falls, and is divided into East Cedar City and West Cedar City. North Cedar is north of downtown Cedar Falls. These areas are characterized by sandy or silty soils which absorb rain water well, however, these areas all lie at least partially within the 100-year-floodplain, and would be severely impacted by a flood of 100-year magnitude.

In a 1992 Reconnaissance Report, the U.S. Army Corps of Engineers proposed plans to limit damage due to floods in these areas. These plans included both structural and non-structural measures of flood control. The structural measures include the building of different types of levees and ring levees around selected areas of Cedar City and North Cedar. Non-structural measures include dredging of the Cedar River, flood warning devices, and raising buildings above the level of flooding events.

Many buildings in these areas are frequently affected by flooding. Construction of levees would undoubtedly reduce the flooding in these areas, however, cost-benefit analysis has shown that these flood control structures are not economically feasible. It is not likely that Cedar City and North Cedar will develop flood control structures until the main city of Cedar Falls implements some type of levee system.

The city of Cedar Falls has specific codes which regulate building on the flood plain. These codes are stated in the Cedar Falls Code, Sections 29-155 through 29-158, where regulations for constructing buildings and other structures of various uses can be found. The code states that new structures which are built within the 100-year flood plain must be built with the habitation level elevated at least one foot above the 100-year flood level. Also, the new structure must not effect the flow of flood waters. Existing structures which are substantially renovated must also meet these requirements. To construct a building that will not effect flooding requires that the structure withstand the impact of a 100-year flood. Storage of materials which cannot be readily removed or which may float and cause damage as a result of being carried by flood waters is also prohibited. Uses of the floodplain which are not strictly regulated by the Cedar Falls City Code include agriculture, recreational facilities, residential lawns, parking, loading areas, and airport landing strips.

Future Plans for the City of Cedar Falls

The lowest areas of Washington Park on the east side of Cedar Falls are flooded annually. The 5-year floodplain extends over the golf course and the low area adjacent to the community's wastewater treatment facilities. A 25-year flood would cover the golf course with 9 feet of water, and the park and athletic field would be submerged under nearly one foot of water. A 25-year flood would also back water up the natural drainage system and flood the low area between the abandoned Chicago and Northwestern Railroad spur and the central business district. The central business district experiences significant damages at this level of flooding.

Cedar Falls has recently developed a new plan to reduce the damages caused by flooding. In 1985 the city submitted a plan to protect the downtown area from what had become an annual $1.3 million disaster. Federal funding for the plan has recently been approved, and construction will begin sometime between 1997 and 1999. The main areas in Cedar Falls that need protection from flooding include the sewage treatment plant, residential areas, many small businesses, and historical sites such as the Ice House Museum and the Broom Factory Restaurant.

The proposed site for the new flood protection system is on the east side of Cedar Falls where the Cedar River passes through the downtown area. This system would include levees, flood walls, and pumping stations. A special pumping area for interior drainage would be built adjacent to the sewage treatment plant. The proposed source for the materials to build the levee system is on the east side of Cedar Falls, near the end of Valley High Drive. From this site earthen materials will be excavated and transported to the levee site. The levee system will protect the downtown businesses, industries, residences, and public facilities from annual flooding.

The Dike and Levee System in Waterloo

The city of Waterloo already has a dike and levee system in place. Construction of a flood control system designed to withstand a 100-year flood was started in 1960 and was completed in blocks; with the final block finished in 1985. The U.S. Army Corps of Engineers built the system and also provided $43 million for construction. The city of Waterloo paid the remaining $22 million for the completion of the project. This system now protects businesses and homes from the annual flooding.

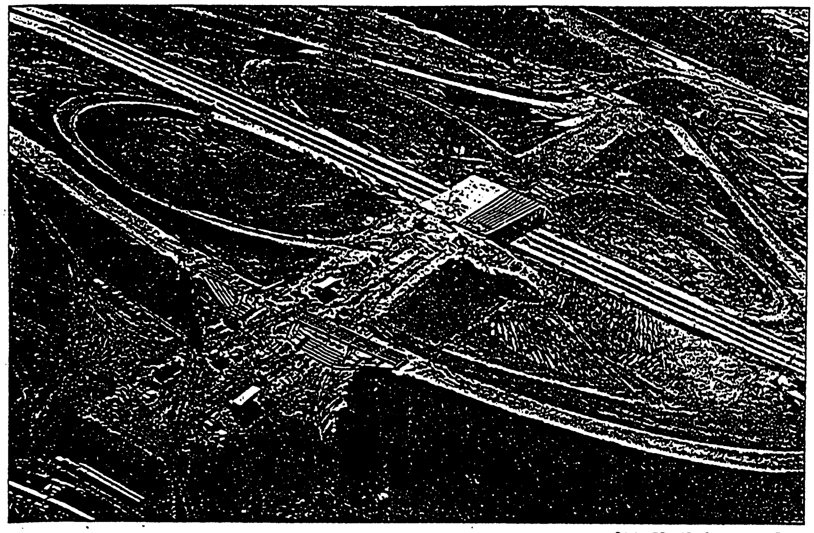
The levees are elongated hills of earth material that parallel the river banks. Waterloo has 18.2 miles of levees along the Cedar River. To ensure that the soil remains intact, grass is grown on all surfaces of the levee. In some areas of Waterloo, the tops of the levees also serve as recreation trails, with the area enclosed within both levees usually serving as a parks.

The dikes are concrete flood walls, and Waterloo has only 1.9 miles of these flood containment structures. Usually where a road crosses a dike, there is a closing structure, of which Waterloo has two. These giant doors can be closed in times of flooding to contain the water. With the doors closed in times of floods, water will pond up on the dry side of the wall. This water is pumped over the dike and into the river by storm water pumping stations.

The flood of 1993 had a strong impact on the area, but the Waterloo flood control system was effective at holding back most the water. Estimates indicate that hundreds of millions of dollars were saved by this $55 million investment in the flood control system.

The following newspaper article is reprinted with permission.

Waterloo/Cedar Falls Courier April 27, 1994



DAN NIERLING / Courier Photo Editor

This interchange of relocated Highway 58 and 218, and the continued construction of relocated 218 to the north, contributed to flooding in the Cedar City and Lincoln Street areas of Cedar Falls last year, an Iowa Department of Transportation study has concluded. The interchange is shown in this view from the northwest looking toward George Wyth State Park.

DOT to help C.F. flood victims

City leaning toward construction of 100-year ring levee

By DEBORA BLUME
Courier Staff Writer

CEDAR FALLS — The Iowa Department of Transportation has agreed to give the city $2.5 million to help correct flooding problems contributed to by highway construction.

A study commissioned by the DOT and the city concluded construction of relocated Highways 58 and 218 may have increased water levels in parts of an area bounded on the south by Highway 57, on the east by Highway 218, on the west by East Main Street and Big Woods Road and on the north by Big Woods Lake.

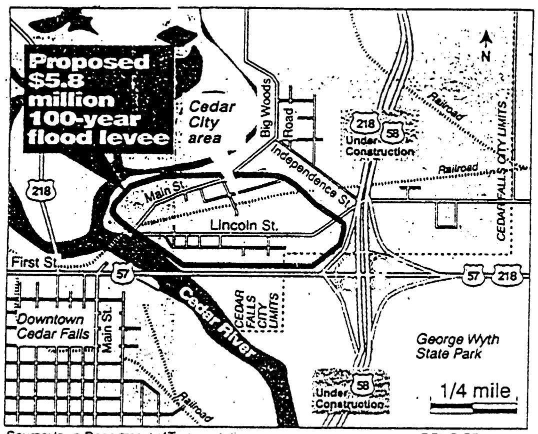
The area includes the Cedar City residential area and Lincoln Street business district.

Cedar Falls Developmental Services Director Jim Krieg told a capacity crowd of flood victims at North Cedar School Tuesday night the money would go toward one of several alternatives being considered by the city.

"We are looking for long-term solutions," he said.

The alternatives include:

- Extending bridges and making channel improvements at a projected cost of $2.2 million.
- Building a 25-year flood levee and channel improvements, plus right-of-way and property acquisitions at an estimated cost of $3.7 million.
- Building a 100-year flood levee, channel improvements, purchasing rights of way and home buyouts at a cost of $5.8 million.
- Acquiring all the property in Cedar City, on Lincoln Street, Independence Avenue and Riverside Drive at an estimated cost of $7 million.
- Acquiring flood easements, which would cost $7 million.



Source: Iowa Department of Transportation COURIER graphic

Mayor Ed Stachovic said the city is leaning toward the construction of the 100-year ring levee.

"It will increase the value of all the properties in that area," he said. "It's going to raise the quality of life for everyone living there and it will improve the business environment for the businesses there.

"The unfortunate part of this process is that we want to clear the floodway. There are some residents who have lived there for years; they want to stay there, and I'm sure they feel they are being sacrificed in this whole project," the mayor said.

The ring would start north of Highway 57 and follows the river north to Main Street. It would also protect areas such as Fifth Avenue, Lincoln Street, McKinley Street and Grant Street.

Stachovic said city staff would start working immediately securing funds for the 100-year levee proposal.

See FLOODING / page A3

FLOODING

State will pay to help C.F. flood victims

Continued from page A1

"We want to ... work with the people from the state allocating those funds to make sure we have the $6 million confirmed for the project, and then it's necessary for the council to support the concept and understand this may involve involuntary acquisition," he said.

Stachovic expects it will take three months to get a plan of action, and the money, in place for the project.

He said the possibility of forced acquisitions makes the project tough.

"When you look at a map from 500 feet up and you envision all these plans and you say, 'We'll just buy all these homes and let the river take its course,' that's easy to do. But when you knock on the door and meet the people there and see the pictures of the family on the wall, this is going to be very difficult," he said.

One option is that the city could offer a "lifelong estate," meaning the city would acquire the homes in the floodway but allow the residents to choose to stay in their homes until they move away or die.

"What that means is they will be living in the floodway and taking the full course of the river when it comes through, and I think that would be a very dangerous thing for them," he said.

The DOT's Tom Cackler called the 100-year flood levee plan a "win-win situation" for everybody.

The state would have to work out a formal agreement with the city on whatever option is chosen. "Part of that agreement would address how and when we would pay (the $2.5 million)," Cackler said.

He said the Iowa DOT is checking into possible environmental problems with the channel clearing. He said an endangered species of salamander may be living in the area, but so far none has been spotted.

Residents are asked to send their choice of alternatives to Krieg at 217 Washington St., Cedar Falls, 50613. The City Council and city staff will review the responses over the next three months.

Waterloo/Cedar Falls Courier

March 12, 1996

Downtown flood levee project put on hold again

By JENNIFER JACOBS

CEDAR FALLS

A proposed flood wall to protect downtown Cedar Falls has been postponed indefinitely because of the federal budget deadlock.

"How long is in the hands of Washington," said Jim Krieg, the city's director of Developmental Services.

Construction of the $5.7 million flood levee was to be 75 percent (about $4.2 million) paid through the federal Department of Defense.

Because of the delay, construction of a storm water detention basin east of Valley High Drive will be postponed.

Krieg said the city had intended "to kill two birds with one stone," by digging dirt from the pond to create the earthen embankment along Cedar River.

But a U.S. Army Corps of Engineers' program budget is being cut about 40 percent, or $10.2 million, so the Corps is discontinuing work on all but priority projects under way, said Charles Cox, Army Corps district engineer in a letter to the city.

"I regret that I am the bearer of this unsettling news," he wrote. "I hope that funding will be restored in the near future."

The project already has been delayed once. When 1993 flooding washed out additional river bank, it prompted a re-evaluation of the height of the flood wall. That took 15 months.

Lee Miller, president of the Cedar Falls Chamber of Commerce, said, "I think it would be a terrible situation if we did not get our flood protection, because this is certainly stalemating a lot of economic development in our downtown area.

"This project has been approved and delayed and delayed and now it's time that they take some action," he added. "We should probably put on the political pressure."

Krieg said the city is keeping in touch with congressional representatives on the matter.

CEDAR VALLEY LAKES

Kari Lundeen
Department of Earth Science
University of Northern Iowa

The Cedar Valley Lakes Project (Chain of Lakes) involves the reclamation of aggregate pits into lakes and wetlands. The lakes were created from areas where sand and gravels were extracted for use as aggregates in the construction of several highways. The Cedar Valley Lakes Project led to the creation of George Wyth Lake, Alice Wyth Lake, Big Woods Lake (West Lake), East Lake, and Prairie Lakes (Fig. 13).

To make the transition from aggregate pits to lakes, the pits were dredged. The coarser materials were hauled away in trucks, while the sand size material was pumped to a different location. Each area contained two to three pumping stations; which utilized twelve inch plastic pipes to transport sand for two miles or more. During the dredging processing, run-off into the existing wetlands was prevented by diverting it into an excavated area for storage. The dredging phase of the Chain of Lakes took over three years to complete.

The goal of the Chain of Lakes Project is to maximize recreation and economic opportunities while protecting the area's natural resources. The project, when completed, will have produced the largest, most diverse natural recreation complex in Iowa, benefiting the environment and the community. The completed complex will include the following (INRCOG, 1991):

1) 10 miles of Greenbelt
2) 700 acres of public recreational waters
3) recreational trails extended and linked to Black Hawk Park and the Cedar Valley Nature Trail
4) 50 acres of newly constructed wetlands, in addition to the development of many acres of oxbow lakes along the Cedar River
5) an expansion of the Hartman Reserve area from 80 acres to 260 acres
6) compatible private development to complement the public facilities within the projected area.

The overall completion schedule for the project will span the next two decades (INRCOG, 1991). The project began with the expansion of George Wyth Lake in 1989; the balancing of the East and West Lakes is projected to take place in the year 2010.

Benefits of the Cedar Valley Lakes Project

One of the most prominent benefits of the Cedar Valley Lakes Project for Black Hawk County is the expansion of recreation facilities. Specific recreation benefits include the following (INRCOG, 1995):

1) additional waters for unrestricted boating, canoeing, and rowing, much appreciated in a county with the State's highest number of registered boats
2) nature trails for hiking and biking
3) additional recreation activities in newly acquired lands
4) the area wildlife will benefits under plans for additional habitat acquisition.

This project was funded by several economic development groups in Black Hawk County. The Department of Transportation (DOT) supplemented the original project by donating land used for construction of highway projects. Recent grants from interested parties have enabled the purchase of additional land.

Ownership and management of the Cedar Valley Lakes has not been determined. It will likely include state, county, and city government. Black Hawk County and the State of Iowa are the principle managers and land owners. The Cedar Falls and Waterloo communities will continue to be secondary managers of the project.

The Cedar Valley Lakes Project will continue to expand as long as community interest dictates. Purchasing additional metropolitan river front property is a prime issue. This property will connect two parts of the Cedar Valley Nature Trail, provide major river front trail connections, enhance river aesthetics, and increase recreational use.

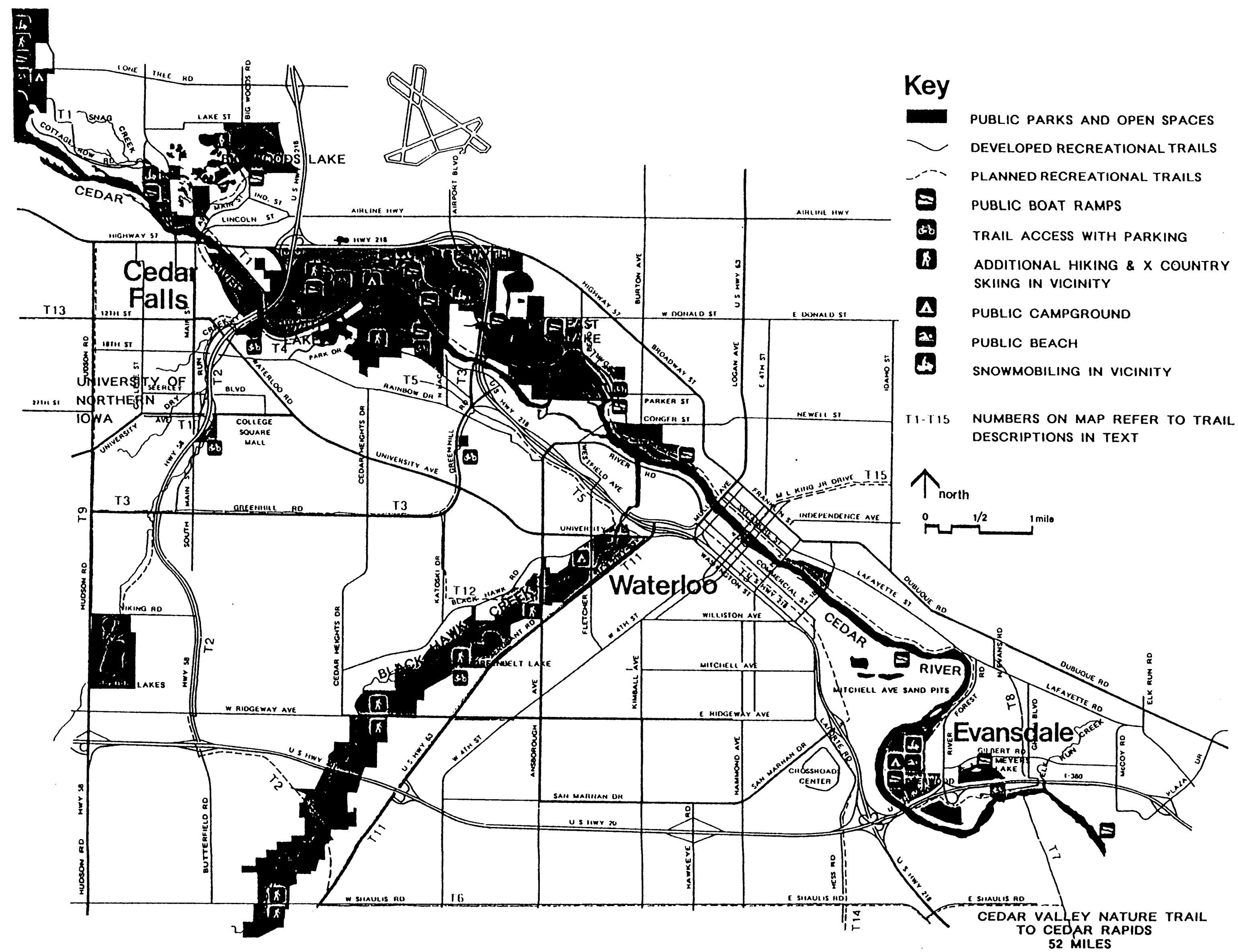


Figure 13. Cedar Valley Lakes recreation guide (INRCOG, 1995).

The following newspaper article is reprinted with permission.

Waterloo/Cedar Falls Courier June 2, 1996

From corn fields to computers

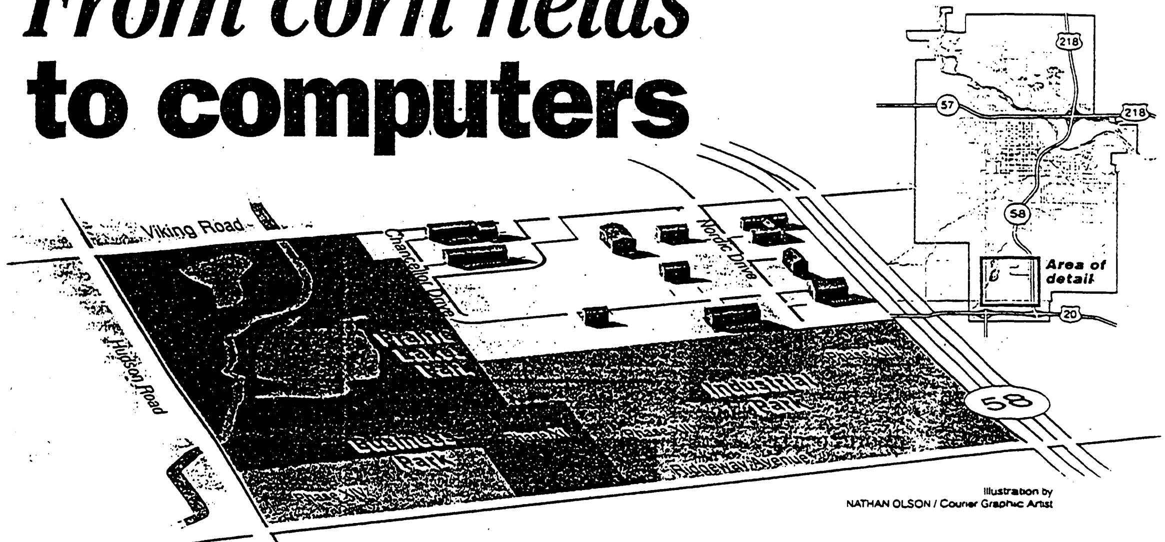


Illustration by NATHAN OLSON / Courier Graphic Artist

Five high-tech firms take up residency in C.F. Technology Park

By PAT KINNEY
Courier Business Editor

CEDAR FALLS

The city has assembled a "starting five" of hometown heroes and hopes to mount a full-court press to bring the metro area a high-tech business park.

Spinning off of the success of the Cedar Falls Industrial Park — the growth of which has taken off since the construction of relocated Highway 58 — the city has now designated a portion of land to the west as a "Technology Park."

The city hopes to ring Prairie Lakes Park on Hudson Road with a necklace of computer-oriented, information age businesses, starting with five homegrown pearls: Congdon Printing, American Color Imaging, Jim Mudd & Associates, TEAM Technologies and R.A. Snyder Consultants.

But don't dare say those five are in the "Industrial Park," even though the area is just west of there. It's contrary to the image city officials have carefully tried to cultivate for the area.

The recipe is as simple as it is methodical:

1. Take a farm field. Build four big four-lane roads around it — in this case, Viking Road, Hudson Road, Highway 20 and Highway 58.

2. Dig a couple of big holes for the dirt to build the roads. Fill the holes with water to make a lake. Make the land around the lake a park.

3. Give a handful of your best, fastest-growing "clean" industries land to locate there, to give the area a high profile, but require them to adhere to landscaping and construction standards.

4. Use those businesses as a cadre to market your finished product to the outside world.

The city is well into the third step of that process, with the fourth step on the horizon, city Developmental Services Director Jim Krieg said. The city hopes to market the Technology Park across the country and through the efforts of the Cedar Valley Economic Development Corp.

Some hooted at the development of "a park out in a corn field," Krieg said. But today, he said, "people can see that Prairie Lakes Park is a reality. People can see the city is very serious about economic development, targeting high-tech jobs. ... A lot of industries are looking at us, saying this is an attractive area that does have a lot to offer."

An additional feature — one not envisioned in the original planning 10 years ago — was the advent of fiber optics capabilities through Cedar Falls Utilities. That, plus the location and incentives, should make the area a compelling sell, Krieg said.

By dubbing the area a "technology park" the city isn't necessarily going for a Micron, the huge computer chip firm that eyed the metro area a year ago.

"You don't go after home runs necessarily," Krieg said. "You go for singles and doubles, and build confidence locally with people that are going to commit to you. It's then you are going to get the home-run hitter."

It's no coincidence that a group of local, related high-tech businesses wanted to be in the same location, said Richard Congdon of Congdon Printing. Some of the companies already are doing or plan to do business with each other.

"To say we didn't all talk prior to going out there would not be fair," Congdon said.

"I don't have any grand, glamorous words, other than it (Technology Park land) was what was available. And also, we felt if that's where the technology businesses were, then we wanted to be there also. It's the same reason why you put a retail business up over at Crossroads (shopping center in Waterloo)."

"In the first place, it's such a nice area," said Don Lohnes of American Color Imaging. "And they're working hard at making it a technology area. All those businesses will complement each other."

American Color may provide graphic services for Mudd's advertising clients, while at the same time purchasing computers from TEAM. "We have a unique business in this area. There's other businesses that will complement ours and vice versa," Lohnes said.

And that first core of hometown businesses may be the gateway to bringing in new ones, Krieg said. "These businesses do business across the country," he said.

The University of Northern Iowa, specifically its burgeoning College of Business — just a "gleam in the eye" of UNI administrators a decade ago, — Krieg says, — is another asset that can be tapped to bring business here.

Quality of life — including good schools and a commute of 10 to 15 minutes, instead of an hour in an urban area — is another very real selling point, Krieg said.

Giving businesses free Technology Park land is a big incentive, but it also, admittedly, raises some eyebrows locally, Krieg said.

"The thing we look at is the long-term commitment," he said. "That business is going to be here 20, 30, or 40 years, plus they're paying electric fees, gas fees, water fees," in addition to the property taxes on the building they will build, separate from any gift of land.

TEAM, one of the Technology Park's "starting five," wavered between the Technology Park and a site near the Waterloo Municipal Airport, where a foreign trade zone and industrial park is being considered. Still, Krieg said he thinks the two projects will complement and not compete with one another.

Businesses in the Technology Park will be able to assist and do business with airport industrial park businesses, Krieg said, with the two areas linked by a short drive on Highways 58 and 218.

Moving in

The following local firms plan to locate and expand in the Prairie Lakes Technology Park in Cedar Falls:

Firm	Building cost	Current jobs	New jobs
Congdon Printing	$1 million	32	12
TEAM Technologies	$1.6 million	75	25
American Color	$2.4 million	87	20
Mudd Associates	$920,000	31	26
R.A. Snyder	$350,000	10	25
Totals	*$6.27 million*	*108*	*245*

Note: Expansion costs are conservative. They include mainly construction costs not equipment purchases.

COURIER graphic

TOXIC WASTE

Jon Yetley, Jeff Brandt, Troy Dooley,
Jeremy Linsenmeyer, Steph Morris,
and Pete Stavlund
Department of Earth Science
University of Northern Iowa
Cedar Falls, Iowa

Blackhawk Iron and Metal Company

Introduction

Three companies conducted reclamation of batteries, transformers, and scrap metal at the Blackhawk Iron and Metal site from 1950 to 1991. As a result of those activities, approximately 200,000 square feet of surface soils had become contaminated with lead, copper, PCBs, and other materials. Based on the samples collected during a removal assessment, it was determined that groundwater contamination had not occurred, although the surface water was contaminated. Surface water was prone to contamination primarily because of the site's proximity to the Cedar River and the presence of a well defined runoff route through a storm sewer where little infiltration occurs. The release of this surface water poses a threat to contaminate the human food chain. The potential for contamination exists because of the urban residential location of the site. Exposure hazards included direct contact with contaminated site soils and off-site migration of windblown, lead-laden particulates (EPA, 1995).

Site Location

The Blackhawk Iron and Metal site is located in the city of Waterloo, at the east margin of the city at the corner of Lafayette Street, between California Street and Zuma Street (Fig. 14). Currently inactive, the site covers an area of approximately 200,000 square feet. To the south, the site is bounded by a sparsely wooded flood plain. The site is bisected by the east-west trending Chicago Central and Pacific Railroad line, which was littered with metal debris and battery casing fragments prior to the cleanup. Approximately 25 abandoned 55-gallon drums were scattered throughout the property. Several large wooden spools were located on the southern portion of the site, with elemental mercury observed on two of the spools and on nearby soil. Structures on the site include a steel frame building, a lean-to shed, and an office building, all located centrally on the site (Fig. 15). Prior to clean-up there was unrestricted access to the site from the south, but during reclamation in June of 1994 a perimeter fence was erected to prevent public access (EPA, 1995).

Site History

The Blackhawk Iron and Metal Company conducted a reclamation of batteries, transformers, and scrap metal from 1950 to 1987. The site was then operated by RNM Midwest Metals, where scrap metal and transformer reclamation continued from 1987 to 1989. Capital Metals continued to reclaim transformers from February 1991 to May 1991 (EPA, 1995). The facilities office building was then destroyed by fire and no further business activities have occurred since.

The contaminants of primary concern at the site were polychlorinated biphenyl's (PCBs), lead, and mercury in site soils. The reclamation of transformers at the site is suspected of being the source of PCB contamination. Elevated levels of lead are assumed to be from the battery reclamation. The elemental mercury was found at the site by local children, which brought the vacant site to public attention in 1993.

Site Status

The site was identified as a potential hazardous waste site when a citizen reported the presence of elemental mercury in on-site soils to the EPA. The report was investigated in December 1993 by a Technical Assistance Team, who collected soil samples throughout the site to identify the major contaminates. Field screening and laboratory analyses of the samples concluded that an isolated area of mercury contamination was present and that elevated levels of lead and copper existed across the site.

A thorough removal assessment was conducted

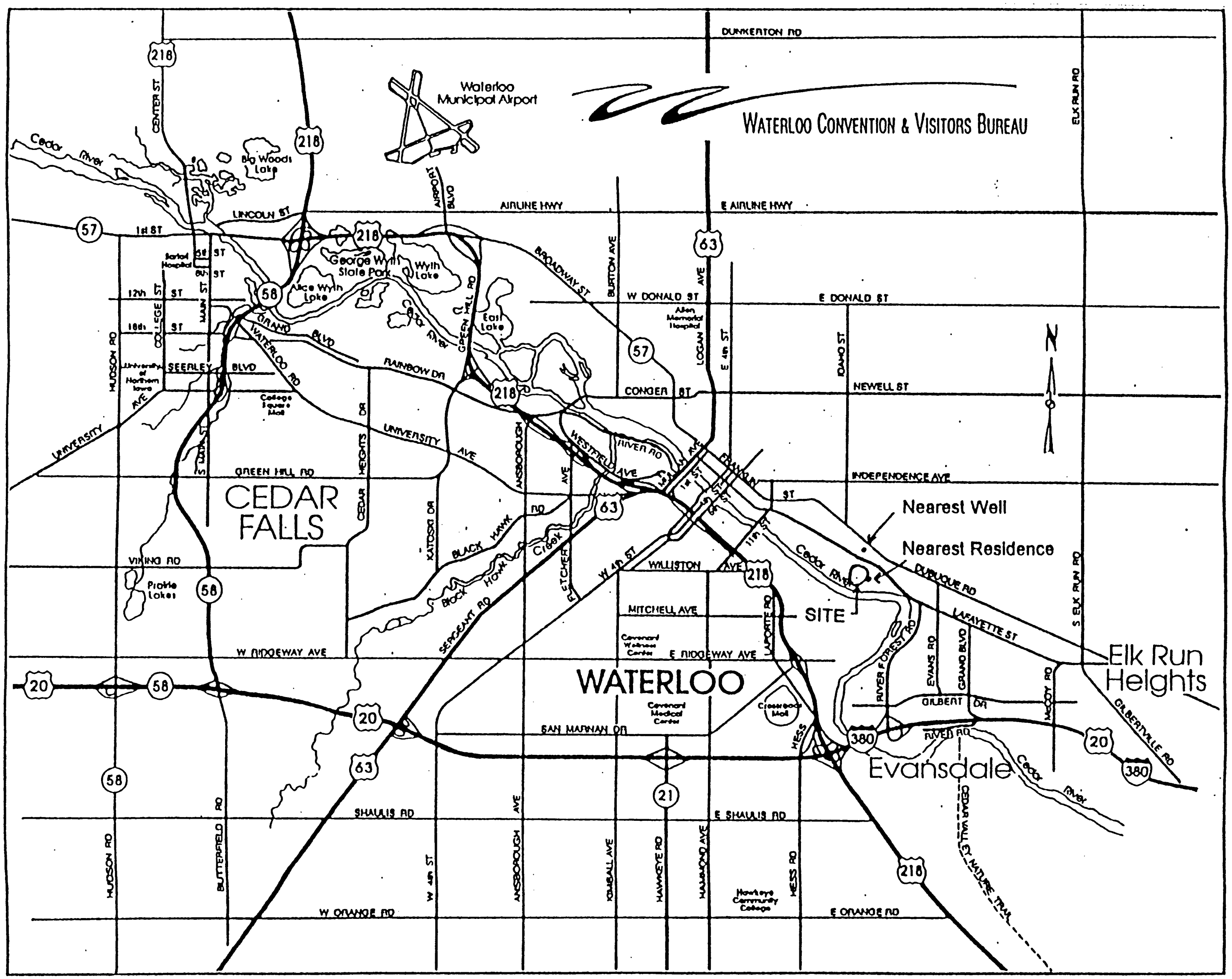


Figure 14. Blackhawk Iron and Metal Company site (Nold, 1994).

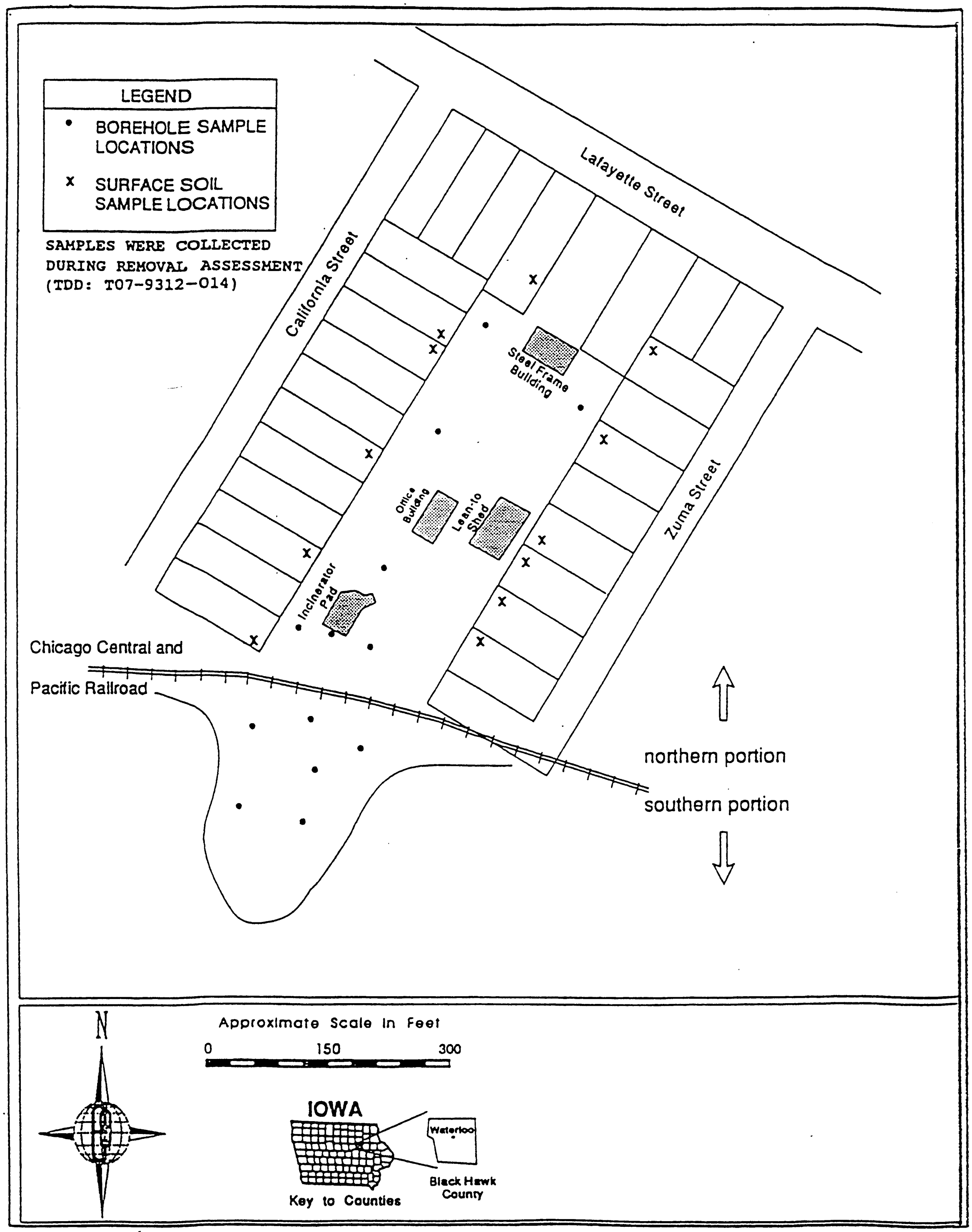


Figure 15. Blackhawk Iron and Metal Company structures (Nold, 1994).

at the site by the Technical Assessment Team in January of 1994 (EPA, 1995). Surface and subsurface soil samples were collected for laboratory analysis along with a groundwater sample from the site. No release of the contents in any of the drums was suspected.

Samples collected on site had documented high concentrations of antimony (1,200 mg/kg), arsenic (59.9 mg/kg), cadmium (22 mg/kg), copper (305,000 mg/kg), lead (53,200 mg/kg), and mercury (3,490 mg/kg) in surficial soils (EPA, 1995).

The uses and health related hazards associated with these substances are summarized below:

Antimony: Antimony is used primarily as a hardening alloy for lead, especially in storage batteries and cable sheaths. Antimony is toxic as fumes.

Arsenic: Smelting of copper and other metals often releases inorganic arsenic into the air. Workers in metal smelters and nearby residents could have been exposed to elevated levels of arsenic. Inorganic arsenic is a human poison; ingested in large doses it can cause death. Inhalation of arsenic can increase the risk of lung cancer (Public Health Statement, 1989).

Cadmium: Cadmium has a number of industrial applications but is used primarily in metal plating, pigments, batteries, and plastics. Exposure pathways include ingestion or absorption from the lungs after inhalation. Kidney damage and lung damage such as emphysema have been observed in people who are exposed to excess cadmium. Cadmium can damage the liver, testes, immune and central nervous systems (Public Health Statement, 1989).

Copper: Copper is used primarily in the manufacturing of metal alloys. Exposure pathways include inhalation or ingestion. Long term exposure to copper dust can cause nose, mouth, or eye irritation and can cause headaches, dizziness, nausea, and diarrhea. Exposure to high concentrations of copper can cause liver and kidney damage and potentially death (Public Health Statement, 1990).

Lead: Lead is used primarily in the manufacturing of storage batteries and as an additive to paint, gasoline, various metal products, and chemicals. Exposure to high levels of lead can cause kidney and brain damage in both children and adults. However, the people most susceptible to lead exposure are children and infants (Public Health Statement, 1990).

Mercury: Mercury is an element which is used in thermometers, barometers, and other common consumer products. Exposure pathways include inhalation and ingestion. Long term exposure to mercury can permanently damage the brain, kidneys, and developing fetuses (Public Health Statement, 1989).

Contaminant Removal

Elemental mercury was removed from site soils during an emergency response conducted by the Technical Assistance Team in December of 1993. A Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) funded the removal in June of 1994. That action entailed the excavation of soil from adjoining residential yards where elevated lead levels (greater than 500 milligrams per kilogram ([mg/kg]) had been identified in surface soils (EPA, 1995). A new perimeter fence was also erected at that time. A large area of lead-contaminated soil remained on site and posed a threat to the surrounding population and environment. Two uncontrolled abandoned drums containing liquid were also on site.

Groundwater

A majority of drinking water is provided to residences in the area via a municipal water system that is supplied by 15 wells located throughout the city. The water supply network is a blended system, with 11 of the wells being located within a

4-mile radius of the site. Those 11 wells serve about 51,500 people. The city of Evansdale, located 1 mile southeast of the site, provides its own municipal water. Evansdale's water system is supplied by two local wells that compose a blended system. Approximately 63 homes within 4 miles of the site have individual wells. At 2.51 persons per household, an estimated 158 residents in the area use private wells for drinking purposes. The nearest residence in the area relying on well water for drinking purposes is located 200 feet northeast of the site (EPA, 1995).

Groundwater samples were collected from a depth of 15 feet at the southern portion of the site during the removal assessment that contained 7.30 μg/L of total lead, 8.32 μg/L total copper, and no PCBs above detectable levels. Because the concentrations are below EPA-established Maximum Contaminant Levels (MCLs), it did not appear that a release to groundwater, including the underlying, interconnected aquifers used to supply drinking water wells in the area, had occurred (EPA, 1995).

Surface Water

Overland drainage flows from the north end of the Blackhawk Iron and Metal Company site into a storm water sewer system that discharges approximately 1,750 feet down gradient into the Cedar River. The Cedar River has an average flow rate of about 3,000 cubic feet per second, and it does not merge with any major rivers for a downstream distance of 15 miles. A map showing surface drainage in the area is included as Figure 15. Average annual precipitation in Black Hawk County ranges from about 31.5 to 32.5 inches. A majority of the site is located in an area between 100-year and 500-year flood limits (EPA, 1995).

There are no drinking water intakes along a 15-mile distance downstream of the site. Residents not served by municipal water systems obtain drinking water from individual wells. The Cedar River is used for recreational fishing in the vicinity of the site. There are two privately owned wetlands 15 miles downstream from the site. There are no state or federally designated endangered species that have been reported in the vicinity of the site.

Because of the close proximity of the site to the Cedar River, along with a well defined runoff route from the site, a release of contaminants to surface water was suspected. The fishery in the Cedar River represented a primary target. The two wetlands located 7 and 9 miles downstream of the site were considered to be secondary targets. Analytical data were not available for those target areas.

Soil

Approximately 200,000 square feet of lead-contamination was identified on the surface of the site. The contamination was detected in some subsurface soil samples, collected from depths of as much as to 10 feet. Although the majority of the site was covered by grass and weeds, the potential for migration of the contaminants by air appeared to exist. Lead-contaminated soil had been identified in the yards of 10 residences located adjacent to former battery reclamation areas. Approximately 58 people lived within 200 feet of the site. The total population within 4 miles of the site was estimated to be approximately 67,500 (EPA, 1995).

During the removal assessment, the following results were obtained:

1. Lead was detected above 500 mg/kg in surface soils throughout the site and in 10 residential yards. The presence of elevated lead concentrations in surficial residence soils near the site suggested that a release of particulates from contaminated site soils had occurred and was likely to continue until those soils were excavated or stabilized (EPA, 1995).

2. Locations of elevated copper levels were found to correspond with the lead contamination.

3. The highest concentration of PCBs was found in a subsurface sample collected from the central portion of the site.

The Waterloo Coal Gasification Plant

Introduction

Coal gasification plants were a fairly common business from the late 1800's through the 1950's. One such plant operated in Waterloo, Iowa from 1890 through the early 1950's. The plant was located on Sycamore Street in Waterloo (Fig. 16).

When the plant began operating it fueled 93 public street lamps. By 1900 approximately 200 street lamps were fueled by the plant, which at the time produced 5 million cubic feet of fuel annually. In 1915, 556 public lamps, 604 commercial lamps, 1041 water heaters and 9600 gas ranges were used in Waterloo. In total, more than 234 million cubic feet of the manufacturer's gas was sold.

The gasification process involved extraction of a crude hydrocarbon gas from coal through a series of steps. The final by-products of the transformation were in the form of a coal tar.

Contaminant Characteristics

The past practice of storage and disposal of the by-products of coal gasification is currently an environmental health concern. Some of the tar waste was sold for roofing material, road construction, and other industrial uses. However, much of the coal tar was disposed of into wells, used as fill, or stored in leaky tanks. The waste contains polynuclear aromatic hydrocarbons (PAHs), which include naphthalene, benzo(a)pyrene, phenanthrene, anthracene, and others. Many of these PAHs are carcinogens or suspected carcinogens. Many other contaminants can also be found in the soils surrounding the old plant (Environmental Geology Class, 1994).

Quantities of Pollutants

Soil samples from a coal gasification plant in Dubuque, Iowa, contained naphthalene and phenathrene at a concentration of 283 and 99.7 ppm, respectively. Similar levels would be expected at the Waterloo plant. Other contaminates include benzo(a)anthracene and dibenzo(a,h)anthranen at 34.5 and 13.0 ppm, respectively. These pollutants occur at a concentration greater than what is considered to be a safe level (Environmental Geology Class, 1994).

Geology of Risk Area

Black Hawk County is located on the Iowan Erosional Surface. The surficial material is typically thin loess or glacial till with bedrock close to the surface. The bedrock ranges from Ordovician to Devonian in age. Black Hawk County has localized karst conditions, scattered glacial boulders, stepped erosion surfaces, pahas, and an integrated drainage network (Arey et al., 1912).

Soils

The soils in Black Hawk County vary from very poorly drained to well drained, and are typically silty, loamy, or loess soils. The soil type can be important to the movement of contaminants, depending on water solubility of the pollutant and organic fraction of soil. The water solubility of the contaminant is important because some of the more polar compounds can move with the percolating water. The organic fraction of the soil plays a large role in the dynamics of contamination. The more lipophilic the compound, the more likely it will bind to the organic fraction of the soil.

Groundwater

Groundwater is the principal water source in Northeast Iowa. Aquifers include unconsolidated surficial materials and underlying limestone, dolostone, and sandstone formations (Horick, 1989). Typically, the saturation level of the soil (water table) in Waterloo lies 3 to 5 feet below the surface. This could have an important impact on the assessment of groundwater contamination.

Potential Risks

The main risk of contamination from the Waterloo Coal Gasification Plant is to the ground and surface water supply. Core samples from the old

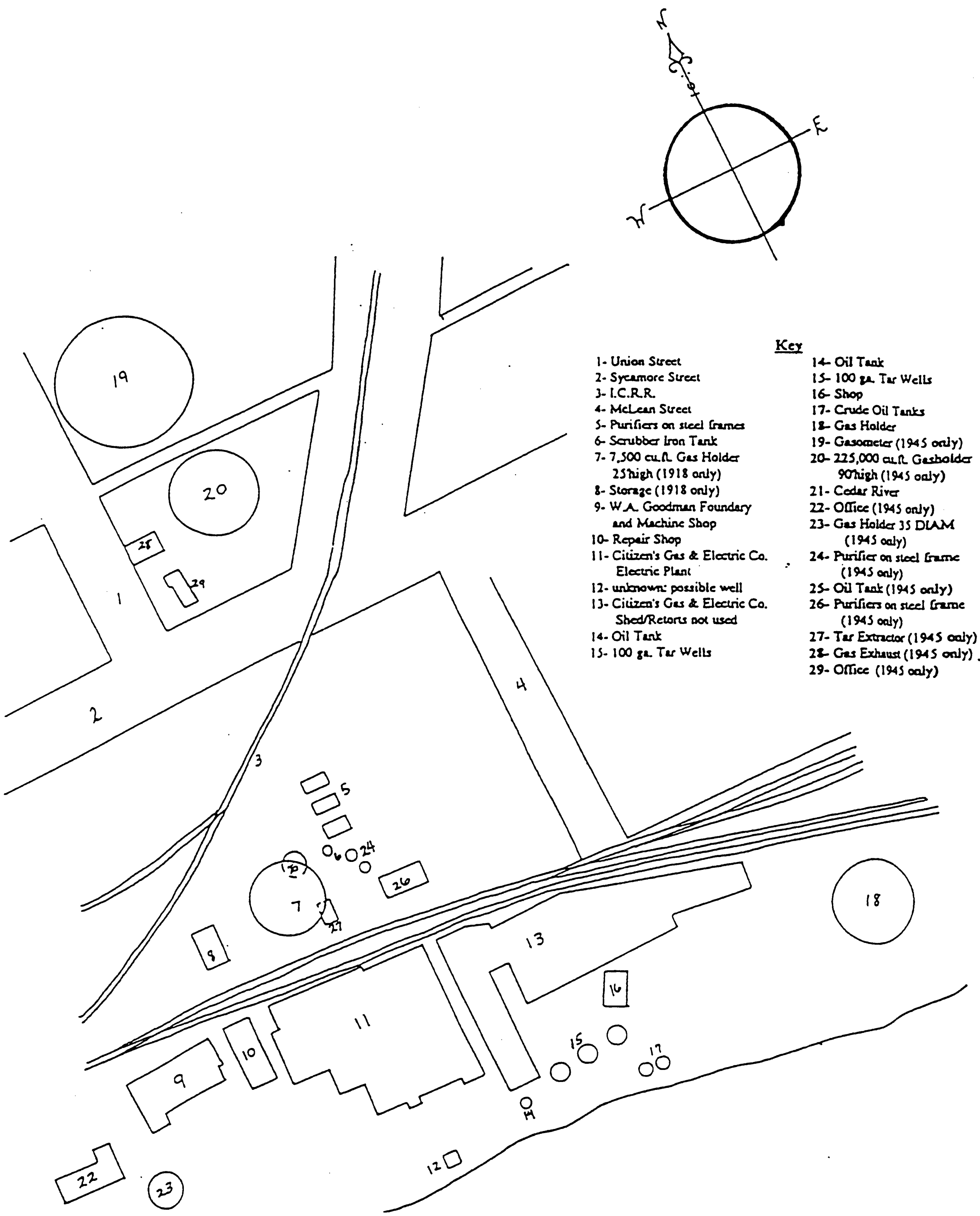


Figure 16. Location of structures at the Waterloo Coal Gasification Plant (Environmental Geology class, 1994).

Rath Packing Plant near the site reveal that fill soil and clay extends to the bedrock surface, 11 feet below the surface. In another well nearer the river, the core penetrated unconsolidated materials to a depth of 30 feet. These core samples indicate a bedrock surface sloping towards the Cedar River. Clay layers near the surface may act as an impermeable layer on top of which the contaminants could flow down slope.

Tar deposits may exist in one of four fractions. The tar may be in solid state, liquid state, at densities greater or less than water, or as an entirely water soluble material. The solid state poses the least risk since it cannot move. If the tar exists in a liquid state more dense than water, then it may travel down to impermeable bedrock and flow horizontally. This tar doesn't pose a large risk since its movement is predictable. The greatest risk would occur when the tar is less dense than water or water soluble, because the tar in these forms is less predictable in its movements. Monitoring wells on coal gasification plant site produced black, oily liquids ranging from fluid to stiff. Well number one had darkened water with an oily sheen and strong odor. Upon continued pumping the color lightened, but an odor was still present. Well number two had brown water with no detectable odor (Environmental Geology Class, 1994). Well number two also had oils in suspension and solution.

Health Risks

Locally, no cases of disease or illness have been linked to coal or tar contamination as confirmed by the Black Hawk County Health Department. However, long term exposure to PAHs is most likely detrimental to health. The fact that no cases of illness have resulted indicates that the tar is either in solution and has moved out of the area, or is in solid or dense liquid state and hasn't moved from the area(s) in which it was deposited. The most likely route of toxicity to humans is to drink the contaminated water or eat fish from contaminated waters. Of the two, the most likely is by eating contaminated fish since water supplies are not taken from the river system.

Site Investigation and Clean-Up

Midwest Gas Company, which was partially responsible for site remediation, collected soil samples by test trenching at the coal gasification site. In June 1994, their site investigation identified areas containing tar residues. These areas were then excavated, processed, and burned in a generating facility. A coal tar storage bunker was subsequently discovered on the adjoining land of the Waterloo Recreation and Arts Center land in 1994. This bunker, discovered during construction of an addition to the building, was cleaned up by Midwest Gas and the City of Waterloo.

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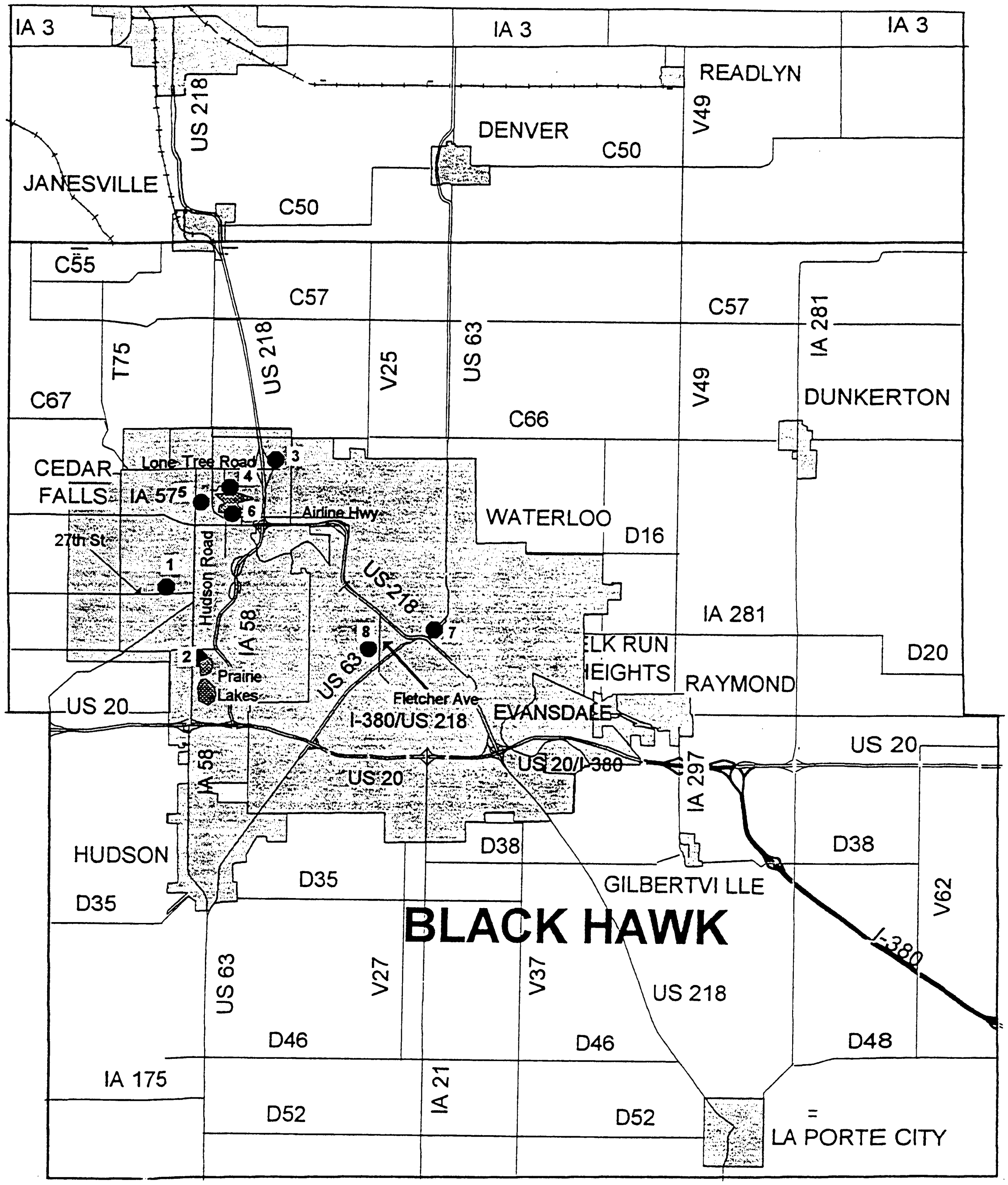
SATURDAY
MORNING
STOPS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SATURDAY MORNING ENVIRONMENTAL GEOLOGY STOPS

Stops 1-8 on Saturday morning will concern themselves mostly with environmental geology topics in the Cedar Falls/Waterloo area. A site description has been prepared for Stop 1, a groundwater study site located west of the UNI campus, but *specific site descriptions have not been written for Stops 2-8.* Rather, *the material they concern themselves with is found in the section of the guidebook referred to as General and Environmental Geology of the Cedar Falls/Waterloo Area.* A listing of these stops follows, and a map showing stop locations appears on the opposite page.

STOP 1: Groundwater study site just west of UNI campus; north side of 27th Street
Discussion of groundwater chemistry and contamination problems;
Park on Cedar Falls Utilities property on south side of 27th St.

STOP 2: Cedar Falls Industrial Park site
Discussion of resource extraction and development of recreational site;
Park at parking area overlooking Prairie Lakes

STOP 3: Local topography overlook site; Lone Tree Rd. off new Hwy. 218
Discussion of fluvial, eolian, and glacial features in the area and their relationships
Park on north shoulder of road
This will be a brief stop, ***Please Be Cautious Of Traffic!***

STOP 4: Big Woods Lake; a new lake formed through sand and gravel extraction as part of the highway construction in the area
Discussion of the Cedar Valley Lakes project
Park in gravel parking lot north of lake

STOP 5: Island Park, along east side of the Cedar River; Coffee Break
Discussion of recreational use of Cedar River floodplain, sand and gravel extraction in the area, and flooding history of the area
Park in the parking area

STOP 6: West end of Lincoln St., Cedar City
Discussion of flooding problems in Cedar City (north Cedar Falls), industry relocation, and possible solutions
Park at end of street

STOP 7: Levee along southwest side of Cedar River
Discussion of flooding problems in Waterloo and dike and levee system
Park in Young Area parking lot off Mullan Ave.

STOP 8: Flood gates in Hope Martin Park, Fletcher Ave.
Discussion of dike and levee system in Waterloo, flood gates, and flooding history
Park in the parking area

Following Stop 8, we will return to UNI for lunch.

STOP 1: HYDROCHEMICAL MODEL OF CONTAMINANT TRANSPORT FROM SURFACE TO THE BEDROCK AQUIFERS OF NORTHEAST IOWA

Mohammad Z. Iqbal
Department of Earth Science
University of Northern Iowa, Cedar Falls, Iowa 50614

ABSTRACT

In the Cedar River watershed of northeastern Iowa, 17 out of 20 private wells sampled demonstrated groundwater contamination with nitrate from agricultural leachates including 9 wells where nitrate concentration exceeded U.S. EPA recommended Maximum Contaminant Level (MCL) of 45 ppm (as NO_3) for drinking purposes. The majority of the bedrock wells showed a consistent increase in nitrate concentration throughout the cropped season in 1995. In contrast, nitrate concentration in shallow wells completed in the alluvial aquifers either decreased or remained relatively constant. Stormwater tracing by artificial application of potassium bromide, corn fertilizer and fluorescein dye demonstrated preferential flow only within the upper 3 ft of loamy sediments which overlies a post-glacially developed pebbly layer admixed with sand, called the Iowan Pebble Band. Continuous preferential flow of stormwater was restricted by the geologic materials in the Pebble Band. Chemical data indicate that the Pebble Band served as a hydraulic conductivity boundary which changed the flow mechanisms from preferential flow to a matrix flow system.

INTRODUCTION

Nonpoint nitrate contamination of groundwater by agricultural practices is a growing global concern (Bogardi and Kuzelka, 1991). In the north and northeastern parts of Iowa, there are cultivated, row-cropped fields with well-drained soils. In these areas, the drinking water aquifer, which is covered by only a thin surficial layer of sediments of glacial origin, is frequently affected by nonpoint source nitrate contamination. Such contamination is exacerbated by nitrogen fertilization and, in some areas, by irrigation in excess of plant requirements. Leachates from commercial nitrogen fertilizers and manure are the prime sources of nitrate in groundwater in the Cedar River watershed of northeastern Iowa. The presence of nitrate in drinking water exceeding Maximum Contaminant Levels (45 ppm as NO_3) may result in suffocation in infant humans, a disease known as Methamoglobinemia. In Iowa, application of commercial fertilizers in cropped areas has been widely practiced since the late fifties. Over the last two decades, the use of fertilizers has reached its peak, and now it is considered one of the most serious threats to the quality of Iowa's drinking water.

STUDY OBJECTIVES

An aquifer overlain by geologic materials of low matrix permeability is usually considered less sensitive to contamination from surface sources. Traditionally, the unsaturated flow has been viewed as water moving through dry soils as a distinct wetting front by completely displacing the previously existing water in the rock matrix (Bodman and Colman, 1943). This traditional concept of water transport mechanism is known as 'matrix flow'. However, in subsequent research, scientists have discovered that a significant amount of contaminated water can move preferentially through clay-soil macropores. Macropores are the cracks, root channels, fissures, animal burrows and textural boundaries in surficial soil-rock system. Some investigators found that a large part of rain or irrigation water entering the soil profile moved immediately through the open channels and interacted only slightly with the water in the soil itself. Water in macropores can move into or below the rooting depth in a matter of minutes after the addition of water to the soil surface (Quisenberry and Phillips, 1976). Numerous field investigators report that an additional force is necessary for water to move rapidly through macropores, which suggests that this kind of macropore transport of water is usually most significant during heavy rain events.

In this field investigation, an approach of quantitative chemical analysis of soil water and groundwater was taken to verify the probable modes of contaminant transport from the surface to the groundwater in the Cedar River watershed of Iowa. The study focused on the effects of glacial events and their deposits on the hydrogeology of the area. The study also verified the effects of a summer storm on the contaminant transport mechanisms.

GROUNDWATER POLLUTION IN NORTHEAST IOWA

The northeastern part of Iowa has numerous wells where nitrate concentration exceeds the U.S. EPA recommended limits for drinking water of 45 ppm of nitrate (Kross et al., 1990). There are two reasons for such elevated concentrations of nitrate, one is that the layer of surficial materials overlying the producing aquifer is less than 100 ft in thickness. The thickness is much less along the Cedar River Valley and associated drainage areas. The other reason is that the area has Agricultural Drainage Wells (ADWs), which act as a point source of nitrate to the aquifer in the growing season. ADWs are drilled shafts that funnel excess drainage water into the underground bedrock aquifer (Libra and Hallberg, 1993). There is a concentration of ADWs in Floyd County, immediately upgradient of the study area in the Cedar River Valley.

There are many shallow wells (less than 50 ft deep) producing water from the alluvial aquifer along the Cedar River Valley. Investigators reported elevated nitrate concentrations in these wells. The groundwater vulnerability map of Iowa, prepared by the Iowa DNR Geological Survey Bureau, marked the study area as having high potential for aquifer and well contamination (Hoyer and Hallberg, 1991).

DESCRIPTION OF THE STUDY AREA

Location

The study area is a part of the Cedar River watershed in Black Hawk and Bremer counties, Iowa (Fig. 1). Groundwater samples were collected from an area approximately 12 miles long in the northwest-southeast direction, and approximately 2 miles wide. The area has agricultural land use where commercial fertilizers and manure are routinely applied to the fields.

A small experimental plot was selected on the University of Northern Iowa campus at Cedar Falls to study the unsaturated flow mechanisms by using tracer application techniques. Suction lysimeters were emplaced at various depths in the plot to collect soil water samples following a major storm event on June 25, 1995.

Hydrogeology

The Devonian carbonate bedrock aquifers are the major sources of drinking water in the study area. Regionally, Devonian strata are best described as a three-part aquifer system with the water producing carbonate strata separated by intervening shales and shaly carbonates (Witzke and Bunker, 1984; Witzke et al., 1988; Libra et al., 1984). The three carbonate layers have been informally referred to as the 'upper', 'middle' and 'lower' aquifers (ibid.). Most of the wells within the study area are completed in the 'upper' carbonate aquifer, and confining units are fairly extensive (Witzke and Bunker, 1985). The producing bedrock wells are less than 100 ft in depth in most parts of the study area. The 'upper' bedrock aquifer is highly contaminated with leachates from commercial fertilizers and pesticides. The quality of groundwater in the 'middle' and 'lower' aquifers, generally greater than 200 ft in depth, is generally considered good. In addition to the bedrock aquifers, are numerous shallow wells, less than 50 ft in depth, which tap the alluvial aquifer system. The alluvial aquifers are composed of sand and gravel situated beneath the floodplains along the river valley and includes alluvial deposits associated with

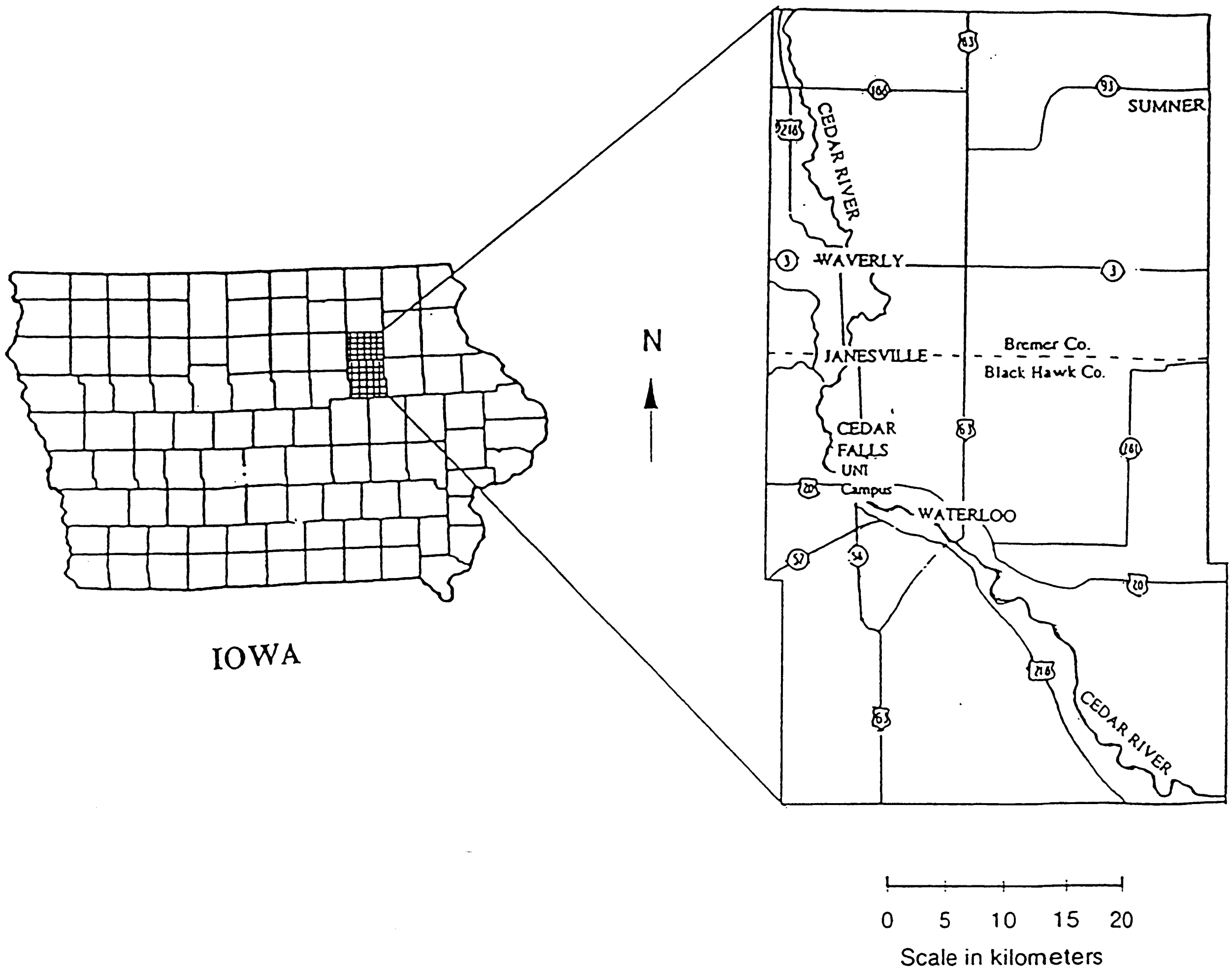


Figure 1. Location of the study area.

stream terraces, contiguous wind blown sand deposits, and glacial outwash deposits (Hoyer and Hallberg, 1991).

The Cedar River Valley along with its numerous tributaries forms the surface drainage system in the area. The Cedar River is northwest-southeast trending and the general direction of groundwater flow within this area is to the southeast. Limited vertical head data in upland areas and in major river valleys indicate regional flow from upland positions to the stream valleys, which act as discharge zones (Munter, 1980; Libra et al., 1984).

Glacial History

The study area is located on the Iowan Surface, which is one of the eight topographic regions of Iowa based on geomorphic features (Prior, 1976). The Iowan Surface, in northeastern Iowa is thought to reflect a post-glacial topography which developed on the glacial till that was deposited over the carbonate bedrock by pre-Illinoian ice sheets. Approximately 50 to 100 ft of till deposits cover the bedrock. Ruhe and others (1968) suggested that the topography of the Iowan Surface resulted from the erosion of pre-Illinoian till as it was exposed during an interglacial period. They hypothesized that post-glacial erosional processes continued for an extended period of time when the fines were removed by wind and running water leaving behind a stone pavement as lag deposits. This erosional pavement is also referred to as the Iowan Pebble Band. Some investigators called it the 'stone line' because of its linear appearance in a vertical cross section. Extensive field investigations have revealed that the stone pavement contains a considerable fraction of interstitial sand as remnant materials (Kane, 1991). After its formation, the erosional pavement was subsequently buried by wind-blown sand, loess and clay derived from higher topographic positions. Several feet of these loamy sediments were deposited above the stone pavement during burial. This makes the Iowan Pebble Band a coarse-textured glacial deposit with contrasting fine-grained materials above and below. The Pebble Band and associated sand deposits constitute a hydrogeologically active zone which may be several feet thick depending on the intensity of post-glacial fluvial processes.

MATERIALS AND METHODS

The investigation was designed to monitor contaminant transport with soil water as a function of time. The unsaturated flow mechanisms were determined by conducting tracer application studies. A hydrogeochemical approach was taken to determine the overall mechanisms of groundwater contamination. Temporal variations in the chemistry of soil water and groundwater were compared with the local land use.

Groundwater Sampling

A total of 20 existing groundwater wells were sampled from the field area during the first week of May, 1995. The wells were selected such that the study area was well represented. Of the 20 wells, 5 representative ones were sampled approximately every two weeks from the middle of May through late July. All samples were filtered and refrigerated immediately after collection, and later analyzed for nitrate concentration. White high density polyethylene plastic bottles were used for collecting all samples.

Soil Water Sampling

Suction lysimeters were installed beneath an experimental plot in the University of Northern Iowa campus to sample soil water (Fig. 2). A total of 6 lysimeters were emplaced at 1 ft, 2 ft, 3 ft, 4 ft, 5 ft and 7 ft depths. The lysimeters were carefully emplaced in vertical holes that were drilled manually using a hand auger. Some white silica flour was placed around the ceramic cup to ensure easy movement of soil water to the cup. Finally, the holes were backfilled with native soil. At the surface, the holes were sealed with commercially available sand mix to prevent water channeling down between the soil and the body of the sampler. The experimental plot was sprayed with corn fertilizer, potassium bromide and fluorescein dye on June 25, 1995, immediately before a major storm event. Fluorescein was primarily used to compare the transport of a typical fluorescent dye with that of inorganic ions. Soil water samples were collected twice a day for the first week after which collections were reduced to once every 3 to 5 days till July 21.

Laboratory Analysis of Water Samples

Chemical analysis of the water samples were performed using an Ion Chromatograph with suppressed conductivity in the Chemistry Department of the University of Northern Iowa. The analytical error margin for the ions was ± 0.5 ppm. The fluorescein concentrations were measured by using a spectrophotometer.

RESULTS AND DISCUSSIONS

Short-Term Nitrate Loading

Of the 20 groundwater wells sampled, 17 wells demonstrated nitrate levels well above the natural background concentration (≈ 10 ppm) including 9 wells where nitrate concentration exceeded the maximum contaminant level for drinking purposes

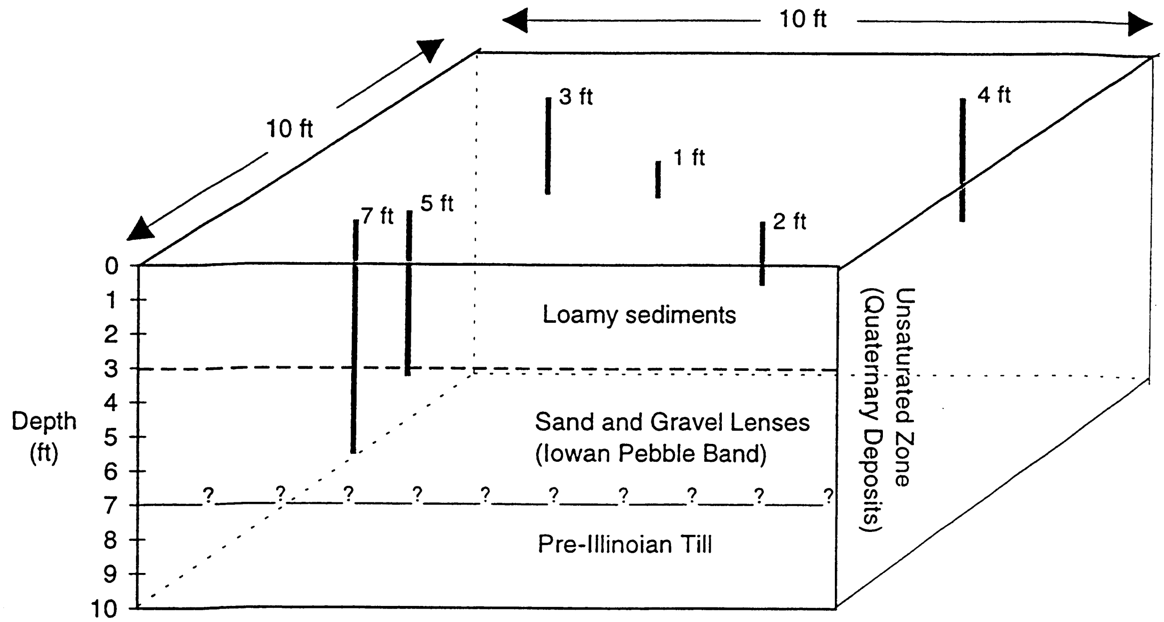


Figure 2. Suction lysimeters placement scheme.

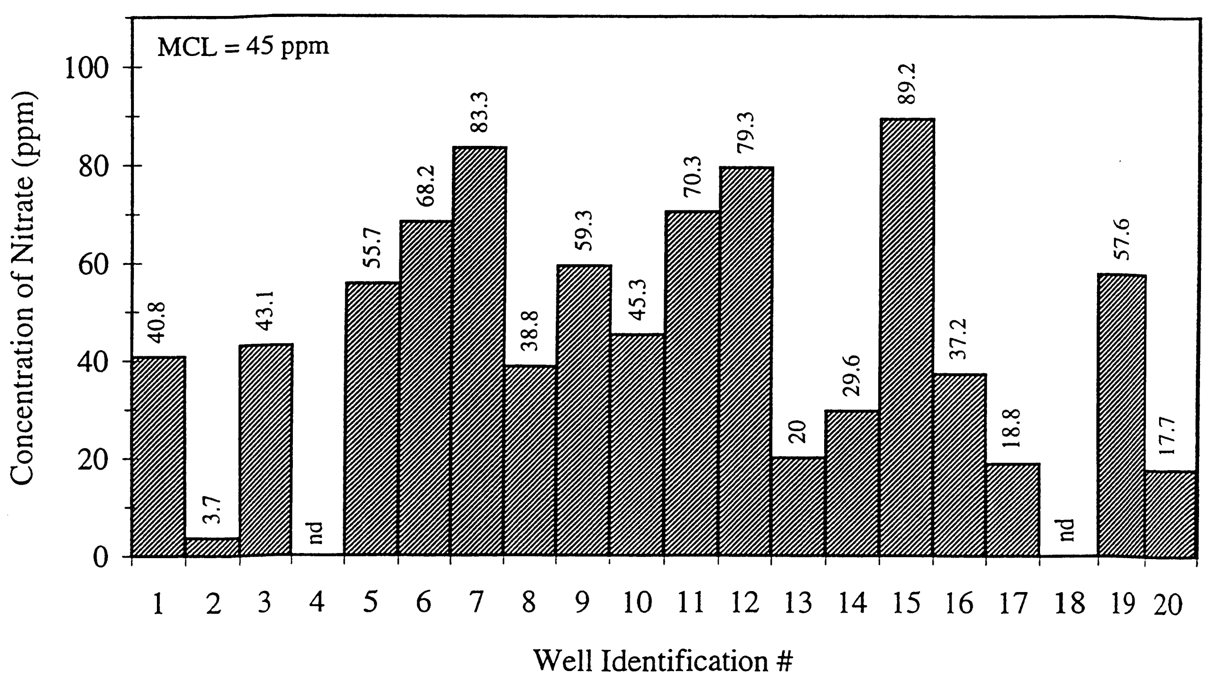


Figure 3. Distribution of groundwater nitrate in the study area.

(Fig. 3). The response of the bedrock aquifer to the surficial activities was different from that of the alluvial aquifer throughout the cropped season. Deep wells that were completed in the Devonian carbonate aquifer system demonstrated a consistent increase in nitrate concentration with time after fertilization of fields (Fig. 4a, 4b). These wells ranged from 75 to 150 ft in depth. The rate of increase in nitrate concentration varied from well to well. Nitrate from the agricultural fields leached vertically through the poorly permeable glacial overburden, and through the permeable glacial melt-water deposits along the drainageways.

The shallow glacial aquifers demonstrated a consistent decrease in nitrate concentration in most wells throughout the cropped season (Fig. 5). A few of the wells showed no change in nitrate concentration even after the surrounding fields received commercial fertilizers. Such a negative response is attributed to the high permeability of the glacial outwash deposits which allows the surface contaminants to move rapidly to the bedrock aquifer during heavy storm events. In addition, continuous flushing by summer rains through rapid horizontal movement of groundwater within the aquifer is probably a significant factor, too.

Vadose Zone Transport Mechanisms

In the experimental plot, a rapid movement of stormwater was observed only through the 3 ft of loamy sediments which overlies the Iowan Pebble Band. This rapid movement was caused by the preferential channeling of stormwater through the macropore structures in the loamy sediments.

The background concentration of bromide in the vadose zone was less than 1 ppm. Following the storm event, bromide transport was significant only at 1 and 2 ft depths (Fig. 6). Although the artificially applied bromide was recovered at 3 ft in low concentration, it abruptly disappeared in all deeper lysimeters. A 200 ppm average breakthrough concentration of bromide at 1 ft depth on day 3 after the storm event is an indication of the preferential channeling of stormwater. In addition, the asymmetry in the concentration curves also demonstrated that vertical movement of bromide was dominantly through preferential channels in the top 3 ft of the vadose zone.

Transport of stormwater through macropore channels is well documented in the current literature. Studies have revealed that water entering soil macropores without visible openings can contribute five times as much to groundwater recharge than does matrix flow (Aley, 1977). In some soils, nearly all the water flows through soil macropores without any displacement of initial matrix water (Quisenberry and Phillips, 1976). Wild and Babiker (1976) used chloride and nitrate as tracers to determine that a large percentage of the applied water percolated past the water initially present with little or no displacement of the initial water. The amount of displacement, when it occurs, depends on the rate of water addition, soil structure, relative sizes of pores, clay orientation, soil water content, and tillage (Thomas and Phillips, 1979). The preferential flow hypothesis in the loamy sediments of the study area is also supported by data obtained through the analysis of the lysimeter samples for nitrate and sulfate. Both of these ions again showed peak concentrations at a depth of 1 ft on day 3 after the storm event (Fig. 7a, 7b). Nitrate from artificially applied corn fertilizers rapidly leached to the 1 ft and 2 ft depths after the storm event. The asymmetric breakthrough curves of nitrate and sulfate again supported the idea that preferential flow component was dominant in the shallow depths of the vadose zone. Silvertooth et al. (1992) reported that nitrate, bromide, and chloride would be rapidly transported at the maximum velocity within preferred macropore channels. The concentrations in lysimeters deeper than 3 ft did not show any significant fluctuations. These lysimeters (deeper than 3 ft) were completed in the Iowan Pebble Band below the loamy sediments. Artificially applied fluorescein dye demonstrated significant recovery at a 1 ft depth with a peak concentration of 650 ppb at approximately 5 days after the storm event (Fig. 8). Fluorescein is more reactive than the inorganic ions and is strongly adsorbed on clay particles in the loamy sediment layer. As a result, fluorescein recovery in the 2 ft-deep lysimeter was minimal. Fluorescein was not detected in any lysimeter deeper than 2 ft.

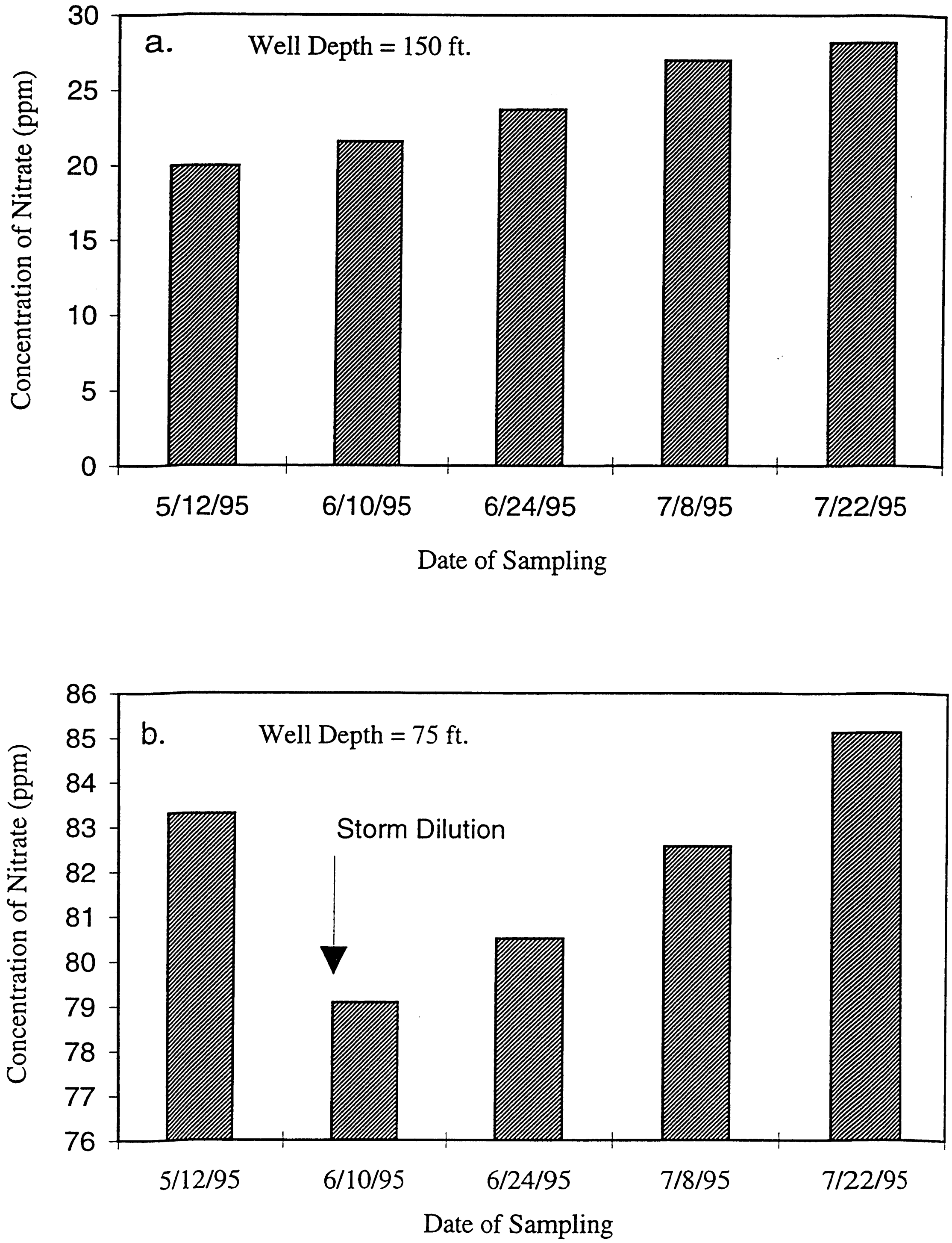


Figure 4. Short term nitrate loading to the aquifers. Deep wells that are completed in the Devonian carbonate aquifer demonstrate general increase in nitrate concentration with time after fertilization of fields.

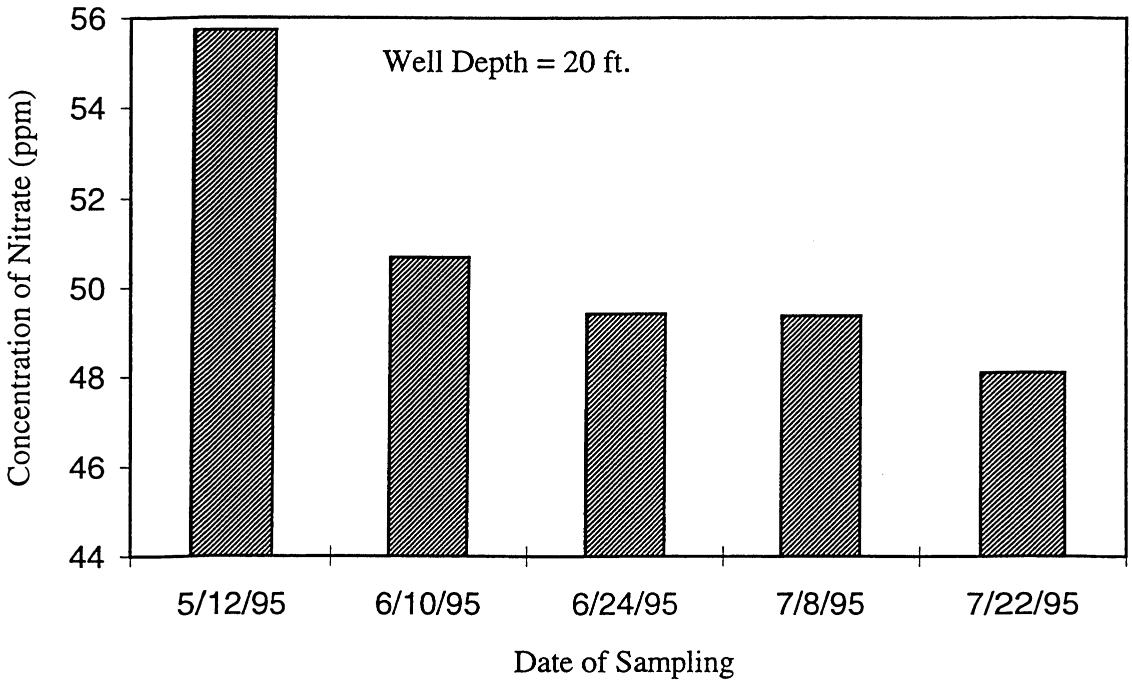


Figure 5. Temporal variations in nitrate concentrations in the shallow alluvial aquifers. These aquifers are composed of sand and gravel situated beneath floodplains along the Cedar River Valley. Most of the wells show general decrease in nitrate concentrations without correlation with local land use. The area did receive commercial fertilizers in May.

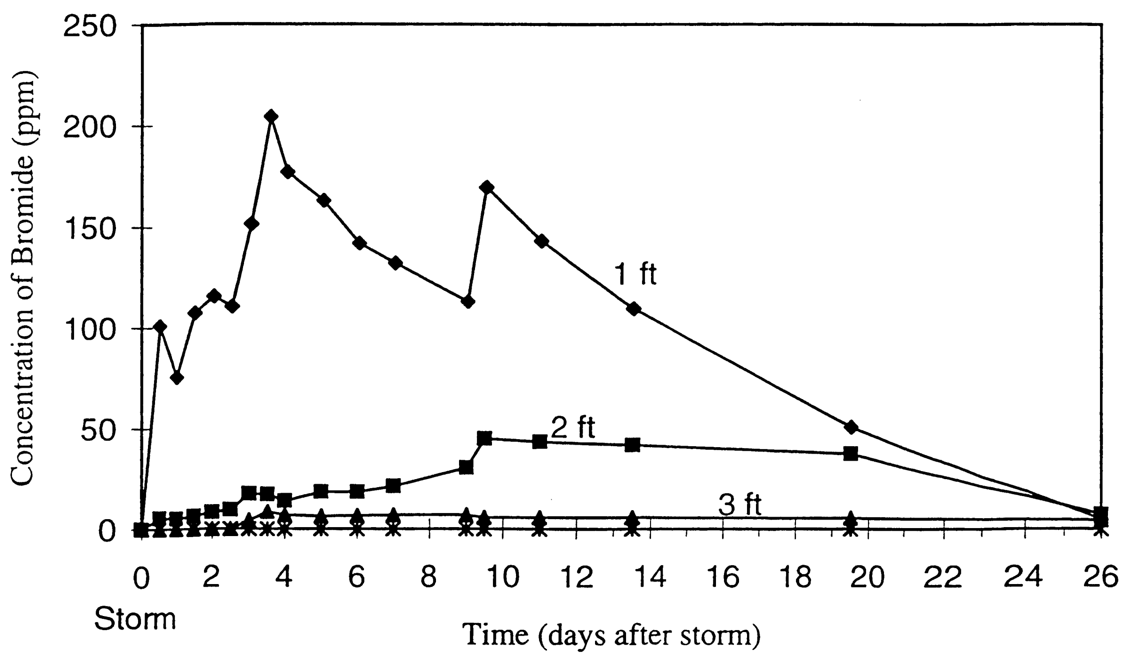
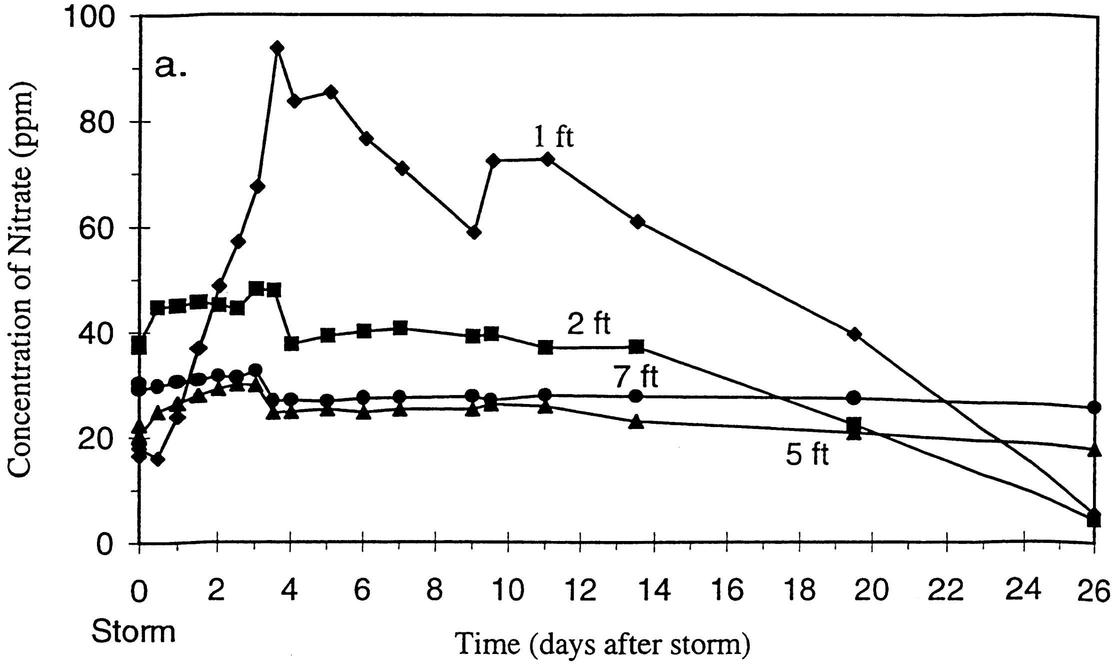


Figure 6. Transport of artificially applied bromide with stormwater through the unsaturated zone.



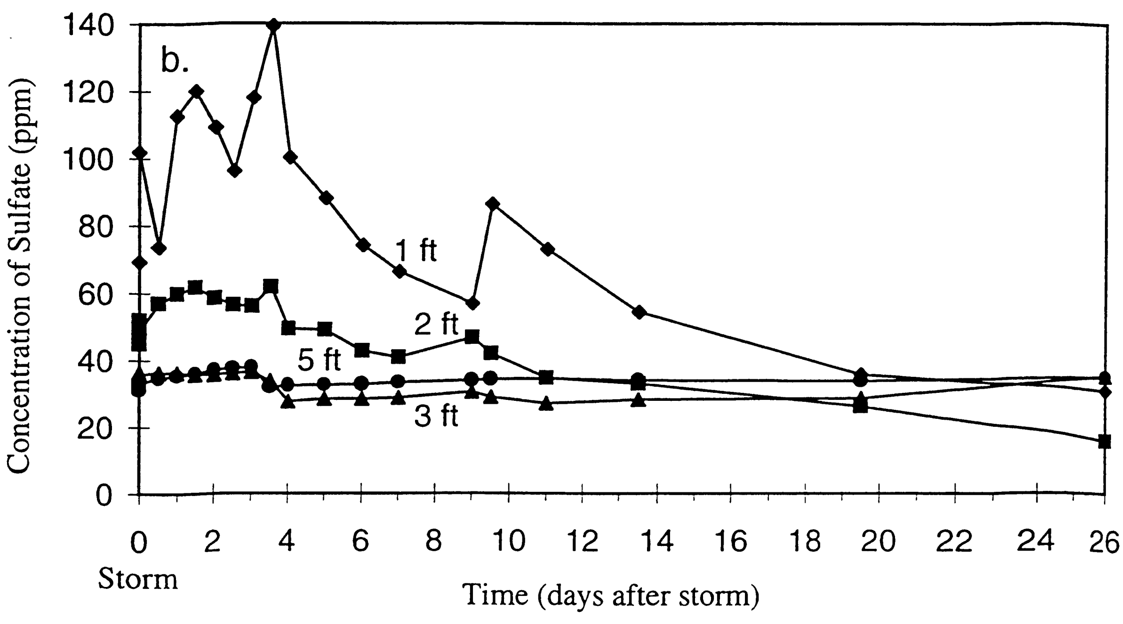


Figure 7. Transport of 9a) nitrate and (b) sulfate with stormwater through the unsaturated zone.

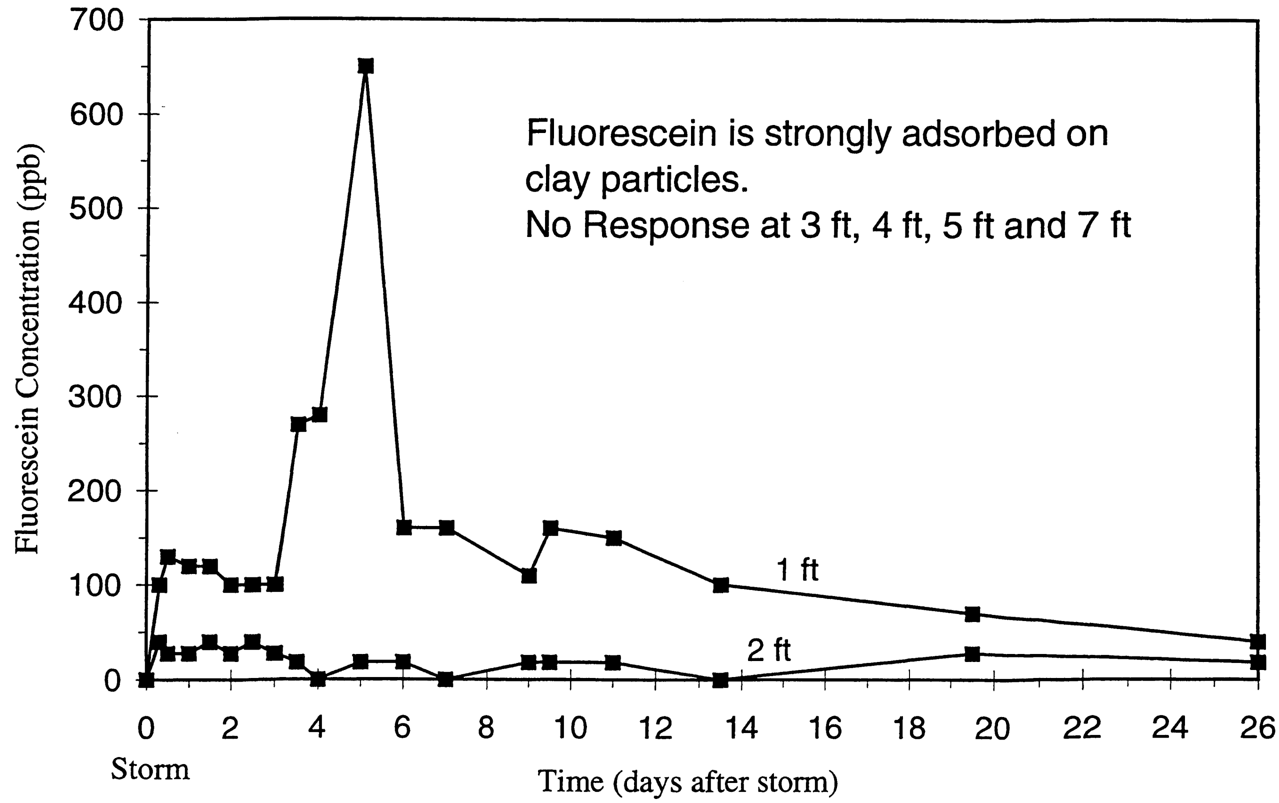


Figure 8. Transport of artificially applied flourescein dye with stormwater through the unsaturated zone.

The chemical analyses of lysimeter samples discussed demonstrated two contrasting vadose zone transport scenarios. One, in addition to the regular rock matrix, infiltrating stormwater also moved vertically through preferential channels even though it was restricted to the top 3 ft of sediments. Second, there was little or no fluctuation in ion concentrations within the Iowan Pebble Band situated at 3 ft below the surface. Ion concentration was either constant or showed little and consistent fluctuation throughout the Pebble Band. The deepest lysimeter is 7 ft deep which is approximately the lower boundary of the Iowan Pebble Band. Predominantly clayey till deposits were recovered below 6½ ft depth during drilling by hand augers. In general, the data demonstrated that stormwater transport through the vadose zone was highly influenced by the post glacial erosional processes associated with the formation of the Iowan Surface.

Conceptual Model of Contaminant Transport

Based on temporal variations in the soil water chemistry, a conceptual model of contaminant transport mechanisms is proposed for the study area. The depth vs. concentration profiles for bromide, fluorescein, nitrate, chloride, and sulfate suggest considerable vertical movement of stormwater for several days after the storm event (Fig. 9a, b, c, d, e). The transport profiles up to the 3 ft depth are asymmetric and inconsistent, suggesting a dominance of preferential channeling of water through macropore structures in the loamy sediments. Such macropore structures are root channels, burrows, and cracks in clays. Although naturally existing in the soil water, nitrate, chloride, and sulfate show more symmetry and consistency in their fluctuations below the 3 ft-depth. This demonstrates that the Pebble Band at 3 ft below the

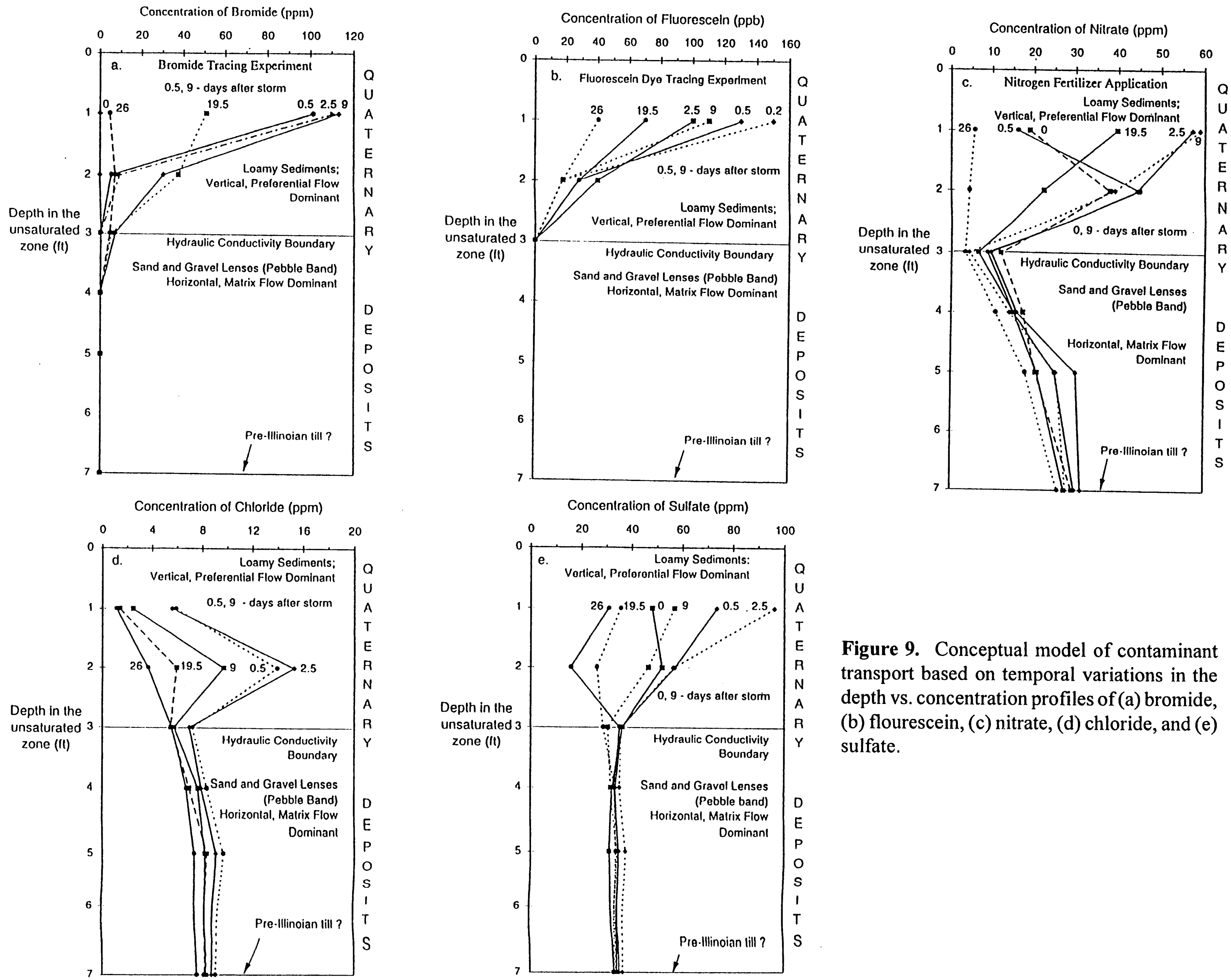


Figure 9. Conceptual model of contaminant transport based on temporal variations in the depth vs. concentration profiles of (a) bromide, (b) flourescein, (c) nitrate, (d) chloride, and (e) sulfate.

surface generally serves as a hydraulic conductivity boundary which changes the transport mechanisms from a preferential flow to more of a matrix flow mode. A highly permeable sand and gravel layer, approximately 3 to 5 ft thick throughout the Iowan Surface, seems to restrict vertical leaching of agricultural chemicals by initiating a rapid horizontal flow of these contaminants during heavy storm events. Stormwater picks up contaminants at the surface, and then preferentially moves through the loamy sediments before it encounters a layer of considerably higher hydraulic conductivity. Thus, the forced channeling of stormwater is interrupted by the highly permeable deposits in the Pebble Band which temporarily maintains complete saturation during and after storm events. Both bromide and fluorescein had no background concentration, and as a result, they quickly disappeared by dilution within the Pebble Band. Such a transport mechanism in Iowa soils and the hydrogeologic control of the Iowan Pebble Band seem to be unique, and of considerable importance from an aquifer contamination standpoint. While macropore transport of stormwater is frequently reported by water scientists as a major cause of groundwater contamination, the Iowan Pebble Band seems to serve as a shallow hydraulic barrier against such contamination. Like many other areas of the Midwest, contaminant transport studies in the southern part of Indiana revealed that the 33 ft deep carbonate aquifer, which did not have any unsaturated hydraulic barrier, received agricultural leachates from the croplands directly through the preferential channels in the vadose zone during a single storm event (Iqbal and Krothe, 1995, 1996).

The Pebble Band overlies approximately 50 ft of glacial till across the study area. Stormwater which laterally spreads within the Pebble Band is subsequently incorporated into the slow moving matrix water in the deeper layers of till deposits. The dominant mode of transport within the pre-Illinoian till is currently unknown. However, due to the exposure of the till deposits during interglacial periods, formation of macropore structures in the top few feet of the till is not unlikely. Some investigators reported jointing in the upper oxidized portion of the till layer. In addition, a hydrogeologic study of the pre-Illinoian till at another site in Iowa has shown that a 30 ft interval of fractured oxidized till has a hydraulic conductivity of 2.3×10^{-5} ft/sec and a 62 ft interval of unoxidized till has a hydraulic conductivity of 2.6×10^{-8} ft/sec (Weis and Simpkins, 1996). Several orders of magnitude higher hydraulic conductivity of the oxidized pre-Illinoian till suggests that preferential flow through the top few feet of till immediately below the Pebble Band is not unlikely. However, the unoxidized portion of the till layer probably has a predominantly matrix flow system of contaminants.

CONCLUSIONS

The following conclusions are made from this investigation:

1) Aquifer contamination in the Cedar River watershed is predominantly associated with a long term matrix transport of contaminants. Preferential channeling is a dominant mode of transport only in the top few feet of the unsaturated zone. Unlike many other areas of the Midwest, direct contamination of the aquifer by preferential channeling of water during a single storm event is not supported by the data.
2) Highly permeable glacial outwash deposits along the drainageways are providing passageways for agricultural contaminants from the surface to the bedrock aquifer.
3) The sand and gravel layer of the Iowan Erosional Surface, called the Pebble Band, serves as a major hydraulic conductivity boundary between the finer loamy sediments above and the fractured oxidized portion of the pre-Illinoian till below. This higher conductivity layer restricts vertical movement of contaminants by initiating a horizontal transport of stormwater which would have otherwise transported rapidly through vertical preferential channels into the deeper layers during heavy storm events.

ACKNOWLEDGEMENTS

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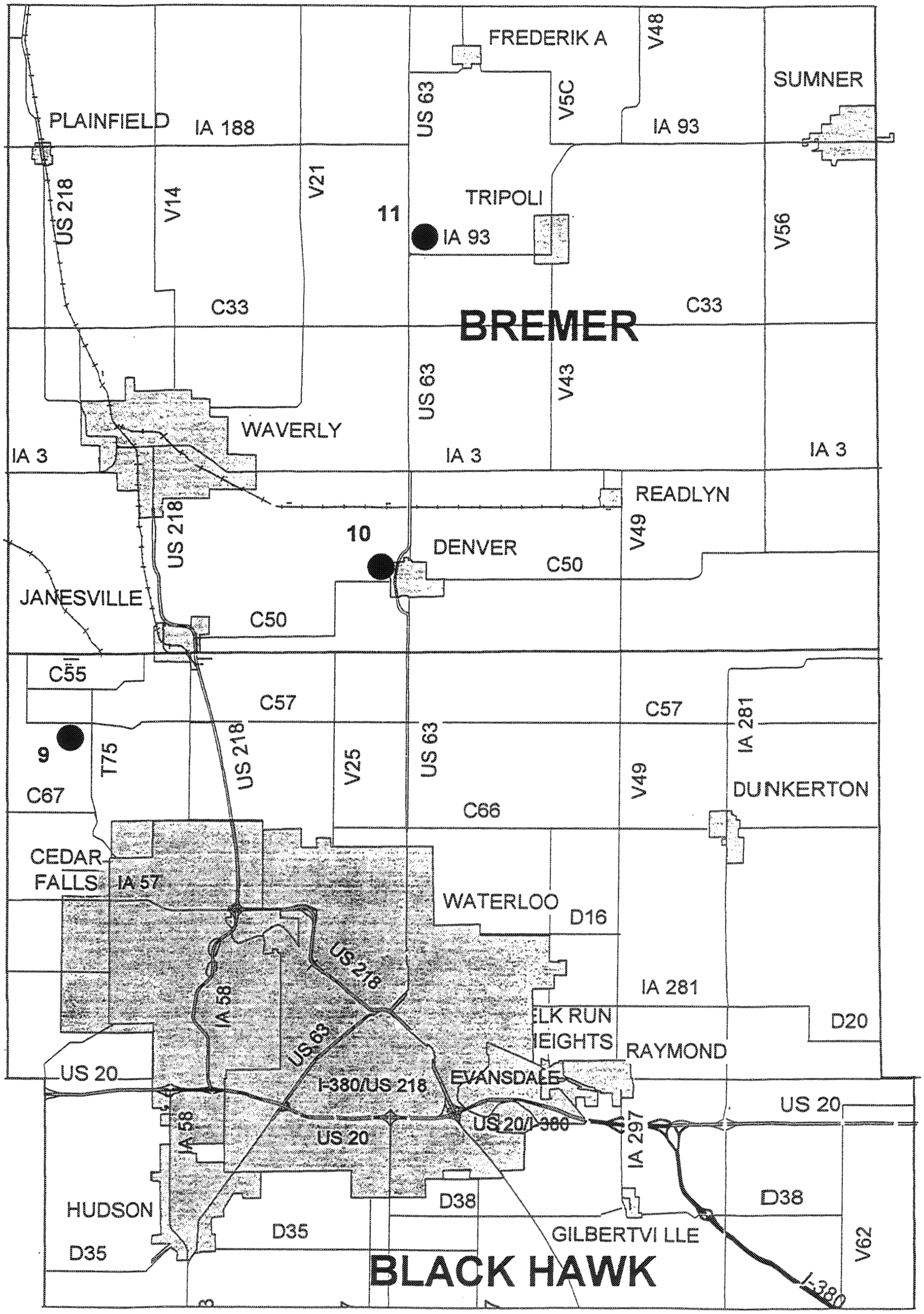
SATURDAY AFTERNOON STOPS


FREDERIKA
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WAVERLY
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READLYN
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US 218
DENVER
V49
C50
JANESVILLE
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C55
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C57
IA 281
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T75
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V25
US 63
V49
DUNKERTON
C67
C66
CEDAR FALLS
IA 57
WATERLOO
D16
US 218
IA 58
IA 281
ELK RUN HEIGHTS
D20
US 63
RAYMOND
US 20
I-380/US 218
EVANSDALE
US 20
IA 58
US 20/I-380
US 20
IA 297
HUDSON
D38
D38
D35
GILBERTVILLE
D35
V62
BLACK HAWK
I-380

STOP 9: CEDAR HILLS SAND PRAIRIE

Daryl D. Smith
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Cedar Hills Sand Prairie is located within the Iowan Surface Region. The prairie is near the eastern terminus of a narrow upland divide between the broad valleys of the West Fork Cedar River to the north, and Beaver Creek to the south (Fig. 1). Both streams join the Cedar River which flows from north to south about three miles east of the prairie.

The property is owned by The Nature Conservancy and consists of a 36-acre native vegetation State Preserve and a 54-acre old field addition that is undergoing secondary succession to prairie.

Most of the area consists of eolian sand deposits, although there are also some alluvial deposits. The deposition undoubtedly coincided with the Wisconsin glacial period when the West Fork Cedar River was carrying meltwater from the Des Moines Lobe. The presence of glacial erratics and Palms muck in the north swale indicate that the overlying deposits were probably eroded away.

The source of the eolian sand is the floodplain of the West Fork Cedar River. The depth of the sand varies, a depth of 25 feet was recorded from a drill sample taken near the preserve in the SW corner of the old field portion. As is typical of upland sand deposits, the area has an undulating topography with dunes, ridges, pockets and depressions. Undoubtedly the surface has been reworked periodically since the original deposition, erosional features such as blowouts are present.

The presence of alluvial deposits within the preserve as well as the topography of the area has led to the conjecture that this area is a part of the breach of the upland divide by the West Fork Cedar River into the Beaver Creek Valley during the height of the glacial meltwater outflow (Prior, 1990). Much of the eolian sand deposition occurred subsequent to the return of the overflow to the current valley.

The eolian sands were probably reworked whenever there was not sufficient vegetation cover to stabilize the surface. Wind erosion was likely heightened 4,000 to 8,000 years ago during the arid Hypsithermal time. A stabilized dune field is located in the north old-field portion and two blowouts occur along the NW to SE sand ridge of the preserve. Wetlands developed as dunes traversed and blocked drainages (Knapp, 1983). A marsh complex is located on the south edge of the preserve. Several other wet prairie sites occur within the preserve and the old field.

The soils of the Cedar Hills Sand Prairie (Fig. 2) are a part of the Sparta-Olin-Dickinson Association. This association is characterized by nearly level to moderately steep, excessively-drained to well-drained sandy and loamy soils formed in eolian sands or eolian sands and the underlying glacial till on upland and terraces. The soil types occurring on the prairie are as follows:

Sparta loamy fine sand- Moderately dark colored, excessively-drained, coarse textured soils formed in eolian sand under native prairie vegetation. They are usually found in river valleys on stream terraces and associated uplands;

Marshan clay loam- Dark colored, poorly drained loams with coarse sand and gravel at about 0.6m (2ft.). They were formed in alluvium and glacial sediment under native prairie vegetation. They are found on stream terraces and on upland glacial outwashes;

Palms muck- Black, very poorly-drained organic soil formed in glacial sediment under native marsh vegetation;

Lawler loam- Black, somewhat poorly-drained loamy soils overlaying sandy substrates, developed under native prairie vegetation. They are found on stream benches and outwash plains;

Marsh- A catch-all term for highly organic soils found in marshes and wetlands;

Hayfield loam- Moderately dark colored, somewhat poorly-drained soils formed in alluvium and leached sand gravel under both native prairie and forest vegetation (Fouts and Highland, 1978).

The vegetation communities are closely aligned with the soil types and topography. They range from a xeric sand community similar to those of the Sandhills of Nebraska through a mesic tallgrass prairie community to a marsh complex on the south side and a fen in the deep moist swale (Fig. 3). *Carex stricta* is the dominant species of the swale and forms dense hummocks. Other species associated with the swale are marsh marigold (*Caltha palustris*), marsh cinquefoil (*Potentilla palustris*) and *Sphagnum* sp. The marsh areas contain *Carex lacustris* and the hardstem bulrush (*Scripus acutus*). Sensitive fern (*Onoclea sensibilis*), marsh fern (*Thelypleris palustris*), northern dewberry (*Rubus fulleri*), and bluejoint grass (*Calamagrostis canadensis*) are abundant in both the swale and around the marshes. The mesic tallgrass prairie is represented by such species as big bluestem (*Andropogon gerardii*) Indian grass (*Sorghastrum mutans*), bird's foot violet (*Viola pedata*), mountain mint (*Pycnanthemum virginianum*), and hoary puccoon (*Lithospermum canescens*). The xeric sand prairie community is dominated by little bluestem (*Schizachyrium scoparium*) and Canada bluegrass (*Poa compressa*) with white sage (*Artemisia ludoviciana*) as an important forb. Characteristic sand species include sand dropseed (*Sporobolus cryptandrus*), hairy grama (*Bouteloua hirsuta*), purple love grass (*Eragrostis spectabilis*), bead grass (*Paspalum ciliatifolium*) and (*Cyperus filiculmis*). Other common species include June grass (*Koeleria macrantha*), porcupine grass (*Stipa spartea*), perennial ragweed (*Ambrosia psilostachya*), rough blazing star (*Liatris aspera*), and Missouri goldenrod (*Solidago missouriensis*).

A variety of rare plants are found on the preserve. Included on the state endangered list are rush (*Juncus greenei*), a sedge (*Carex leptalea*), least grape fern, *Botrychium simplex*, milkwort (*Polygala incarnata*) and northern panic grass (*Dicantholium boreale*) *Ophioglassum vulgatum* is on the state threatened list while the sage-leaved willow (*Salix candida*) and tall cotton grass (*Eriophorum angustifolium*) are considered to be plants of special concern in Iowa. (*Veronica scutellaria*) and (*Juncus vaseyi*) are rare in Iowa and the populations on the preserve are considered to be disjunct.

A complete inventory of the animal species is lacking. The eastern gartersnake (*Thamnophis sirtalis*) and bullsnake (*Pituophis melanoleucus*) are common as are the plains pocket gopher (*Geomys bursarius*) and white tailed deer (*Odocoileus virginianus*). Twenty-five species of mammals have been observed including the short-tailed shrew (*Blarina brevicauda*), masked shrew (*Sorex cinereus*), meadow vole (*Microtus pennsylvanicus*), meadow jumping mouse (*Zapus hudsonius*), gray fox (*Urocyon cinereoargenteus*), ermine (*Mustela erminea*), long-tailed weasel (*Mustela frenata*) and white-tailed jack rabbit (*Lespus townsendii*). Birds known from the prairie include the killdeer (*Charadrius vociferus*), upland sandpiper (*Bartramia longicauda*), common yellowthroat (*Geothlypis trichas*), bobolink (*Oolichonyx oryzivorus*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*) and song sparrow (*Melospiza melodia*). Prairie chickens (*Tympanuchus cupido*) were last reported present in the early 1940's (Polder, 1986). Long-eared and short-eared owls (*Asio otus and A. flammeus*) have over-wintered in a small cedar grove on the north of the preserve. Thirty-eight butterfly species have been recorded on the Cedar Hills Sand Prairie which has often been a migration site for large numbers of monarch butterflies (*Danaus plexippus*).

Primary management concerns of the preserve are expansion of Siberian elm (*Ulmus pumila*) from the windbreak across the road, continued encroachment of smooth brome (*Bromus inermis*) and increased woody growth in the southwest and northeast corners. The old field portion to the north is being managed to enhance secondary succession to prairie.

The preserve was burned in 1973 to initiate control of eastern red cedar (*Juniperus virginiana*). The use of fire and selective cutting have reduced the eastern red cedar expansion.

A prescribed burn program was initiated in 1985. Portions of the preserve have been burned annually, with the exception of 1991 and 1993, since that time (Figs. 4, 5). Fire management has not been sufficient to control the Siberian elm expansion so girdling and cutting management activities have been initiated.

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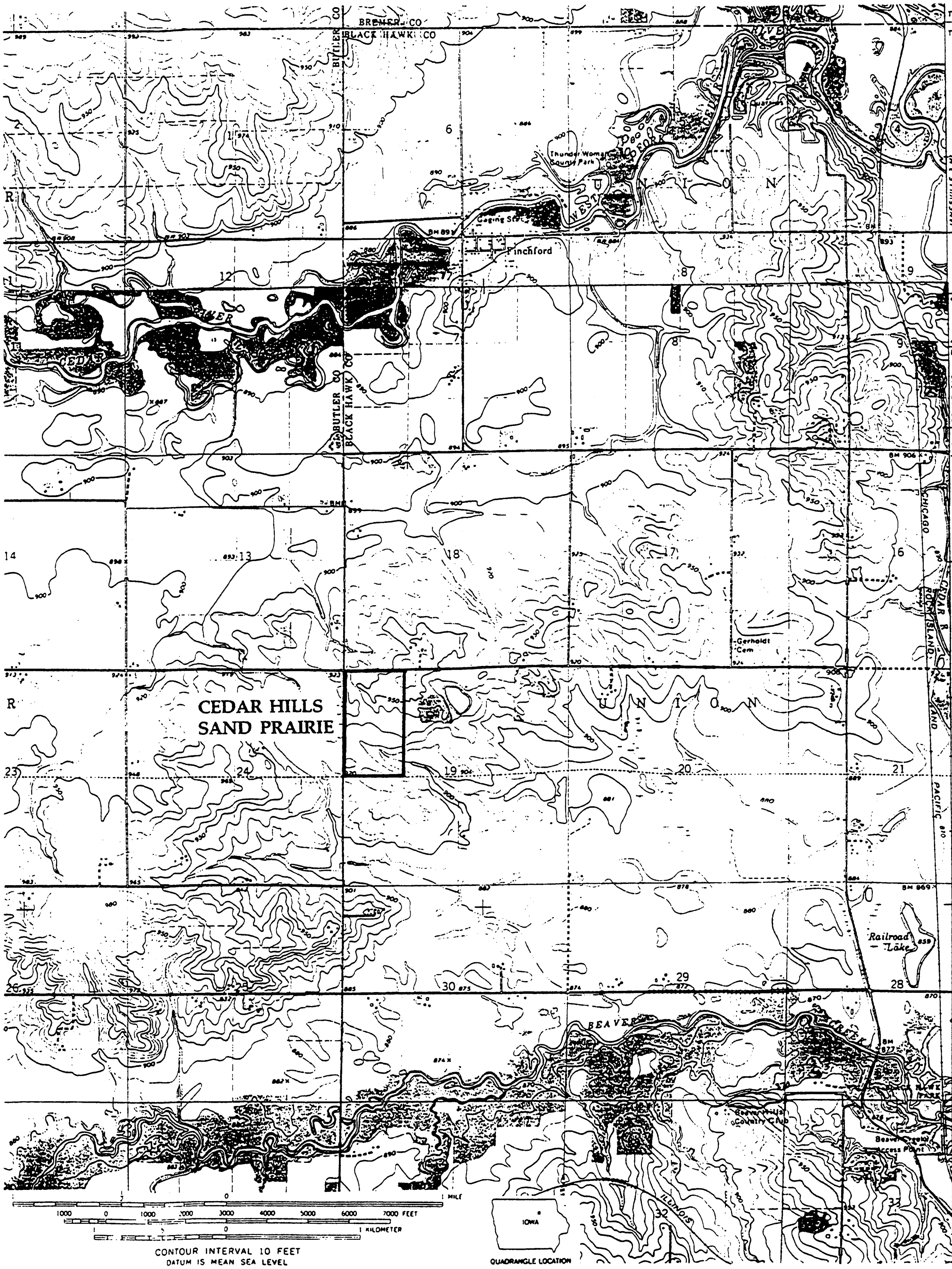
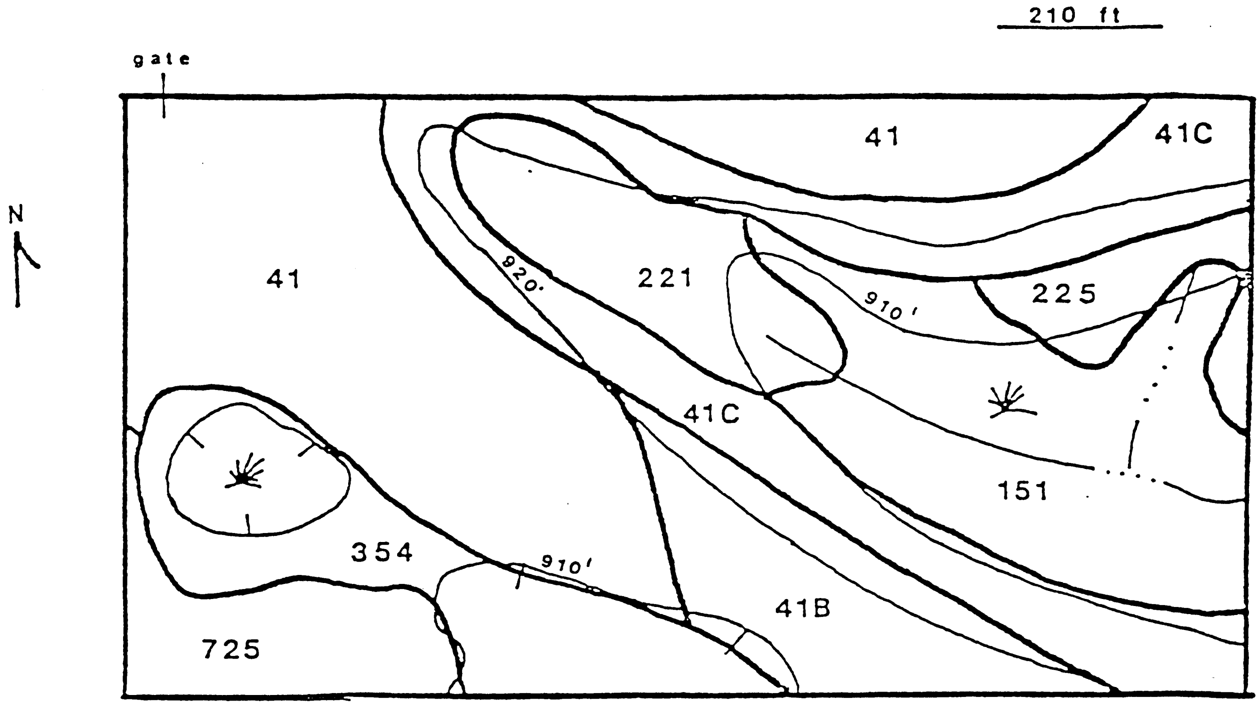


Figure 1. Location map of Cedar Hills Sand Prairie.



Soil No.	Name
41	Sparta loamy fine sand, 0-2 percent slope
41B	Sparta loamy fine sand, 2-5 percent slope
41C	Sparta loamy fine sand, 5-9 percent slope
151	Marshan clay loam
221	Palms muck
225	Lawler loam
354	Marsh
725	Hayfield loam

Figure 2. Soil map of the Cedar Hills Sand Prairie.

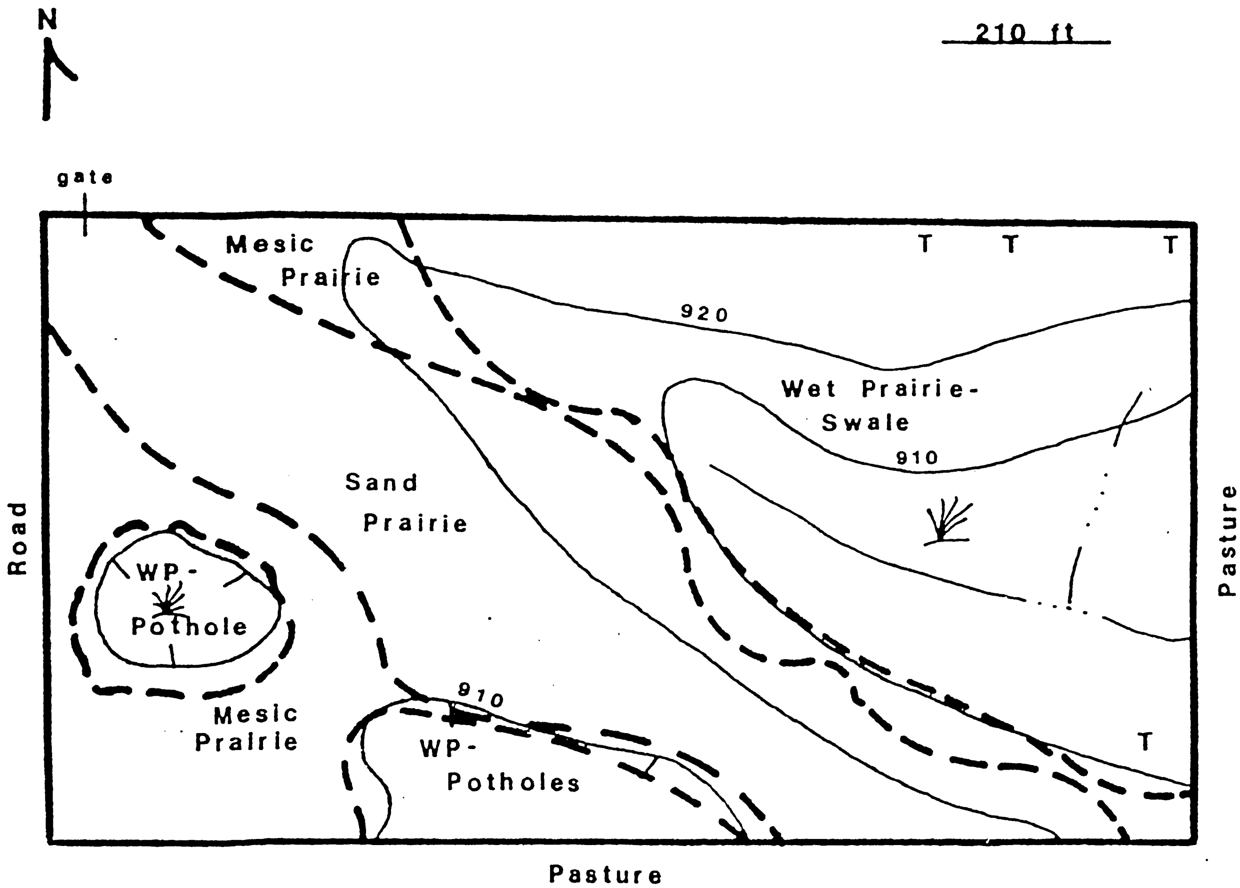


Figure 3. Cedar Hills Sand Prairie.

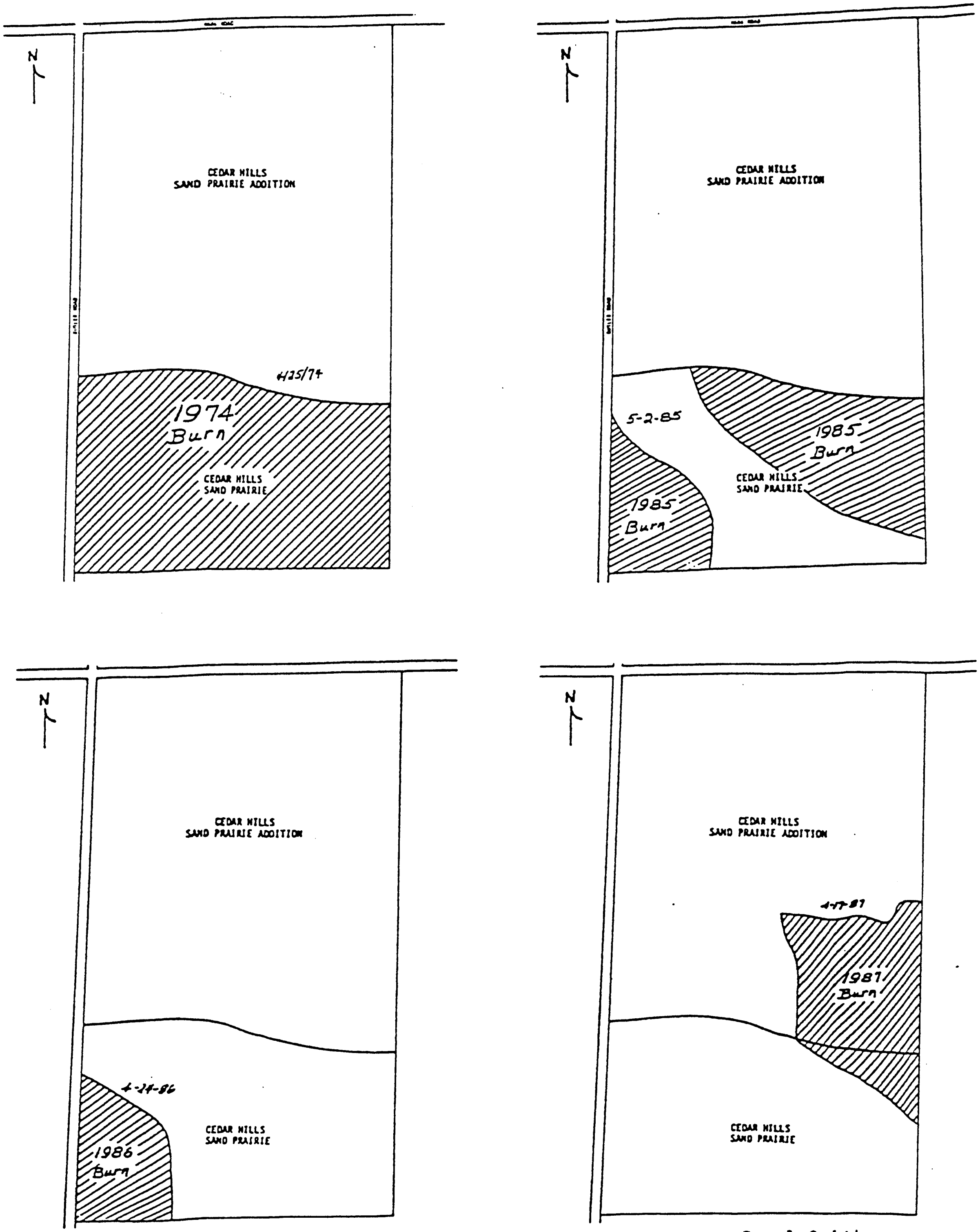


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Figure 4. Cedar Hills Sand Prairie Burns, 1974, 85-87.

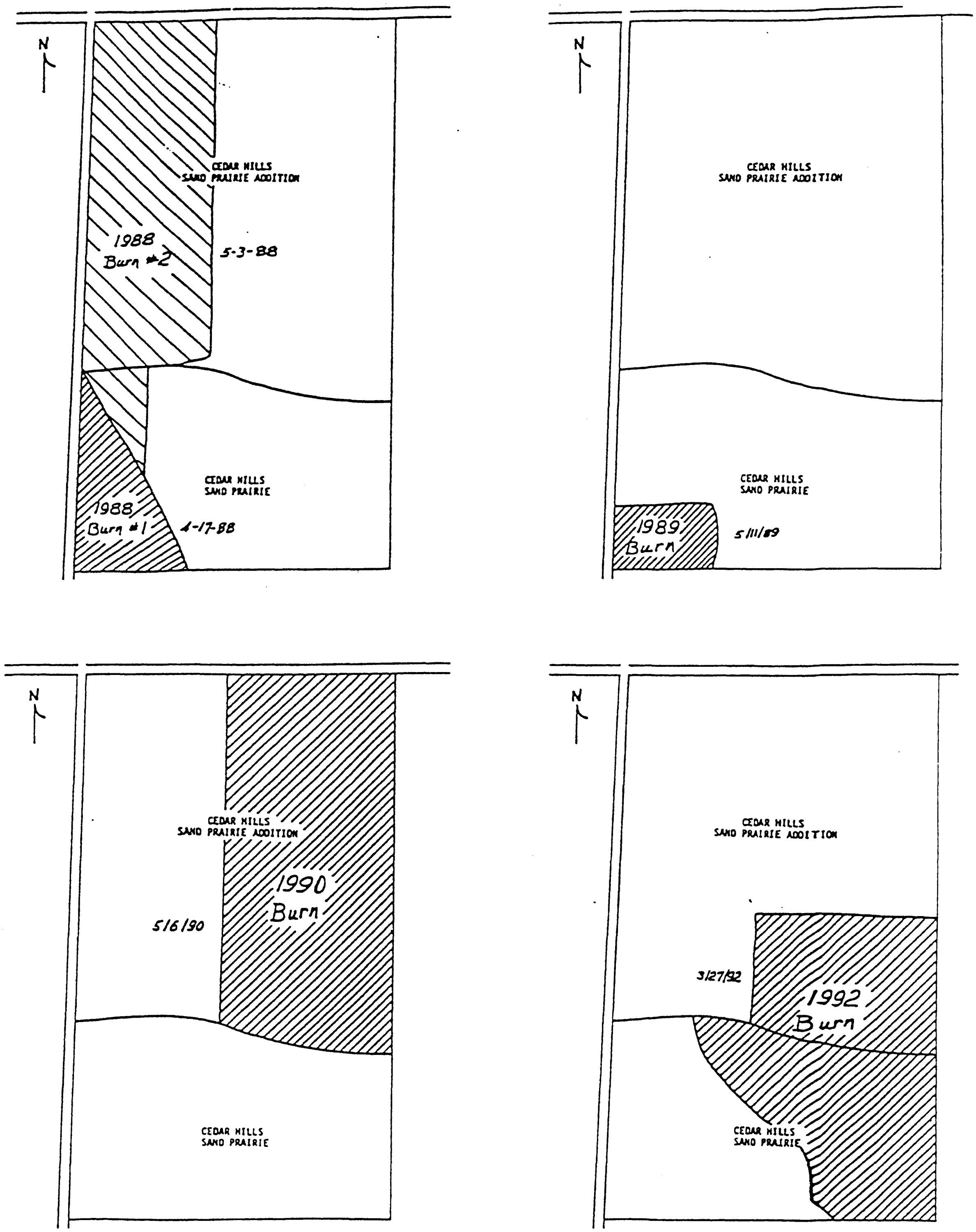

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Figure 5. Cedar Hills Sand Prairie Burns, 1988-90, 92.

VASCULAR FLORAL CHECKLIST
Cedar Hills Sand Prairie, Black Hawk County, Iowa

Ed L. Freese

Pteridphyta
Aspleniaceae

Athyrium filix-femina (L.) Roth var. angustum (Willd.) Moore. Northern Lady fern
Dryopteris cristata (L.) Gray Crested Shield Fern.
Onoclea sensibilis L. Sensitive Fern
Thelypteris palustris Schott var *pubescens* (Lawson) Fern. Marsh Fern

Equisitaceae

Equisetum arvense L. Common Horesetail
Equisetum laevigatum A. Br. Prairie Scouring Rush
Equisetum sylvaticum L. Woodland Horsetail

Ophioglossaceae

Botrychium dissectum Sprengel form *obliquum* (muhl.) Fern. Oblique grape fern
Botrychium multifidum (Gmelin) Rupr. Leathery grape fern.
Botrychium simplex E. Hitchc. Least Grapefern
Ophioglossum pusillum Raf. Adder's Tongue

Osmundaceae

Osmunda claytoniana L. Interrupted Fern

Spermatophyta
Gymnospermae
Cupressaceae

Juniperus virginiana L. Red Cedar

Pinaceae

**Pinus resinosa* Alt. Red Pine

Angiospermae
Monocotyledoneae
Alismataceae

Alisma plantago-aquatica L. Water Plantain
Sagittaria cuneata Sheldon Arrowhead
Sagittaria latifolia Willd, Arrowhead
Sagittaria rigida Pursh Arrowhead

Amaryllidaceae

Hypoxis hirsuta (L.) Coville Yellow Stargrass

Commelinaceae

Tradescantia bracteata Small Spiderwort
Tradescantia ohiensis Raf. Spiderwort

Cyperaceae

Carex annectens (Bickn.) Bickn. var *xanthocarpa* (Bickn.) Wieg.
Carex atherodes Sprengel
Carex bickneilii Britton
Carex buxbaumii Wahl.
Carex conjucta Boott
Carex conoidea Schkuhr ex Willd.
Carex gravida Bailey
Carex haydenii Dewey
Carex interior Bailey
Carex lacustris Willd.
Carex lasiocarpa Ehrh. var *americana* Fern.
Carex leptalea Wahl.
Carex meadii Dewey
Carex muhlenbergii Schkuhr ex Willd.
Carex sartwellii Dewey
Carex suberecta (Olney) Britton
Cyperus filiculmis Vahl
Carex scoparia Schkuhr ex Willd.
Carex stricta Lam.
Carex vesicaria L.
Carex vulpinoidea Michx.
Cyperus esculentus L.
Cyperus schweinitzii Torrey
Cyperus strigosus L.
Dulichium arundinaceum (L.) Britton Three-way sedge
Eleocharis compressa Sulliv. Spike Rush
Eleocharis erythropoda Steudel Spike Rush
Eleocharis macrostachya Britton Spike Rush
Eriophorum angustifolium Honck. Cotton Grass
Scirpus actus Muhl. ex Bigelow Hardstem Bulrush
Scirpus cyperinus (L.) Kunth Wool Bulrush
Scirpus fluviatilus (Torr.) Gray River Bulrush
Scleria triglomerata Michx. Nut Rush

Iridaceae

Iris shrevei Small Blue Flag
Sisyrinchium campestre Bickn. Blue-eyed Grass

Juncaceae

Juncus canadensis J. Gay ex Laharpe Rush
Juncus greenei Oakes & Tuckerman Rush
Juncus tenuis Willd. Path Rush
Juncus vaseyi Engelm.

Lemnaceae

Lemna minor L. Duckweed
Spirodela polyrhiza (L.) Schleiden Greater Duckweed

Liliaceae

**Asparagus officinalis* L. Asparagus
Polygonatum biflorum (Walt.) Ell. Solomon's Seal
Smilacina stellata (L.) Desf. False Solomon's Seal

Orchidaceae

Liparis loeselii (L.) L.C. Rich Bog Twayblade
Spiranthes cernua (L.) L.C. Rich Ladies' Tresses

Poaceae

**Agrostis gigantea* Roth Redtop
Agrostis hyemalis (Walt.) BSP. Ticklegrass
Alopecurus aequalis Sobol. Foxtail
Andropogon gerardii Vitman Big Bluestem
Aristida basiramea Engelm. ex Vasey Needle Grass
Boutelous hirsuta Lag. Hairy Grama
**Bromus inermis* Leyss. Smooth Brome
**Bromus tectorum* L. Downy Chess
Calamagrostis canadensis (Michx.) Beauv. Bluejoint
Calamovilfa longifolia (Hooker) Scrib. Prairie Sandreed
Cenchrus longispinus (Hack.) Fern. Sandbur
**Dactylis glomerata* L. Orchard Grass
Phalaris arundinacea L. Reed Canary Grass

Dichanthelium acuminatum (Sw.) Gould & Clark var *implicatum* (Scrib.) G. & C.
Dichanthelium boreale (Nash) Freckm.
Dichanthelium oligosanthes (Schultes) Gould var *scribnerianum* (Nash) G.
Dichanthelium perlongum (Nash) Frekm.
Echinochloa muricata (Beauv.) Fern. Barnyard Grass
Elymus canadensis L. Canada Wild Rye
Eragrostis spectabilis (Pursh) Steudel Purple Lovegrass
Glyceria grandis S. Wats. Reed Meadow Grass
Glyceria septentrionalis A. S. Hitchc. Manna Grass
Glyceria striata (Lam.) A. S. Hitch. Fowl Manna Grass
Hierochloe odorata (L.) Beauv. Holy Grass
Hordeum jubatum L. Squirrel-tail Barley
Koeleria macrantha (Lebed.) Schultes June Grass
Leersia oryzoides (L.) Sw. Rice Cutgrass
Muhlenbergia glomerata (Willd.) Trin. Muhly Grass
Muhlenbergia mexicana (L.) Trin. Muhly Grass
Panicum virgatum L. Switchgrass
Paspalum setaceum Michx. var *ciliatifolium* (Michx.) Vasey Bead Grass
**Phleum pratense* L. Timothy
**Pos compressa* L. Canadian Bluegrass
Poa palustris L. Fowl Meadow Grass
**Poa pratensis* L. Kentucky Bluegrass
Schizachyrium scoparium (Michx.) Nash Little Bluestem
**Setaria faberi* Herrm. Giant Foxtail
**Setaria glauca* (L.) Beauv. Yellow Foxtail
Sorghastrum nutans (L.) Nash Indian Grass
Spartina pectinata Link Slough Grass
Sphenopholis obtusata (michx.) Scrib. var *major* (Torrey) K.S. Erdman Wedge Grass
Sporobolus cryptandrus (Torrey) Gray Sand Dropseed
Sporobolus heterolepis (Gray) Gray Prairie Dropseed
Stipa spartea Trin. Porcupine Grass
Festuca octoflora Walter var. *tenella* (Willd.) Fern. Six-weeks fescue

Sparganaceae

Sparganium americanum Nutt. Burreed (may be *S. androcladum* - special concern)

Typhaceae

Typha angustifolia L. Narrow-leaved Cattail
Typha latifolia L. Cattail

Dicotyledoneae
Aceraceae

Acer negundo L. Boxelder
Acer saccharinum L. Silver Maple

Aizoceae

**Mullugo verticillata* L. Carpetweed

Amaranthaceae

Froelichia floridana (Nutt.) Moq. var *campestris* (Small) Fern. Cottonweed

Anacardiaceae

Rhus glabra L. Smooth Sumac
Toxicodendron radicans (L.) Kuntze ssp. *negundo* (Greene) Gillis Poison Ivy

Apiaceae

Cicuta maculata L. Water Hemlock
Eryngium yuccifolium Michx. Rattlesnake-master
Oxypolis regidior (L.) Raf. Cowbane
Sium suave Walt. Water Parsnip
Pastinaca sativa L. Wild Parsnip
Zizea aurea (L.) Koch. Golden Alexander

Apocynaceae

Apocynum sibiricum Jacq. Indian Hemp

Asclepiadaceae

Asclepias amplexicaulis J.E. Smith Sand Milkweed
Asclepias incarnata L. Swamp Milkweed
Asclepias syriaca L. Common Milkweed
Asclepias verticillata L. Whorled Milkweed
Asclepias viridiflora Raf. Green Milkweed

Asteraceae

Achillea millefolium L. ssp. *lanulosa* (Nutt.) Piper Yarrow
Ambrosia artemisiifolia L. Common Ragweed
Ambrosia psilostachya DC. Western Ragweed
Ambrosia trifida L. Giant Ragweed
Antennaria neglecta Greene Pussytoes
Artemisia ludoviciana Nutt. White Sage
Aster azureus Lindley Sky Blue Aster
Aster ericoides L. Heath Aster
Aster lanceolatus Willd. Panicled Aster
Aster novae-angliae L. New England Aster
Aster pilosus Willd. Hairy Aster
Aster puniceus L. Swamp Aster
Aster umbellatus Miller Flat-topped Aster
Bidens cernua L. Sticktight
Bidens coronata (L.) Britton Swamp Beggar-ticks
Brickellia eupatorioides (L.) Shinner False Boneset
**Cirsium arvense* (L.) Scop. Canada Thistle
Cirsium discolor (Muhl. ex Willd.) Sprengel Field Thistle
Conyza canadensis (L.) Cronq. Horesetail
Coreopsis palmata Nutt. Prairie Coreopsis
Erechtites hieracifolia (L.) Raf. ex. DC. Fireweed
Erigeron annuus (L.) Pers. Annual Fleabane
Cirsium billii (Cenby) Fern. Hill's Thistle
Antennaria plantaginifolia (L.) Richardson. Plantain-leaved pussytoes.
Crepis tectorum L. Hawksbeard.
Erigeron strigosus Muhl. ex Willd. Daisy Fleabane
Eupatorium maculatum L. Spotted Joe-pye-weed
Eupatorium perfoliatum L. Boneset
Euthamia graminifolia (L.) Nutt. ex. Cass. Lance-leaved Goldenrod
Gnaphalium obtusifolium L. Sweet Everlasting
Helenium autumnale L. Sneezeweed
Helianthus grosseserratus Martens Saw-tooth Sunflower
Helianthus petiolaris Nutt. Prairie Sunflower
Helianthus rigidus (Cass.) Desf. Sunflower
Helianthus tuberosa L. Jerusalem Artichoke
Krigia biflora (Walt.) Blake Dwarf Dandelion
Lactuca canadensis L. Wild Lettuce
Lactuca serriola L. Prickly Lettuce
Liatris aspera Michx. Blazing Star
Liatris pycnostachya Michx. Blazing Star
Prenanthes racemosa Michx. White Lettuce
Rudbeckia hirta L. Black-eyed Susan
Rudbeckia subtomentosa Pursh Fragrant Coneflower
Senecio pauperculus Michx. Prairie Ragwort
Solidago canadensis L. Tall Goldenrod

Solidago gigantea Aiton Large Goldenrod
Solidago missouriensis Nutt. Missouri Goldenrod
Solidago nemoralis Aiton Field Goldenrod
Solidago rigida L. Stiff Goldenrod
Solidago speciosa Nutt. Showy Goldenrod
**Taraxacum laevigatum* (Willd.) DC. Red-seeded Dandelion
**Taraxacum officinale* Weber Common Dandelion
**Tragopogon dubius* Scop. Goat's-beard
Vernonia fasciculata Michx. Ironweed
Xanthium strumarium L. Cocklebur

Betulaceae

Corylus americana Walt. Hazel Nut

Boraginaceae

Hackelia virginiania (L.) Johnst. Stickseed
Lithospermum canescens (Michx.) Lehm. Hoary Puccoon
Lithospermum caroliniense (Walt.) MacM. Hairy Puccoon

Brassicaceae

Berteroa incana (L.) DC. Hoary Alyssum
Lepidium densiflorum Schrad. Pepper Grass
Rorippa palustris (L.) Besser Yellow Cress
**Thlaspi arvense* L. Field Pennycress

Campanulaceae

Campanula aparinoides Pursh Bellflower
Lobelia siphilitica L. Great Blue Lobelia
Lobelia spicata Lam. Pale-spike Lobelia
Triodanis perfoliata (L.) Nieuw. Venus' Looking-glass

Cannabinaceae

**Cannabis sativa* L. Hemp

Caprifoliaceae

**Lonicera tatarica* L. Tartarian Honeysuckle
Sambucus canadensis L. Elderberry
Triosteum perfoliatum L. Feverwort
Viburnum lentago L. Nannyberry
Viburnum trilobum Marsh. Highbush Cranberry

Caryophyllaceae

**Cerastium vulgatum* L. Mouse-ear Chickweed
**Dianthus armeria* L. Deptford Pink
Silene antirrhina L. Sleepy Catchfly
**Silene pratensis* (Raf.) Gren. & Godron Evening Lychnis
Stellaria longifolia Muhl. ex Willd. Chickweed

Celastraceae

Celastrus scandens L. Bittersweet

Chenopodiaceae

**Chenopodium album* L. Lamb's-quarters
Cycloloma atriplicifolium (Spreng) Coulter Winged Pigweed

Cistaceae

Helianthemum bicknellii Fern. Frostweed
Lechia intermedia Leggett Pinweed
Lechia stricta Leggett Pinweed

Convolvulaceae

Calystegia sepium (L.) R. Br. Hedge Bindweed

Cornaceae

Cornus foemina P. Miller ssp. *racemosa* Gray Dogwood

Cucurbitaceae

Echinocystis lobata (Michx.) T. & G. Wild Cucumber

Euphorbiaceae

Euphorbia corollata L. Flowering Spurge
Euphorbia dentata Michx. Toothed Spurge
**Euphorbia esula* L. Leafy Spurge
Euphorbia geyeri Engelm. Prostrate Spurge
Euphorbia glyptosperma Engelm. Prostrate Spurge
Euphorbia maculata L. Carpet Spurge
Euphorbia nutans Lag. Nodding Spurge

Fabaceae

Amorpha canescens Pursh Lead Plant
Amphicarpa bracteata (L.) Fern. Hog Peanut
Astragalus canadensis L. Milk-vetch
Baptisia bracteata Muhl. ex. Ell. var *glabrescens* (Larisey) Islely Cream Wild Indigo
**Coronilla varia* L. Crown Vetch
Crotalaria sagittalis L. Rattlebox
Dalea candida Willd. White Prairie Clover
Dalea purpurea Vent. Purple Prairie Clover
Dalea villosa (Nutt.) Sprengel Silky Prairie Clover
Desmodium canadense (L.) DC. Showy Tick-trefoil
Desmodium illinoense Gray Illinois Tick-trefoil
Gleditsia triacanthos L. Honey Locust
Lespedeza capitata Michx. Round-headed Bush Clover
**Medicago lupulina* L. Black Medic
**Melilotus alba* Medicus White Sweet Clover
**Melilotus officinalis* (L.) Pallas Yellow Sweet Clover
Strophostyles helvula (L.) Ell. Trailing Wild Bean
**Strophostyles umbellata* (Michx.) Britt. Pink Wild Bean
**Trifolium pratense* L. Red Clover
**Trifolium repens* L. White Clover
**Vicia tetrasperma* (L.) Moench
**Medicago sativa* L. Alfalfa

Fagaceae

Quercus borealis Michx. f. var. *maxima* (Marsh.) Ashe Red Oak
Quercus macrocarpa Michx. Bur Oak

Gentianaceae

Gentiana andrewsii Griseb. Closed Gentian
Gentiana puberlenta J. Pringle Prairie Gentian
Gentiana x *billingtonii* Farw. (*G. andrewsii* x *G. puberlenta*) Soapwort Gentian

Hypericaceae

Hypericum majus (Gray) Britton
Hypericum mutilum L. St. John's Wort
Triadenum fraseri (Spach) Gl. Marsh St. John's-wort

Juglandaceae

Juglans nigra L. Black Walnut

Lamiaceae

Hedeoma hispidum Pursh Mock-pennyroyal
Lycopus americanus Muhl. ex Barton Bugleweed
Monarda fistulosa L. Horesemint
**Nepeta cataria* L. Catnip

**Prunella vulgaris* L. Self-heal
Pycnanthemum tenuifolium Schrader Slender Mountain Mint
Scutellaria galericulata L. Skullcap
Scutellaria lateriflora L. Mad-dog
Scutellaria parvula Michx. Skullcap
Stachys palustris L. Hedge Nettle

Lentibulariaceae

Utricularia vulgaris L. Bladderwort

Linaceae

Linum sulcatum Riddell Yellow Flax

Lythraceae

Lythrum alatum Pursh Winged Loosestrife

Moraceae

**Morus alba* L. White Mulberry
Morus rubra L. Red Mulberry

Oleaceae

Fraxinus pennsylvanica Marsh. Red Ash

Onagraceae

Epilobium coloratum Biehler Willow Herb
Epilobium leptophyllum Raf. Narrow-leaved Willow Herb
Ludwigia polycarpa Short & Peter False Loosestrife
Oenothera biennis L. ssp. *centralis* Munz Evening Primrose
Oenothera rhombipetala Nutt. ex T. & G. Sand Primrose

Oxalidaceae

Oxalis stricta L. Yellow Wood Sorrel
Oxalis violacea L. Purple Wood Sorrel

Plantaginaceae

Plantago aristata Michx. Bracted Plantain
Plantago patagonica Jacq. Wooly Plaintain
Plantago rugelii Dcne. Common Plantain

Polemoniaceae

Phlox maculata L. Wild Sweet William
Phlox pilosa L. Prairie Phlox

Polygalaceae

Polygala incarnata L. Pink Milkwort
Polygala sanguinea L. Field Milkwort

Polygonaceae

Polygonum amphibium L. var *emersum* Michx. Water Smartweed
**Polygonum convolvulus* L. Black Bindweed
Polygonum hydropiper L. Water Pepper
Polygonum pensylvanicum L. var *laevigatum* Fern. Pinkweed
Polygonum ramosissimum Michx. Bushy Knotweed
**Rumex acetosella* L. Red Sorrel
**Rumex crispus* L. Curly Dock
Rumex orbiculatus Gray Great Water Dock
Polygonum sagittatum L. Tearthumb
Polygonum punctatum Ell. Water smartweed

Primulaceae

Dodecatheon meadia L. Shooting Star
Lysimachia ciliata L. Fringed Loosestrife
Lysimachia hybrida Michx. Loosestrife
Lysimachia terrestris (L.) BSP. Swamp Candles

Ranunculaceae

Anenome canadensis L. Canada Anenome
Anenome cylindrica Gray Thimbleweed
Caltha palustris L. Marsh Marigold
Delphinium virescens Nutt. Prairie Larkspur
Ranunculus fascicularis Muhl. Buttercup
Thalictrum dasycarpum Fisch. & Ave-Lall. Purple Meadow-rue
Pulsatilla patens (L.) P. Miller ssp *multifida* (Pritz.) Zamels Pasque flower
Anenome virginiana L. Tall anenome

Rhamnaceae

Ceanothus americanus L. var *pitcheri* T. & G. New Jersey Tea
Rhamnus cathartica L. Buckthorn

Rosaceae

Malus sp. apple.
Geum laciniatum Murray Rough avens
Agrimonia pubescens Wallr. Soft Agrimony
Crataegus mollis (T. & G.) Scheele Hawthorne
Fragaria virgininans Duchesne Wild Strawberry
Potentilla arguta Pursh Tall Cinquefoil
Potentilla norvegica L. Cinquefoil
**Potentilla rectra* L. Five-finger
Potentilla simplex michx. Common Cinquefoil
Prunus americana Marsh. Wild Plum
Prunus serotina Ehrh. Black Cherry
Rosa arkansana Porter var *suffulta* (Greene) Cockerell Wild Rose
Rosa carolina L. Pasture Rose
**Rosa multiflora* Thunb. Multiflora Rose
Rubus allegheniensis Porter ex Bailey Blackberry
Rubus fulleri Bailey Dewberry
Spiraea alba DuRoi Meadowsweet
Potentilla palustris (L.) Scop. Marsh Cinquefoil
Geum aleppicum Jacq. var. strictum (Aiton) Fern. Yellow Avens

Rubiaceae

Galium obtusum Bigelow Wild Madder
Galium trifidum L. Bedstraw

Rutaceae

Zanthoxylum americanum P. Miller Prickly Ash

Salicaceae

Populus deltoides Bartram ex Marsh. ssp. *monilifera* (Aiton) Eckenw. Cottonwood
Populus tremuloides Michx. Quaking Aspen
Salix amygdaloides Andersson Peach-leaf Willow
Salix bebbiana Sarg. Beaked Willow
Salix candida Fluegge ex Willd. Sage Willow
Salix discolor Muhl. Pussy Willow
Salix nigra L. Black Willow
Salix petiolaris Smith Willow
Salix rigida Muhl. Heart-leaved Willow
Salix exigua Nutt. ssp. interior (Rowlee) Cronq. Sandbar Willow.

Santalaceae

Heucharia richardsonii R. Br. Alumroot
Penthorum sedoides L. Ditch Stonecrop
Saxifraga pennsylvanica L. Swamp Saxifrage

Scrophulariaceae

Agalinis purpurea (L.) Pennel Gerardia
Mimulus ringens L. Monkey Flower
Pedicularis lanceolata Michx. Swamp Lousewort
**Verbascum thapsus* L. Mullein
Veronica scutellata L. Marsh Speedwell
Veronicastrum virginicum (L.) Rarw. Culver's Root
Agalinis tenuifolia (Vahl) Raf. Slender Gerardia

Solonaceae

Physalis heterophylla Nees Ground Cherry
Physalis virginiana P. Miller Ground Cherry
Solanum americanum P. Miller Black Nightshade
Solanum carolinense L. Horse Nettle

Ulmaceae

Celtis occidentalis L. Hackberry
Ulmus americana L. American Elm
**Ulmus pumila* L. Siberian Elm

Urticaceae

Parietaria pensylvanica Muhl. ex Willd. Pellitory
Pilea pumila (L.) Gray Clearweed

Verbenaceae

Verbena hastata L. Blue Vervain
Verbena stricta Vent. Hoary Vervain
Verbena x *rydbergii* Moldenke (*V. hastata* x *V. stricta*)

Violaceae

Viola nephrophylla Greene Bog Violet
Viola pedata L. Bird's-foot Violet
Viola pedatifida G. Don Prairie Violet
Viola pratincola Greene Common Violet
Viola sagittata Aiton Arrow-leaved Violet
Viola sororia Willd. Hairy Blue Violet

Vitaceae

Parthenocissus quinquefolia (L.) Planchon Virginia Creeper
Vitus riparia Michx. Wild Grape
Vitus vulpina L. Frost Grape.
Parthenocissus vitaceae (Knerr) Hitchc. woodbine.

• non-native plants

Mammal species known or expected from the Cedar Hills Sand Prairie

(Schwartz from Cuthrell and Perkins 1989)

Scientific name	Common name
Didelphis virginiana	Virginia opossum
Sorex cinereus	masked shrew
Blarina brevicauda	short-tailed shrew
Scalopus aquaticus	eastern mole
Sylvilagus floridanus	eastern cottontail
Lepus townsendii	white-tailed jack rabbit
Marmota monax	woodchuck
Spermophilus franklinii *	Franklin's ground squirrel
S. tridecemlineatus	13-lined ground squirrel
Geomys bursarius	plains pocket gopher
Perognathus flavescens *	plains pocket mouse
Reithrodontomys megalotis	western harvest mouse
Peromyscus leucopus	white-footed mouse
P. maniculatus	deer mouse
Microtus ochrogaster *	prairie vole
M. pennsylvanicus	meadow vole
Mus musculus	house mouse
Zapus hudsonius	meadow jumping mouse
Canis latrans	coyote
Vulpes vulpes	red fox
Urocyon cinereoargenteus	gray fox
Procyon lotor	raccoon
Mustela erminea	ermine
M. frenata	long-tailed weasel
M. nivalis	least weasel
Taxidea taxus	badger
Spilogale putorius *	spotted skunk
Mephitis mephitis	striped skunk
Odocoileus virginianus	white tailed deer

* expected to occur at the prairie but not verified

Bird species known from the Cedar Hills Sand Prairie

(Cuthrell and Perkins 1989)

Scientific name	Common name
Anas platirhynchos	Mallard
A. discors	Blue-winged teal
Phasianus colchicus	Ring-necked pheasant
Charadrius vociferus	Killdeer
Bartramia longicauda	Upland sandpiper
Zenaida macroura	Mourning dove
Geothlypis trichas	Common yellowthroat
Agelaius phoeniceus	Red-winged blackbird
Carduelis tristis	American goldfinch
Colinus virginianus	Bobwhite
Oolichonyx oryzivorus	Bobolink
Xanthocephalus xanthocephalus	Yellow-headed blackbird
Melospiza melodia	Song sparrow
Tyrannus tyrannus	Eastern kingbird

Butterfly species recorded at the Cedar Hills Sand Prairie
(Cuthrell 1988-89 & Schlicht 1989 from Cuthrell & Perkins 1989)

Scientific name	Common name
Pholisora catullus	Common sootywing
Polites coras	Yellowpatch skipper
P. themistocles	Tawny-edged skipper
P. origenes	Crossline skipper
P. mystic	Long dash
Atrytone delaware	Delaware skipper
Poanes hobomok	Hobomok skipper
Poanes viator	Broad-winged skipper
Euphyes dion	Sedge skipper
E. conspicua	Black dash
E. bimacula	Two-spotted skipper
Pontia protodice	Checkered white
Artogeia rapae	Cabbage white
Colias philodice	Common sulphur
C. eurythem	Orange sulphur
Lycaena phlaeas	American copper
Gaeides xanthoides	Great grey copper
Hyllolycaena hyllus	Bronze copper
Epidemia helloides	Purplish copper
Harkenclenus titus	Coral hairstreak
Strymon melinus	Gray hairstreak
Everes comyntas	Eastern tailed blue
Celastrina ladon	Spring azure
Euptoieta claudia	Variegated fritillary
Speyeria cybele	Great spangled fritillary
S. aphrodite	Aphrodite
S. idalia	Regal fritillary
Clossiana selene	Silver bordered
C. bellona	Meadow fritillary
Charidryas gorgone	Gorgone crescentspot
C. nycteis	Silvery crescentspot
Phyciodes tharos	Pearly crescentspot
Vanessa virginiensis	American painted lady
V. cardui	Painted lady
V. atalanta	Red admiral
Satyrodes eurydice fumosa	Eyed brown
Cercyonis pegala	Wood nymph
Danaus plexippus	Monarch

512 2nd Ave., SE
Dyersville, IA 52040
Sept. 11, 1986

Dr. Daryl Smith
Head-Dept. of Biology
UNI
Cedar Falls, IA

Dear Dr. Smith:

Sorry I couldn't get to the Prairie Heritage meeting this week. I am interested in the Cedar Hills Prairie since I once lived a mile north of this place and spent a few years of my youth hunting and trapping over this prairie and the marshes to the east. Later as a student at Iowa State Teachers Dr. Roy Abbot and I collected small mammals on this prairie.

I recall crossing the sand prairie in April and early May in 1932 and finding the wooly precocious young of the white-tailed jackrabbit crouched in barren sand depressions where they were born. The lark sparrow and the little red squirrel were two unusual animals that I found in a black oak savannah to the northeast of the prairie site. The red squirrel is probably endangered in Iowa now. The only other place where I have seen the lark sparrow was in the Rockville Cedar Glade four miles south of Dyersville. One specimen of red squirrel was caught in a trap by George Pashby a mile north of the sand prairie and I placed the skin in the Iowa State University mammal collection in 1938.

In 1932 a few prairie chickens used the sand prairie for their mournful, moaning mating rites. They nested and raised their chicks in the spartina and blue stem swales and I saw as many as 30 in a winter flock that foraged in our corn and bean fields. These birds were still around in 1940, the last time I visited the area.

Dr. Abbot and I collected small mammals on the prairie and on farms in the next section north of the prairie. The dusky pocket mouse and Dykes harvest mouse lived in sand burrows and were quite abundant. (the harvest mouse could be easily mistaken for a house mouse except for the grooves in the upper incisors.) The prairie whitefooted mouse, Pennsylvania vole, the prairie vole, large shortailed shrew, pocket gopher, 13 lined ground squirrel, Franklin's ground squirrel, and the common mole were common in the area. Predators were the long-tailed weasel which used gopher and Franklin squirrel burrows for dens, the least weasel which used mole runs for den sites, and the spotted skunk which also lived in the burrows of gophers and Franklin squirrels. The large striped skunk and the opossum used the dens of badgers and woodchucks. Two varieties of muskrat were found in the prairie marshes. About 3/4 of the population was the dark eastern form and 1/4 are in the intergradation zone. The mink commonly used muskrat dens, woodchuck and Franklin squirrel burrows for their den sites.

Both the red fox and racoon ranged over the prairie and bedded down in the spartina grass swales. Gray foxes and fox squirrels lived in the black oak savannahs and chipmunks, flying squirrels and the deer mouse also were found there. Both the red bat and hoary bat roosted in the wild grape and hazle brush of the savannah during the summer months.

In the winter barred owls and great horned owls hid in the brown leaves that remained on the black oaks. I often saw ten to twenty short eared owls flying over the tallgrass swales on winter days and they sometimes roosted in the black oaks and in the white pines on a farmstead north of the prairie.

Three species of rails reared their black chicks in the wet swales of the prairie. In the spring of the "bump-wump" of the American bittern drowned out the raucus call of the yellow headed blackbird. I also found at least bittern hiding in the tall grass in the prairie swale.

Meadow larks, horned larks, field sparrows and vesper sparrows nested on the prairie and I often saw the killdeer there but never found a nest. The upland plovers reared young on the prairie each summer and bob-o-links nested in the tall grass bordering the swales.

These are recollections of nearly 50 years ago and many changes since then have no doubt changed the picture. I took the Iowa ornothologists to this prairie in 1936 or 1937 during their spring meeting and found a large number of northern phalaropes, greater yellowlegs, and lesser yellowlegs on one of the seepage ponds. I called this prairie to the attention of Martin Grant in 1950 and am surprised that no interest was taken in this place till 1969.

Best wishes for your preservation efforts.

Sincerely,

Emmett Polder

P.S. May 21, 1990

I just uncovered this letter and will add that spring peepers, chorus frogs, leopard frogs, toads, and spotted salamanders lived in and about the marshes of the sand prairie. The leopard frogs & toads were preyed on by red banded garter snakes, yellow striped ribbon snakes and hog nosed snakes. Both the bull snake and the fox snake were abundant there. The red shouldered hawks that nested in the Bensen woods on Beaver Creek preyed on the garter and ribbon snakes of the sand prairie.

Insects and spiders of the sand prairie were quite different from those on the black soils south and west of the prairie. I particularaly remember the ants with red abdomens, red winged grashoppers and the big black wolf spiders that made deep burrows in the sand.

This list may give you some idea of changes that occurred in the 50 years since I last visited this place.

By the way could you check with the curator of the UNI museum to see if there is a pleistocene bison skull in the collection? I unearthed this skull near the Union bridge about 6 or 7 miles north of Cedar Falls and left it with Dr. Cable to put in the museum. My full name then was Polderboer. I have since shortened the name.

If the skull is still there I may come to C.F. and have another look at it.

Sincerely,

E. Polder

P.S. again--

There was a small marsh in the middle of the section north of the sand prairie. As I recall there was a fen-like growth of moss on the south bank of the marsh. It may still be there and be of interest to you. I often thought I should have trapped it to see if there were red-backed mice and short-tailed weasels living there.

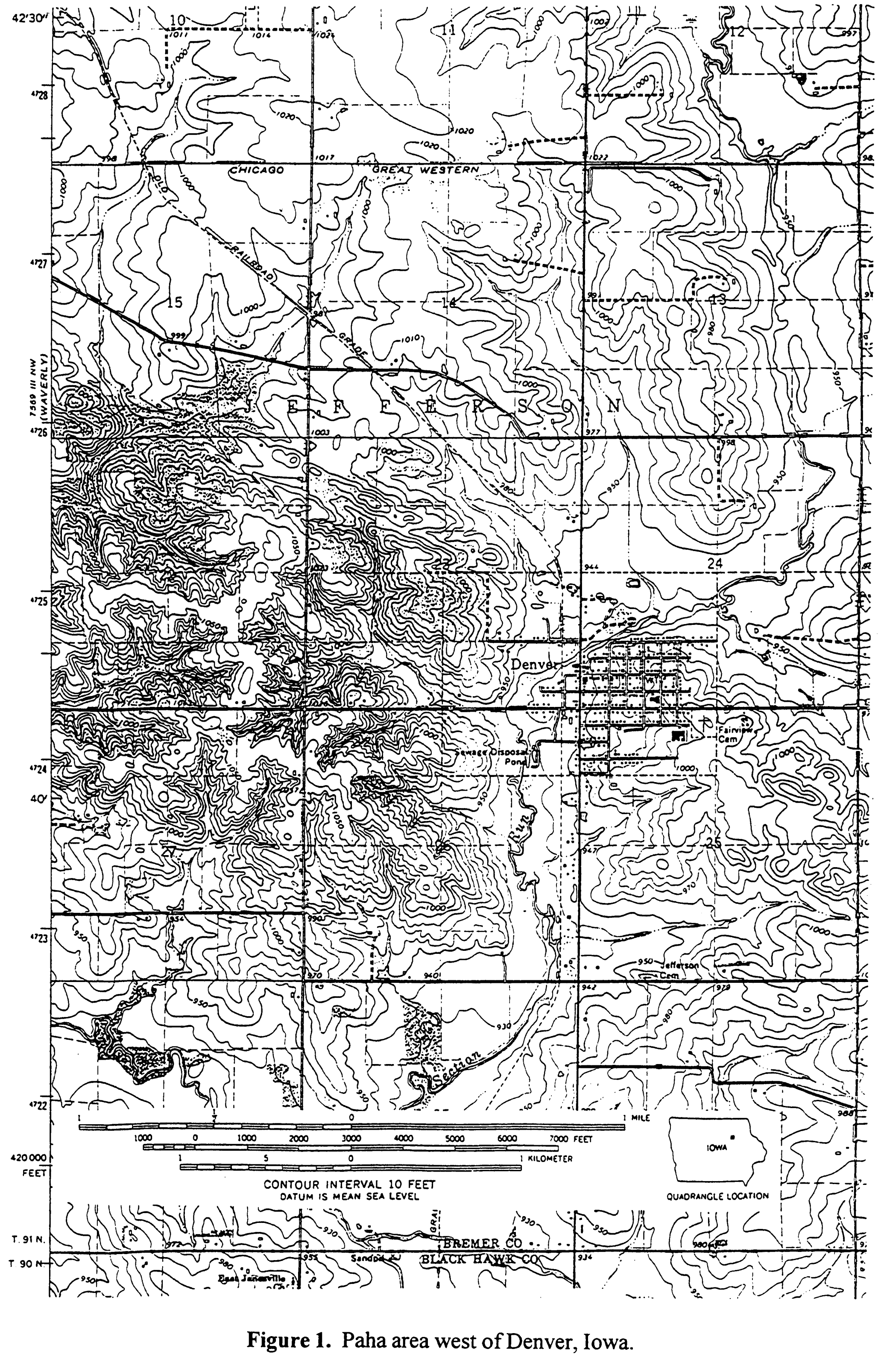

Figure 1. Paha area west of Denver, Iowa.

STOP 10: PAHA AREA WEST OF DENVER, IOWA

James C. Walters
Department of Earth Science
University of Northern Iowa

We will drive through the area west of the town of Denver known as the Denver Hills (Fig. 1). This area is a dissected paha, and in recent years this wooded hilly terrain has seen increasing development of housing. We will be making a brief stop at the east end of the paha, where recent road construction has exposed a portion of this feature. The topographic map (Fig. 1) shows the northwest-southeast orientation of the paha and its dissected topography.

As mentioned in the general geology section of this fieldtrip guidebook, paha are characteristic features of the Iowan Surface. Paha is an Indian word meaning hill, but the term was first used in a geological sense by McGee in 1891 for constructional ridges of wind-blown silt and clay in the area of the so-called "Iowan Glaciation" of northeastern Iowa. Early geologists developed the idea that a period of glacial activity called the "Iowan" existed between the Illinoian and Wisconsinan glacial periods. Later, the Iowan was assigned to the earliest substage of the Wisconsinan. Over the years, controversy surrounded the glacial deposits and associated paha of northeast Iowa. In 1968, Robert Ruhe and colleagues presented evidence for an erosional origin both of the paha cores and the lower lying Iowan surface (Ruhe and others, 1968). Much of their evidence was based on a detailed drilling program that traced the Pleistocene stratigraphy from southern Iowa into northeast Iowa. It was shown that the cores of the paha are composed of paleosols and glacial tills that represent erosional remnants that stand above the Iowan surface at interstream divides. It was further shown that the Iowan Glaciation did not exist, and that the Iowan plain is an erosion surface cut into Pre-Illinoian ("Kansan" and /or Nebraskan) tills. Dating indicates that the Iowan surface evolved between about 29,000 and 14,000 years BP (Prior, 1986), and it is known that an especially intense episode of erosional development occurred between 21,000 and 16,500 years ago during the coldest part of the Wisconsinan. Periglacial conditions existed in northeast Iowa at that time, and a tundra environment with permafrost was present.

In order to understand what paha are and how they formed, it is necessary to examine their stratigraphy. Figure 2 shows a cross section through an idealized paha, and Figure 3 shows the steps involved in paha formation. The surrounding plain, referred to as the Iowan Surface, is an erosion surface cut into Pre-Illinoian tills. The erosion surface encroached on the paha areas from all directions but did not completely destroy them. They persisted as erosional remnants along drainage divides. This explains their northwest-southeast orientation. As remnants, these areas received relatively thick deposits of loess during the Wisconsinan in contrast to the lower lying erosion surface which received a much thinner cover of loess.

The exposure at this site, since it is not in the center or core area of the paha, shows features more typical for the flanks of the paha. The section here includes a thick deposit of Wisconsinan loess over a thin layer of pedisediment over Pre-Illinoian till. No paleosol is found at this location, instead a layer of pedisediment is present. This is common along the flanks of paha, where slope movement, perhaps due to solifluction, has occurred on top of the glacial sediments. Loess deposits later capped the sequence. Features to note here include:

1. the upper loess which is well oxidized
2. the lower loess which is less well oxidized and contains secondary carbonates and pipestems
3. basal eolian sand layer below the lower loess unit
4. pedisediment layer

5. oxidized Pre-Illinoian till
6. unoxidized Pre-Illinoian till
7. contortion and disruption of the lower till into the upper till unit
8. occasional pieces of wood in the till

We will spend some time examining these features and discussing the possible sequence of events which took place here and the time frame.

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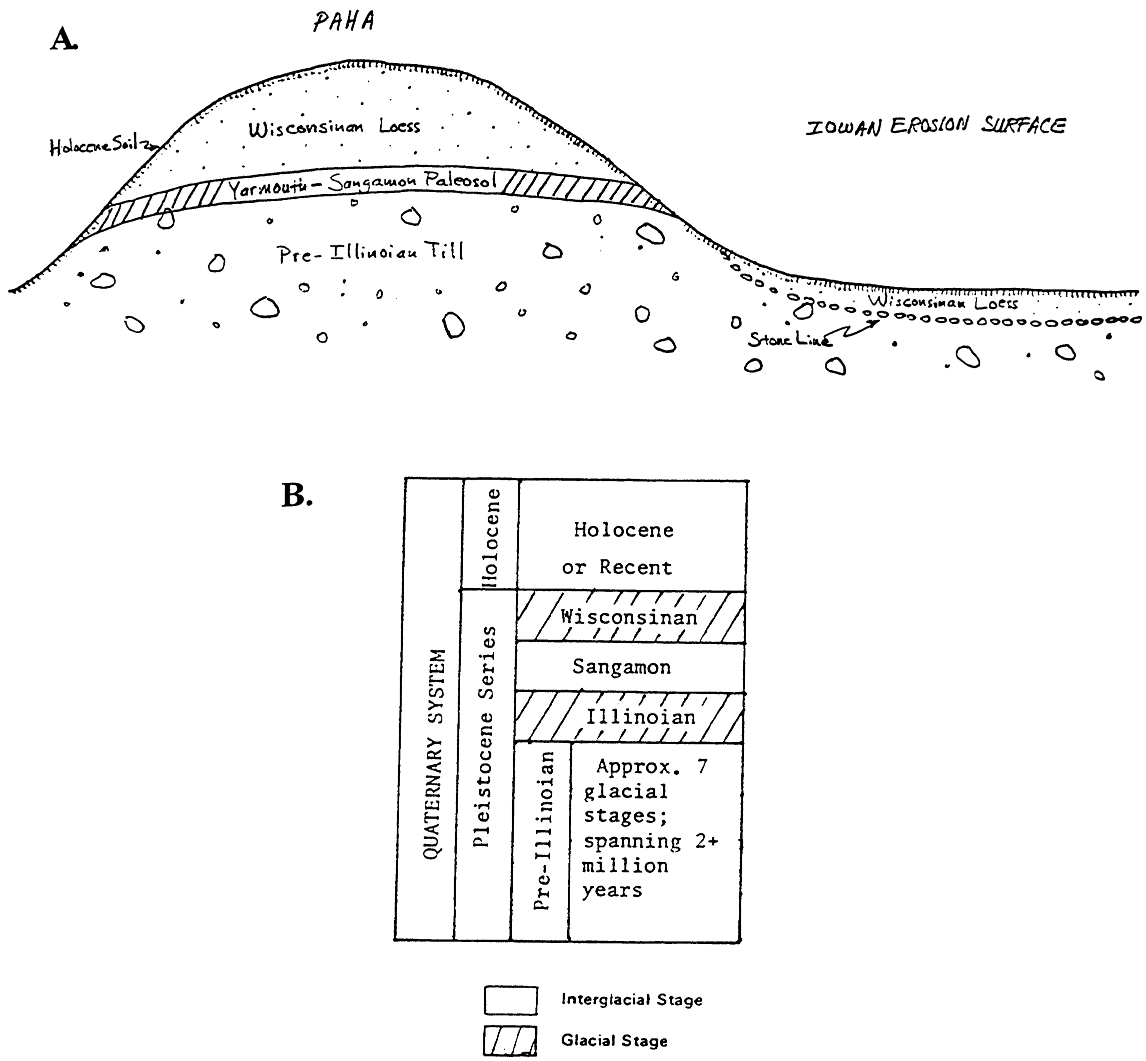


Figure 2. A. Cross section through an idealized paha. B. Stratigraphic column of Quaternary system, listing the principal glacial and interglacial stages.

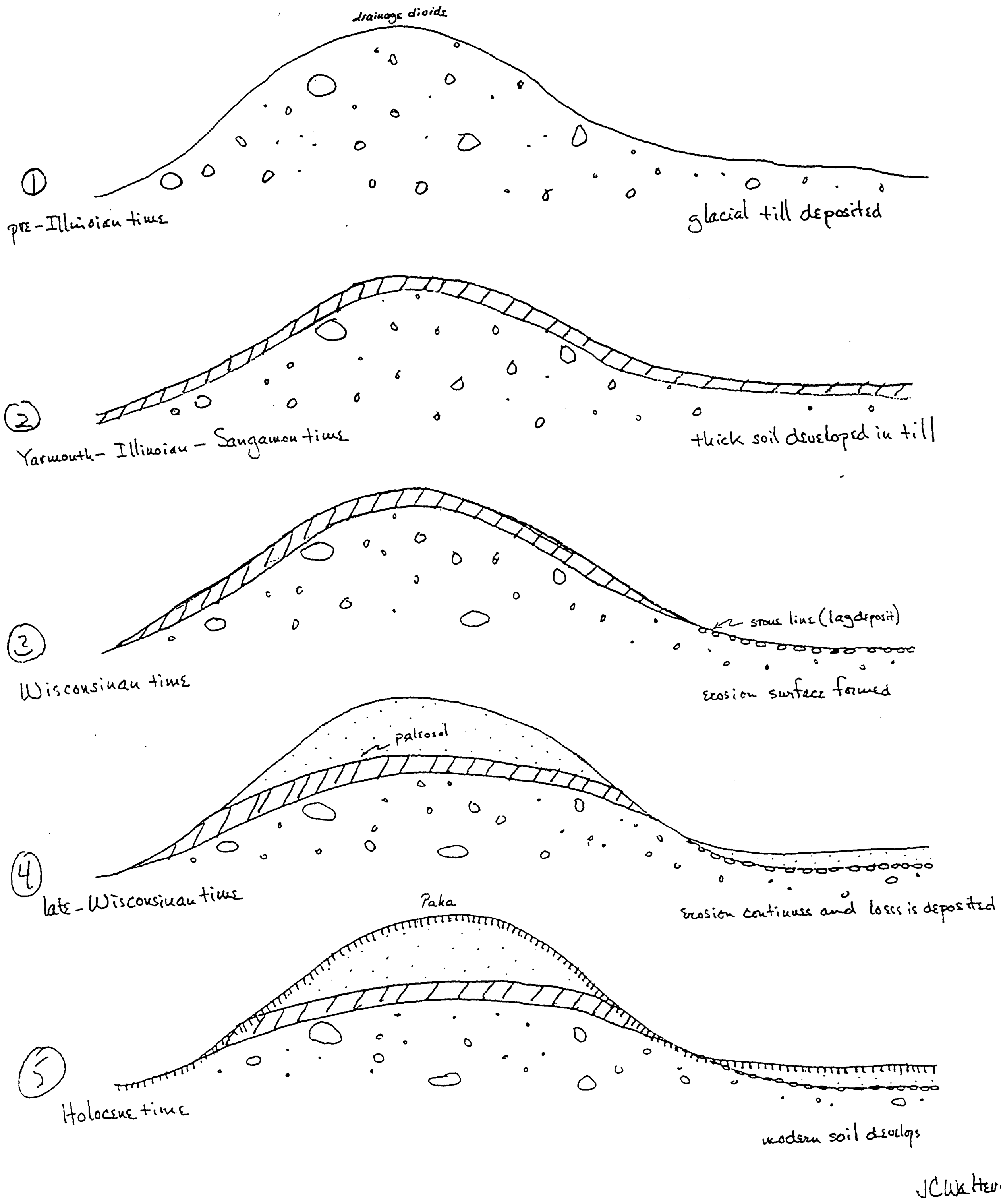


Figure 3. Stages in the formation of a paha.

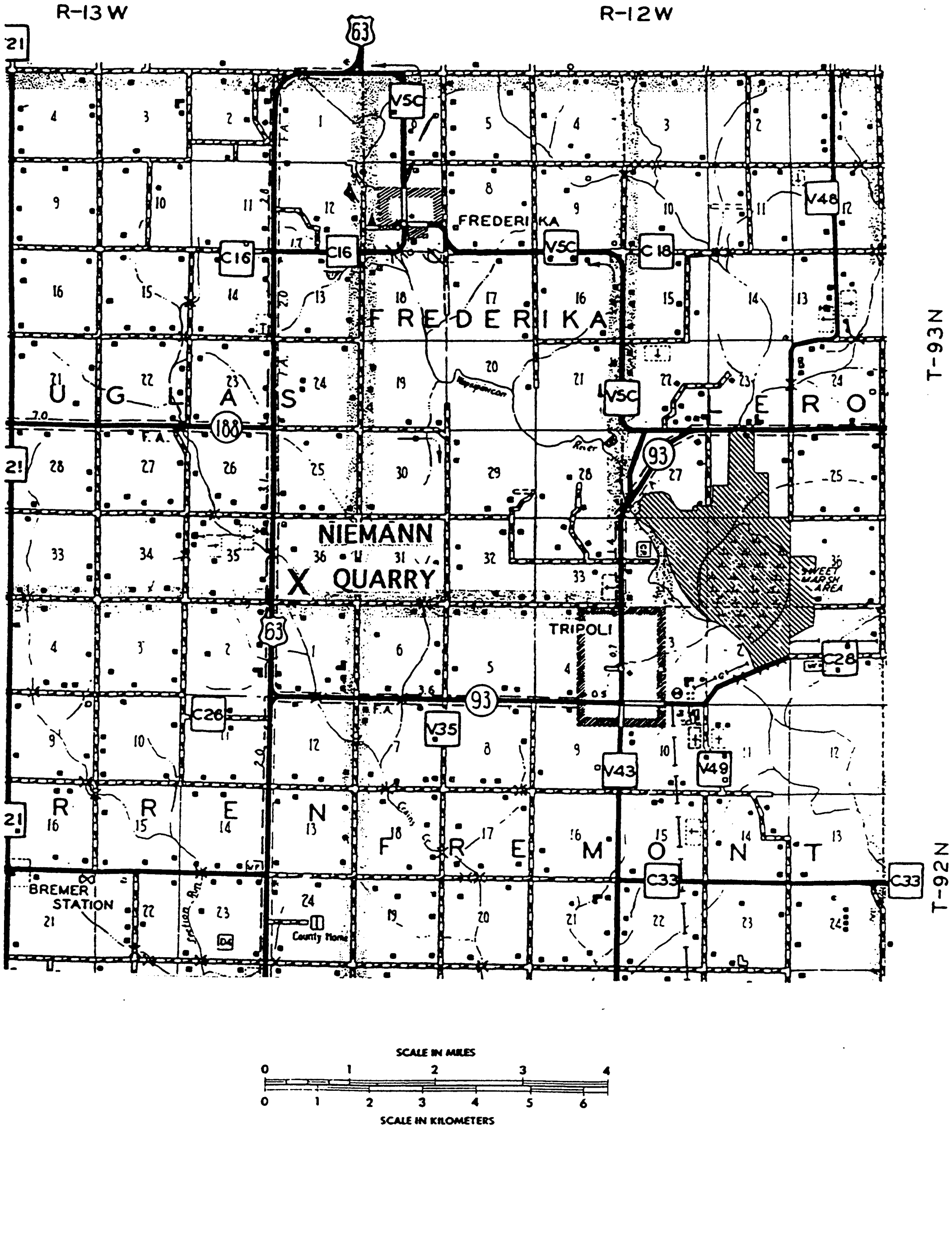


Figure 1. Location map of Niemann's Tripoli Quarry, Bremer County, Iowa. (Iowa Department of Transportation, General and Highway Transportation Map of Bremer County, 1980).

STOP 11A: PLEISTOCENE SECTION AT THE TRIPOLI QUARRY

James C. Walters
Department of Earth Science
University of Northern Iowa

A brief visit to examine the Pleistocene sediments above the Silurian rocks at the quarry was made by Jim Walters (Univ. of Northern Iowa) in June and a second visit was made by Walters, Art Bettis (Iowa Geological Survey Bureau), and Dennis Dahms (Univ. of Northern Iowa) in July. The first visit determined the existance of probable ice-wedge casts, involutions, and other relict periglacial phenomena in Pre-Illinoian till at the site. The later visit confirmed these findings, discovered addtional glacial and periglacial features, and led to an appreciation for the complexity of the Pleistocene section here.

We have just began to unravel the complicated nature of the sediments here and the processes they represent. There are numerous interesting features to study at this site, and we invite those of you who are interested to examine these deposits and offer suggestions and comments in an effort to interpret past environments. Some of the features to note at this site include:

1. stone line at the top of the section (disturbed in places by scraping back of topsoil by quarry operators)
2. ventifacts in the stone line
3. vertical orientation of pebbles and cobbles in the stone line in many places
4. numerous ice-wedge casts below the stone line
5. nature of sand infilling in the wedges
6. involutions below the stone line in places
7. association of involutions with ice-wedge casts
8. at least two debris flow, channel-fill features in the till (due to solifluction ?)
9. paleosol remnants which seem to have moved downslope, perhaps while frozen, in the till
10. upper oxidized Pre-Illinoian till
11. lower unoxidized Pre-Illinoian till
12. well-developed oxidized joints in the till
13. occasional pieces of wood in the till
14. lowermost stratified diamicton (basal till ? or proglacial sediment?)

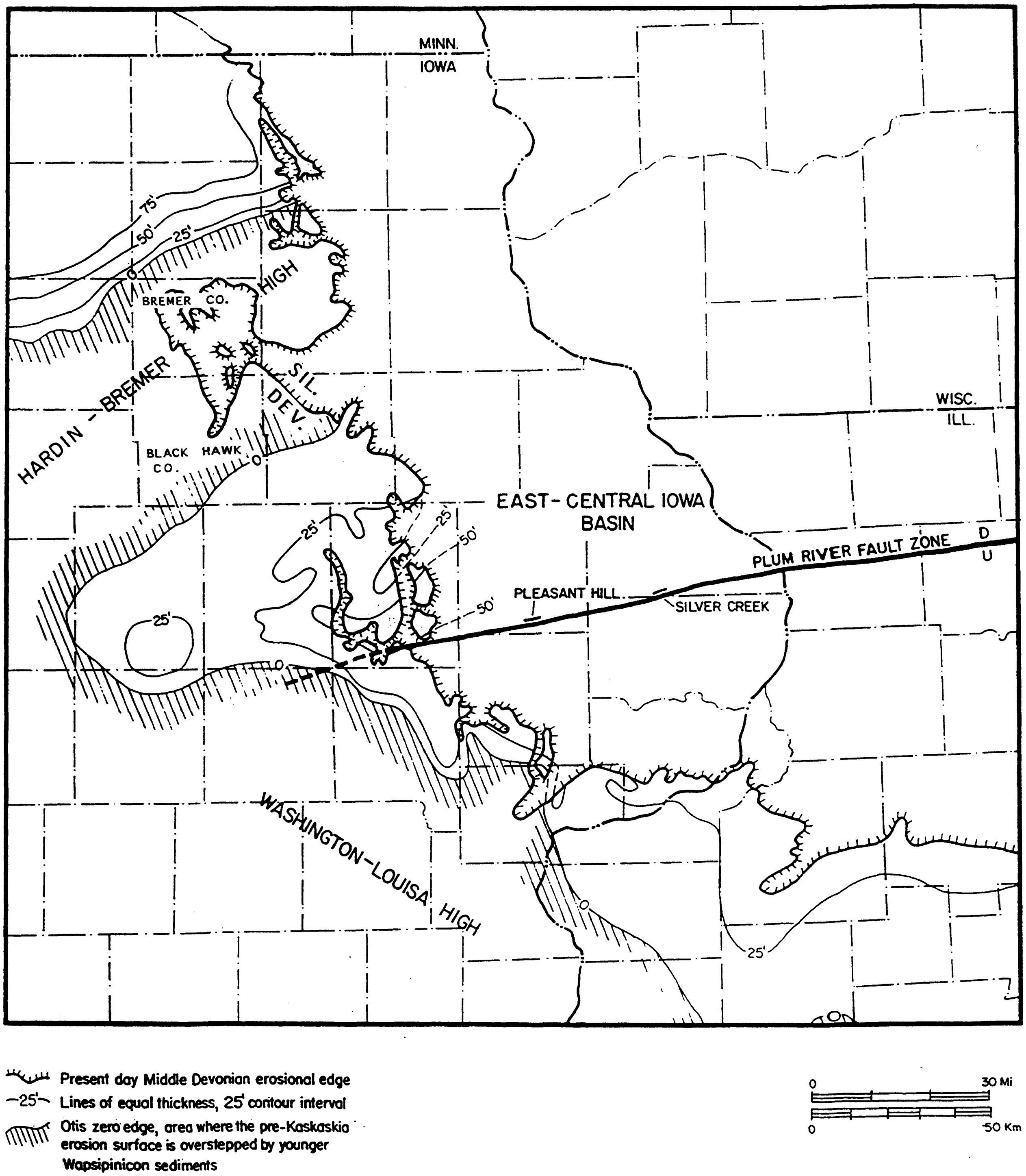


Figure 2. A map showing the configuration of the Silurian-Devonian bedrock contact and the Hardin-Bremer County High (Bunker et al. 1985).

STOP 11B: A STRUCTURALLY-COMPLEX, CARBONATE-MOUND FACIES IN THE LOWER HOPKINTON FORMATION (SILURIAN)

PAUL NIEMANN CONSTRUCTION COMPANY'S TRIPOLI QUARRY, BREMER COUNTY, IOWA. SW1/4, SEC. 36, T.93N., R.13W.

Wayne I. Anderson
Department of Earth Science
University of Northern Iowa
Cedar Falls, Iowa 50614

INTRODUCTION

The location of the Tripoli Quarry is shown in Figure 1. The quarry reveals structurally-complex strata of the Silurian Hopkinton Formation.

The presence of Silurian strata in Bremer County has been recognized for a long time. William Harmon Norton noted the occurrence of Silurian rocks in his 1906 report on the geology of the county and attributed the exposures in Bremer County to structural causes. He stated that local upwarps lifted the Silurian to the surface at several points in the county—" about three and a half miles west of Tripoli and, southeast of Waverly, on Baskin run and near the mouth of Quarter Section run."

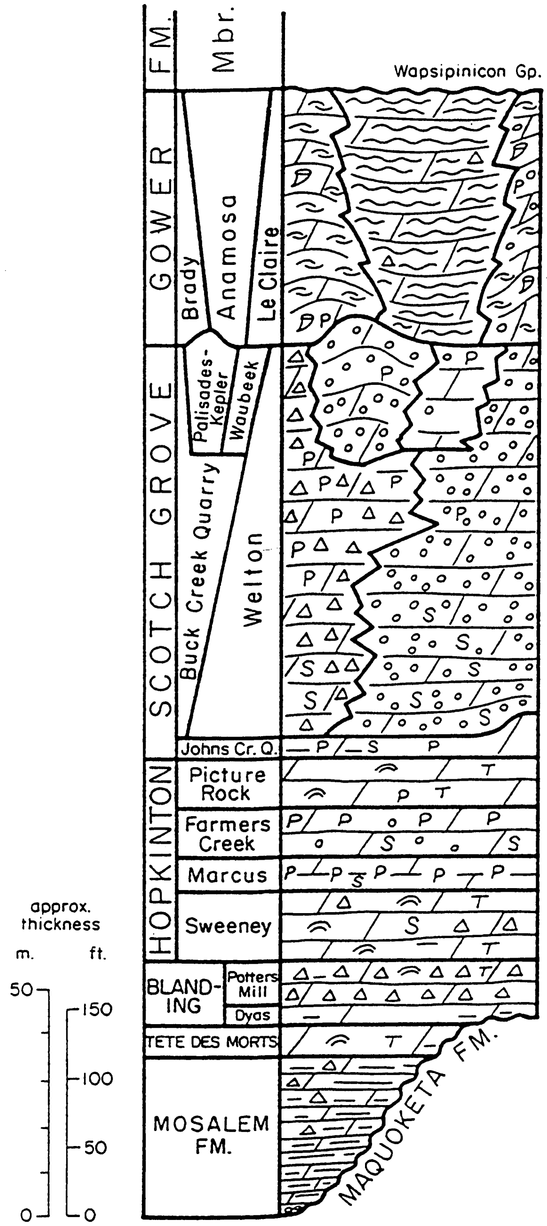
At the time of Norton's mapping in Bremer County, the distributions of the Silurian and Devonian outcrop belts were being clarified in other areas of the state as well. Hear the words of Norton (1906): "As in other counties so here detailed investigations of the present Survey have rectified the frontier between the Devonian and the Silurian largely at the expense of the former as drawn on the geological maps on the earlier surveys. Thus in Buchanan county Calvin found that a strong upfold of the strata had lifted the Niagara (Silurian) above the position which it naturally would occupy. To this upwarp is due the broad triangular salient of the Niagara in northern Buchanan and southern Fayette counties which brings it nearly the width of an entire county west of the general trend of its boundary line. The survey of Bremer county again advances the Niagara to the west by nearly a county breadth, bringing it to the Cedar river below Waverly. Nowhere above this point is the Niagara seen in the immediate valley of the Cedar, nor does it again appear to the south until one reaches the Niagara outcrops of southern Linn county below Cedar Rapids. The outcrop near Tripoli is aligned with the Oelwein-Fairbank anticline and is perhaps an extension of it. No rock outcrops between the Tripoli and Fairbank exposures, the entire county being buried beneath one hundred feet and more of drift."

Figure 2 depicts the configuration of the Silurian and Devonian bedrock in Bremer and Black Hawk counties. Bunker et al. (1985) include the Bremer County area as part of a low structural feature called the Hardin-Bremer High.

Bremer County is the only county in Iowa named in honor of someone eminent in literature. The county bears the name of the distinguished Swedish novelist and traveler, Fredrika Bremer. However, Miss Bremer's Christian name is incorrectly recorded on county maps because of an unfortunate interpolation of a letter, in the township and village of "Frederika" (Norton, 1906).

STRATIGRAPHY, STRUCTURE, AND ENVIRONMENT OF DEPOSITION

A generalized stratigraphic column for the Silurian System of eastern Iowa is shown in Figure 3. Silurian rocks in the Tripoli Quarry consist of fine to medium crystalline dolomites with a variety of fossils including pentamerid brachiopods, tabulate corals, laminar stromatoporoids, crinoid columnals, and others. A representative assortment of fossils occurs in the large blocks that mark the edge of the



P = pentamerid brachiopods
S = stricklandiid brachiopods
T = tabulate corals
°° = crinoidal content
⌒ = laminar stromatoporoids
△ = chert
~ = brachiopods

Figure 3. A generalized stratigraphic column for the Silurian System of eastern Iowa. (Witzke, 1992).

upper level of the quarry. Even though the rocks of the quarry are extensively dolomitized, their original depositional textures are recognizable as mud-supported according to Dunham's (1962) classification of carbonate rocks. The strata exposed in the quarry appear to correlate with the lower Hopkinton Formation, probably equivalent to the Sweeney-Marcus interval.

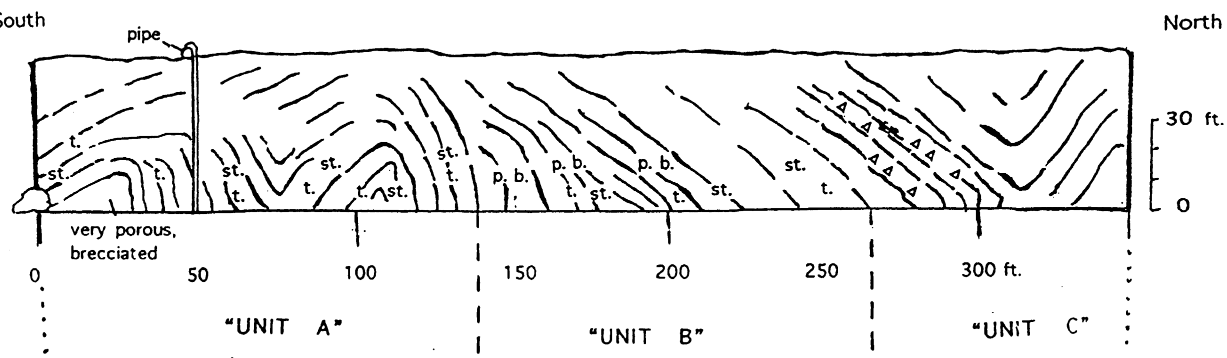
Figure 4 illustrates the structural configuration of beds in the northwest portion of the quarry and provides lithologic descriptions of the strata exposed there. Beds with dips of approximately 30 degrees are common on the west face of the quarry, and inclinations of 10 to 20 degrees are the norm for beds on the north wall of the quarry. Steeply-inclined, nearly-vertical, and overturned beds dominate the south face of the quarry (Fig. 5).

The author proposes that the structural setting of the Tripoli Quarry represents a carbonate mound facies of the lower Hopkinton Formation. Some dipping beds in the 10 to 40 degree range may reflect original depositional slopes, with later enhancement of inclinations by compaction processes. The more steeply-inclined units on the south face of the quarry probably represent post-depositional compaction and slumping. The origin of the structural complexity found in the Tripoli Quarry is not completely resolved; it may involve slumping of beds and rotation of blocks over a carbonate mound (or mounds) with complex original geometry. Look around and see what you can figure out!

Brian J. Witzke constructed a relative sea-level curve for the Silurian sequence of eastern Iowa (Fig. 6). Five transgressive-regressive cycles are associated with Iowa's Silurian. The Hopkinton Formation was deposited during the second Silurian T-R cycle; it represents open-marine deposition with well-oxygenated bottom waters (Witzke, 1992).

Carbonate mounds occur in the Scotch Grove and Gower formations of eastern Iowa. The Scotch Grove and Gower mounds are usually associated with intervals of deepening of the seas (Fig. 6). Although no carbonate mounds have been recognized previously in the Hopkinton Formation of Iowa, the depositional setting of the formation does not rule out the possibility of mound development. Note that two cycles of deepening occur within the

PAUL NIEMANN CONSTRUCTION COMPANY'S
TRIPOLI QUARRY, BREMER COUNTY, IOWA
SW SEC. 36, T. 93 N., R. 13 W.



t. = tabulate corals
st. = stromatoporoids
p.b. = pentamerid brachiopods
Δ = chert

lower Hopkinton Formation

NW corner of quarry
10-1-95

"UNIT A"
DOLOMITE: grayish orange; med. crystalline; thick bedded; solution molds of fossils, including crinoid columnals, horn corals, and others; fossiliferous with abundant tabulate corals and laminar stromatoporoids; fractured.

"UNIT B"
DOLOMITE: grayish orange; med. crystalline; thick bedded; solution molds of fossils; fossilferous with abundant pentamerid brachiopods, also tablulate corals and laminar stromatoporoids; fractured.

"UNIT C"
DOLOMITE: lt. grayish orange; fine to med. crystalline; white to light gray chert beds and nodules; med. bedded; dense and less porous than units "A" and "B"; silicified fossils, but less fossilferous than units "A" and "B".

Figure 4. A diagram showing the structural configuration and lithologic composition of the Hopkinton Formation in the northwest corner of Niemann's Tripoli Quarry. Prepared by the author, October 1995.

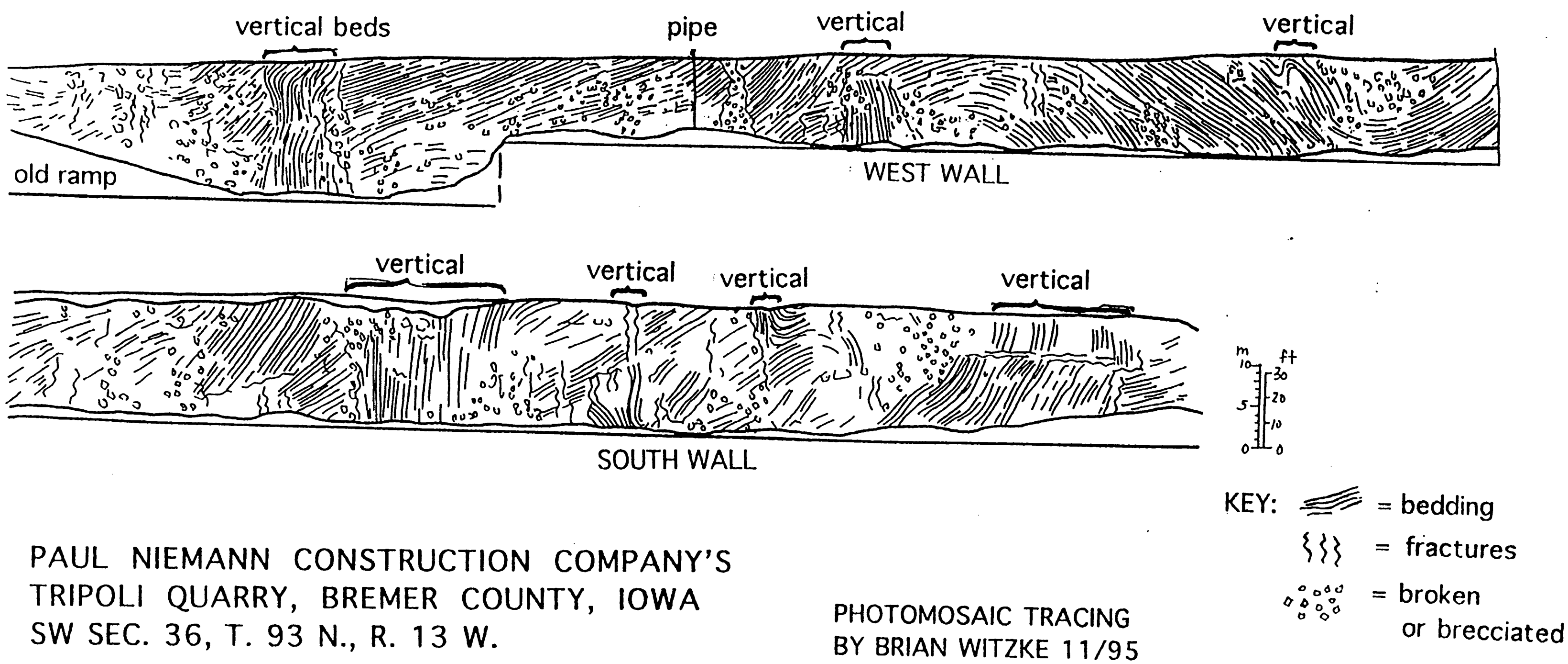


Figure 5. A diagram showing the structural relationships on the south and west walls of Niemann's Tripoli Quarry. Prepared by Brian J. Witzke from a photomosaic tracing, November 1995.

interval when the Hopkinton Formation was laid down (Fig. 6).

Markes E. Johnson (1988) provided estimates of depths in the Silurian seas based on the occurrences of benthic fossil communities. According to Johnson, the Pentamerid Brachiopod Community was associated with water depths of 30-60 meters and the Coral-Stromatoporoid Community corresponded to water depths of 10-30 meters. Pentamerid brachiopods are common in the Tripoli Quarry, as are tabulate corals and stromatoporoids. If Johnson's estimates for water depths are correct and applicable to this locality, we can conclude that the strata in this quarry formed in a sea that may have ranged from as shallow as 10 meters to as deep as 60 meters.

CARBONATE MOUNDS

Carbonate mounds are well documented in the Scotch Grove and Gower formations of Iowa's Silurian (Fig. 3), but this is the first description of such features in the Hopkinton Formation of our state. Carbonate mounds ("coral bioherms") were previously described by Philcox (1970) and assigned to the Hopkinton Formation. However, these deposits are now recognized as part of the Scotch Grove Formation (Witzke, 1985).

The following points about Silurian carbonate mounds are summarized from Witzke (1992):

1) Eastern Iowa contains the westernmost exposures of carbonate mounds within the Midwestern "reef" belt.
2) Silurian carbonate mounds in Iowa and elsewhere in the Midwest have been described by a variety of terms such as "reefs", "mounds", "buildups", "bioherms", and "clinothems".
3) If the term "reef" is used in a genetic sense to suggest a wave-resistant feature with a rigid organic framework, then it is inappropriate terminology for the Silurian mounds of Iowa.
4) The carbonate mound facies in Iowa's Silurian are dominated by carbonate mud fabrics, with no evidence of an organic framework.
5) Although corals are present in the Silurian carbonate mounds of Iowa, they are insignificant components compared to carbonate mud and to other skeletal grains and skeletal debris (especially crinoids and brachiopods).
6) An ecological reef model based on modern coral reefs fails to explain the features found in the carbonate mounds of Iowa's Silurian.
7) The Lower Carboniferous Waulsortian mounds of North America and Europe (Wilson, 1975) have several features in common with the Silurian mounds of Iowa and the Midwest, namely:

a) central mounds dominated by lime muds which display skeletal mudstone and wackestone textures.;
b) the presence of skeletal debris of crinoids, with scattered corals, brachiopods, and other fossils;
c) mounds that lack an organic framework;
d) mounds that are surrounded by inclined beds (5-50 degrees), with some slump features;
e) the occurrence of submarine cements and the suggestion of early lithification;
f) mounds that display a wide variation in scales, ranging between 3-150 meters in height with lateral dimensions of 60 meters to 3 kilometers;
g) mounds that often display a simple "haystack" geometry, although complex growth forms and bank facies are also known;
h) mounds that have been interpreted as forming below fair-weather wave base. (According to Byers and Dott (1995), fair-weather wave base in modern marine settings varies from as little as 20 meters to more than 70 meters.)

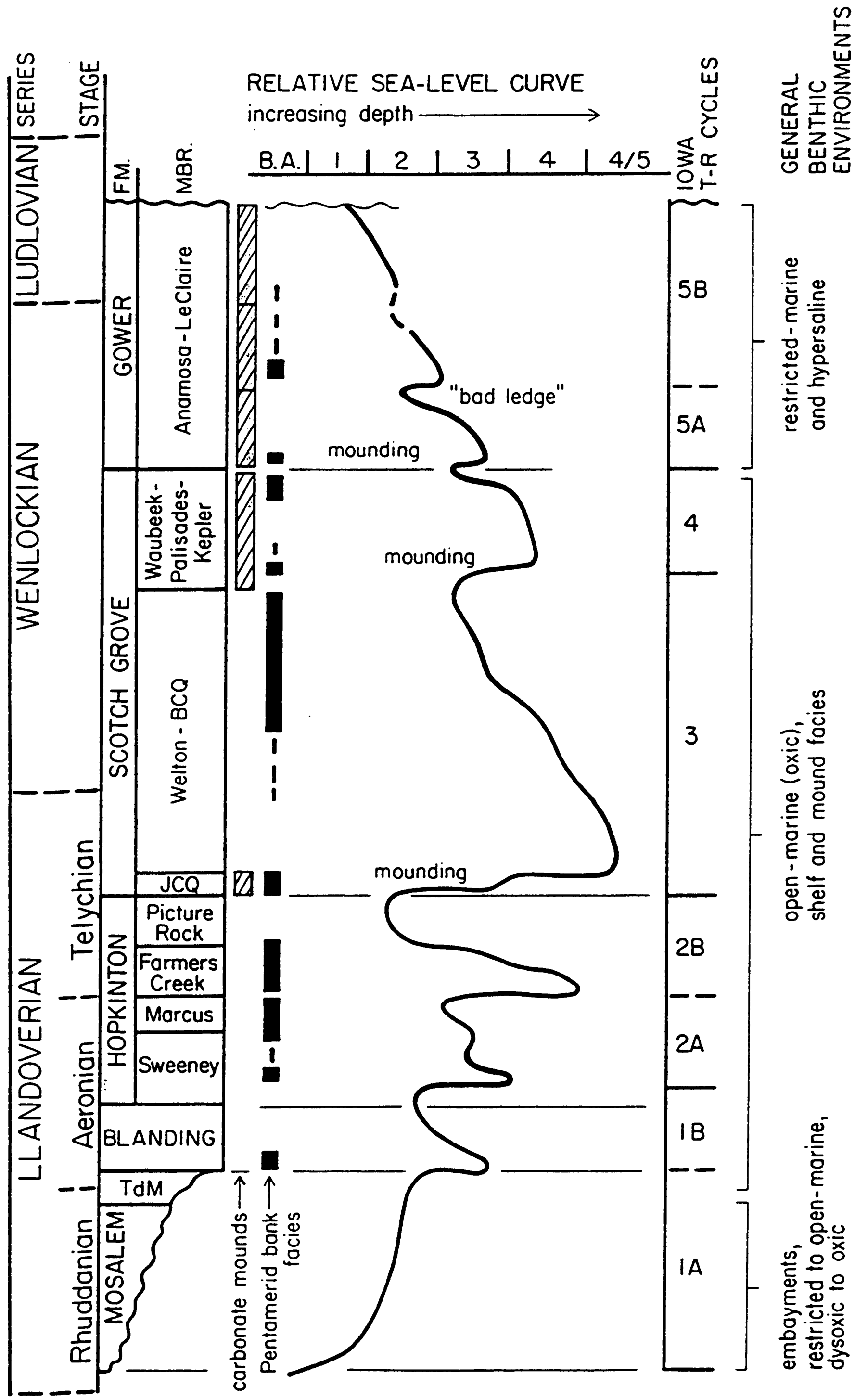


Figure 6. A sea-level curve for the Silurian sequence of eastern Iowa. Note the presence of carbonate mounds in the Scotch Grove and Gower formations. Strata in the Tripoli Quarry are interpreted by the author as a carbonate mound facies within the lower Hopkinton Formation. (Witzke, 1992).

ACKNOWLEDGEMENTS

Brian Witzke and Bill Bunker, Geological Survey Bureau of the Iowa Department of Natural Resources, spent time with me in the Tripoli Quarry on a cold November day in 1995. I acknowledge their discussions and insights. Brian Witzke provided the drawing of the structural relationships on the south face of the quarry (fig. 5). Wendell Dubberke, Iowa Department of Transportation, first called the quarry to my attention and provided background information. Timothy D. Schroeder completed an undergraduate research project in 1994 involving exposures in the Tripoli Quarry.

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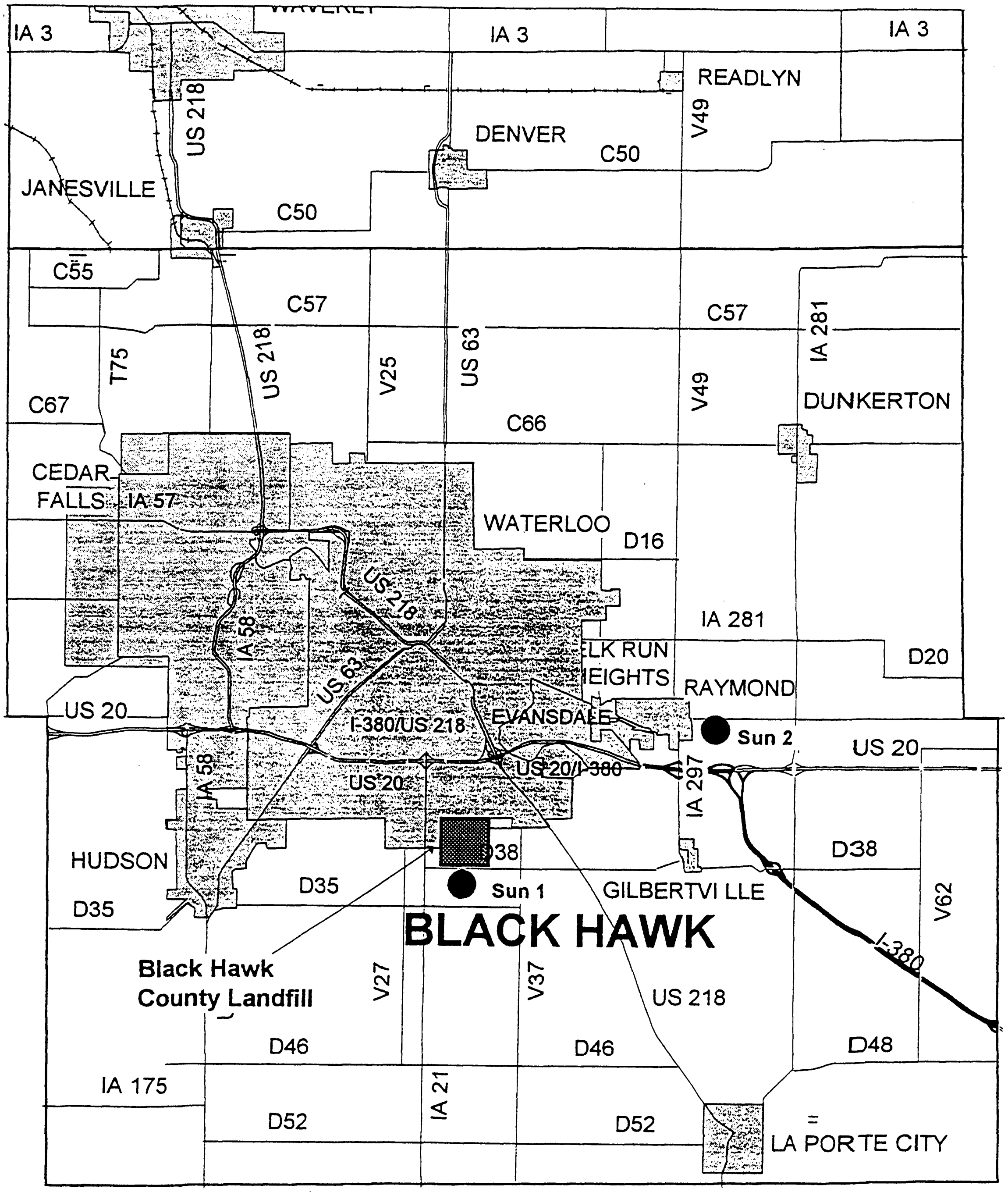
SUNDAY

MORNING

STOPS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DUNKERTON
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CEDAR FALLS
IA 57
WATERLOO
D16
US 218
IA 281
IA 58
ELK RUN HEIGHTS
D20
US 63
RAYMOND
US 20
I-380/US 218
EVANSDALE
Sun 2
US 20
IA 58
US 20/I-380
US 20
IA 297
D38
D38
HUDSON
D35
Sun 1
GILBERTVILLE
V62
D35
BLACK HAWK
I-380
Black Hawk County Landfill
V27
V37
US 218
D46
D46
D48
IA 175
IA 21
D52
D52
LA PORTE CITY

STOP 1: BLACK HAWK COUNTY LANDFILL

Melissa Harbaugh-Adams and Robert Sullivan
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University of Northern Iowa

INTRODUCTION

In today's society there is an ever increasing need for the environmentally safe methods for the disposal of waste material. Black Hawk County manages wastes using a variety of methods including recycling, composting, landfilling, and waste water treatment; however, waste disposal is a continuing problem.

HISTORY

In the past, people frequently dumped their unwanted materials in low lying, often damp areas. These areas were generally considered undesirable because they were not suitable for agriculture or development. This was also the practice in the Cedar Falls/Waterloo area. Many of these makeshift dumps were located in low lying areas along the Cedar River, such as ditches, old limestone quarries, and abandoned sand pits. The Mitchell sand pits, next to the Cedar River, is an example of an old dumping site. This practice of indiscriminate dumping poses a potential environmental hazard. During periods of high water and flooding, water frequently infiltrates these dumps, carrying leachate and even washing waste materials down stream. These unlined dumps also pose a threat of groundwater contamination by leaching.

These concerns led to the development of modern sanitary landfill technology. Construction of the original Landfill Service Corporation landfill began in 1974 by Peterson Contractors and Lockard Realty and Construction. In 1975, the landfill officially opened to accept hazardous and municipal waste.

Landfill Services Inc. collected hazardous waste between the years of 1975 and 1985 (Versar Inc., 1987). Taking in hazardous waste is more profitable than municipal waste; hazardous waste disposal can cost up to $200.00 per ton, municipal waste only $2.50/ton. Landfill Services Inc. proposed to expand the hazardous waste operations to include all of the Midwest (Bartlett et al., 1995). Opposition to this proposal by the residents of Black Hawk County let to a referendum in which the residents voted for the county to buy the landfill. The Black Hawk County landfill was subsequently purchased by the local government for $2.2 million dollars in 1985, and the acceptance of hazardous waste discontinued (Wilcox, 1996).

GEOLOGY AND HYDROLOGY

The Black Hawk County landfill is located on 160 acres of land south of Waterloo one mile east of Highway 21, and is southwest of the Cedar River. The site for the landfill was selected based on both its geology and its semi-central location in the county. The site is located on a physiographic province called the Iowan Surface. Unconsolidated materials at the site are dominantly glacial till overlain by approximately 3 feet of loamy sediments. Low lying areas may include coarse to fine grained alluvium (Versar Inc., 1987).

The thickness of the glacial till is approximately 100 feet and with an estimated permeability of 10^{-8} to 10^{-9} centimeters per second (Versar Inc., 1987). The thickness and low permeability of the till slows leaching into the groundwater of the underlying bedrock aquifer, and clay minerals in the till adsorb heavy metals such as chromium and lead leached from the collected garbage (Wilcox, 1996). The underlying bedrock is the Middle Devonian Cedar Valley Group, which serves as a regional aquifer. The unit consists of argillaceous dolomite underlain by 45 to 70 feet of fossilferrous limestone and dips to the southeast (Versar Inc., 1987). For a more detailed description on the bedrock geology of the landfill see Figure 1.

According to Versar Inc. (1987), the stratigraphy at the landfill site produces two groundwater flow regimes. The first of these flows is a perched water table which occurs in the loam/alluvium overlying the slowly permeable glacial till. Within the perched water regime, the water generally flows along surface contours to the east-southeast. The perched layer is more pronounced in the low lying areas where alluvium is thickest. This shallow flow may not be present in other portions of the site (Versar Inc., 1987).

The second of these groundwater flow regimes is the Cedar Valley Aquifer, the predominant source of water for most people in the Cedar Falls/Waterloo area. The general groundwater flow in this aquifer is east-northeast toward the Cedar River. The groundwater is somewhat mineralized and contains moderate concentrations of sulfate and trace concentrations of numerous other minerals and is considered "hard" (Versar Inc., 1987). The perched water table is affected by seasonal fluctuations, but the Cedar Valley Aquifer is relatively stable (Versar Inc., 1987)

Groundwater is susceptible to contamination by landfill leachate. Therefore, the Black Hawk County landfill utilized 56 monitoring wells at various depths to monitor any water contamination. Shallow monitoring wells range from 15-20 feet deep, intermediate wells range from 40-50 feet, and the deepest wells reach to 80 feet, into the bedrock. Each year $125,000.00 is spent on testing water from these monitoring wells for contaminants. Water samples are analyzed only every six months because they have tested within groundwater regulations. For a more details on the groundwater at the landfill, see Figures 2 and 3.

LANDFILL TECHNOLOGY

The Black Hawk County landfill is situated in an agricultural area with higher land elevation (940 feet above mean sea level) to the northwest and lower land elevation (900 feet above mean sea level) to the southeast (Versar Inc., 1987). Although there are some field tiles on the site, surface runoff is generally discharged via the waterway running through roughly the middle of the site. Most of the tiles were installed prior to construction of the landfill to maximize the farmability of the land. The surface waters eventually empty into the Cedar River.

A trench 25-30 feet deep and 3 feet wide was dug and a slurry wall composed of a till and bentonite mixture, was installed paralleling the eastern border of the landfill in 1975 as a barrier to the migration of leachate from the site (Versar Inc., 1987). Along with the construction of the slurry wall, a neutral trench was constructed as a disposal cell for industrial haazardous waste. It consisted of a clay liner and had three rock-filled trenches containing collection pipes. The collection pipes were tied into a raster pipe manhole from which leachate was collected for eventual discharge to the sanitary sewer (Versar Inc., 1987).

The waste materials are placed in a series of cells, which consist of large excavated pits with multiple protective layers. The basal protective layer is 40 feet of glacial till with crushed rock on the top of it. The crushed rock layer acts as a ground water interception layer that prevents outside water from entering the cell. Four feet of clay-rich material with a permeability of 1×10^{-7} is layered on top of the crushed rock layer. Finally there is one foot of sand which is used to collect leachate. The leachate is continuously pumped out of the sand and sent to the Waste Water Treatment Center in Waterloo.

About 400 tons of garbage is added to the landfill each day. It is compacted by heavy tractors passing over it a minimum of 3-5 times. The garbage weighs about 300-600 pounds per cubic yard when it arrives and is normally compacted to a density of at least 1,200-1,400 pounds per cubic yard (Wilcox, 1996), although it could potentially be compacted as dense as 1600-1800 pounds per cubic yard (Bartlett et al., 1995).. The current policy is to cap the cells with 2 feet of compacted glacial till and 2 feet of soil. The compacted till layer prevents precipitation from entering the waste and the soil layer is for the growth of vegetation (Bartlett et al., 1995).

For the following information, see Figure 4.

Area 'A' on Figure 4 has been closed since 1980. At the time of closing the common practice was to cap the cell with fill dirt. The Co-Disposal area 'F' is also closed, but is capped with a synthetic plastic liner and four feet of clay. The capping also has a drainage system, which will help in keeping the rain water out of the cell. Area 'C' is also closed and was capped using procedures similar to area "F". Figure 4 also shows the current cell area and the positions of future development.

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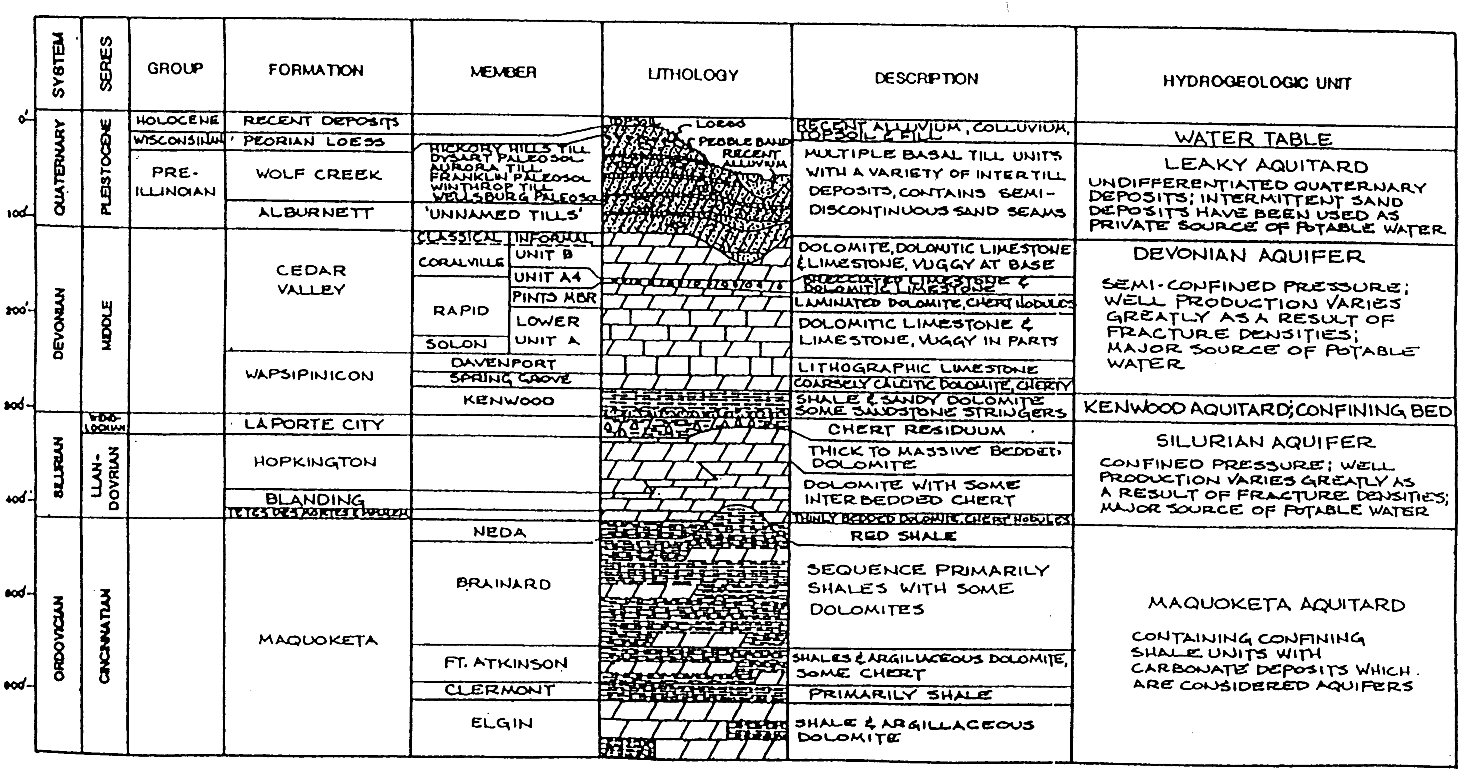

Figure 1. Geologic profile of the Black Hawk County Landfill (Donohue Engineers, 1990).

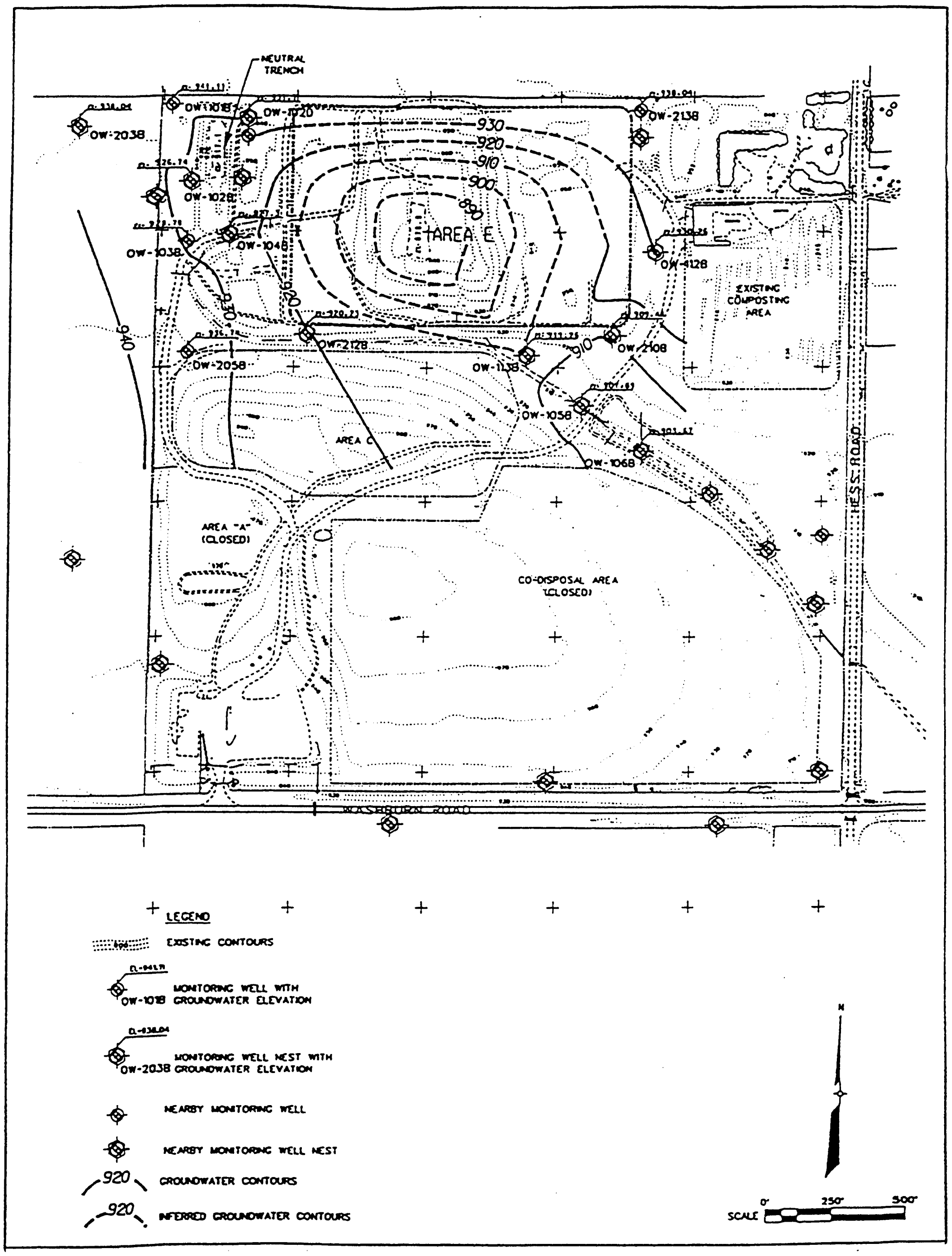

Figure 2. Groundwater contour of Black Hawk County Landfill (Versar, 1987).

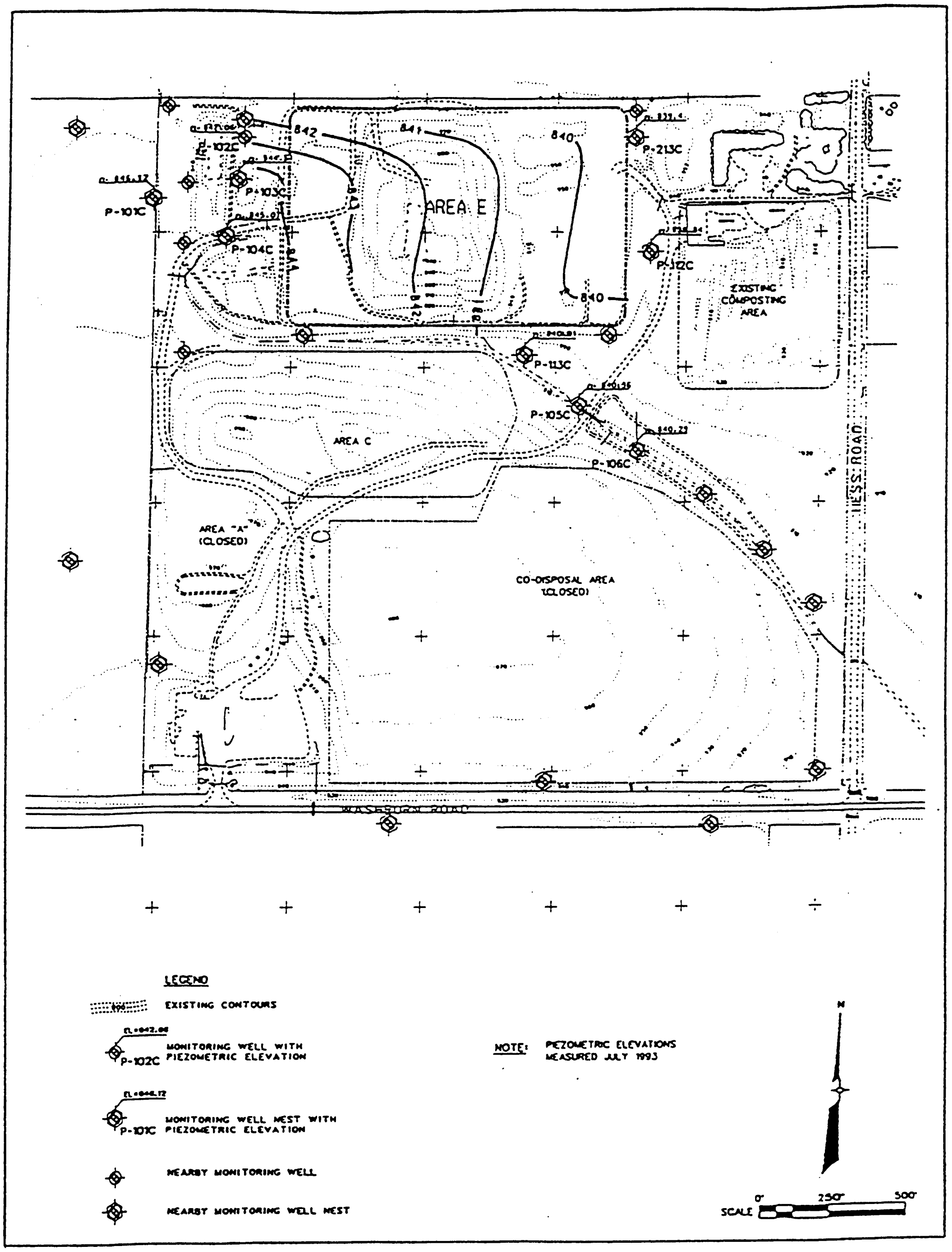

Figure 3. Piezometric surface of Black Hawk County Landfill (Versar, 1987).

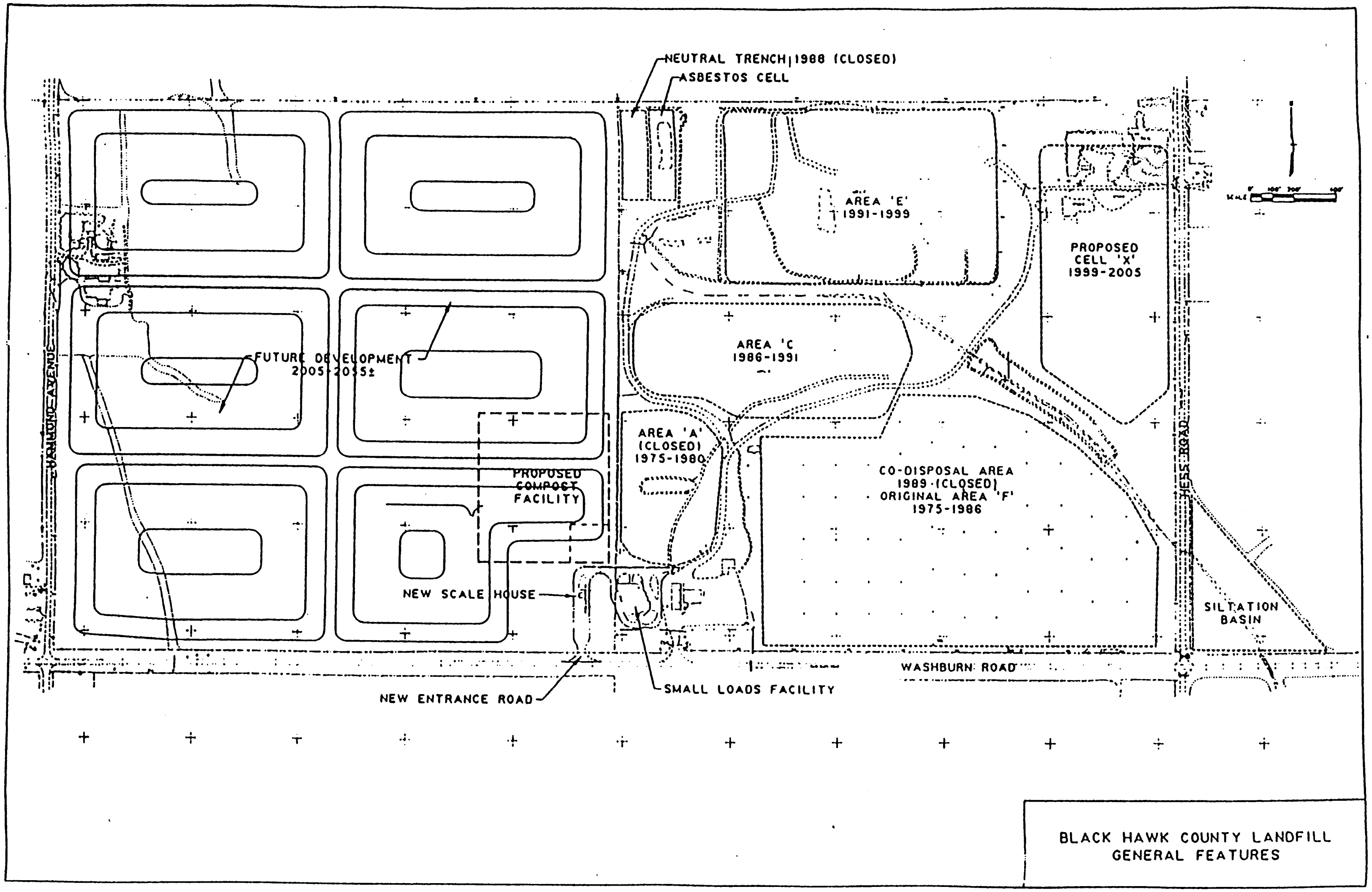

Figure 4. General features of Black Hawk County Landfill (Wilcox, 1987).

The following newspaper article is reprinted with permission.

Waterloo/Cedar Falls Courier June 12,1996

'Nicest dump in the state'

County landfill improvements make things easier for users

GREG BROWN / Courier Staff Photographer

Sean Duggan shovels debris from his truck into a metal container at the county's new small-load facility at the county landfill.

By CARI NOGA
Courier Staff Writer

WATERLOO

With the completion of a $500,000 capital improvement project earlier this month, Black Hawk County's landfill might almost be called swanky — as landfills go.

On June 1, a new vehicle scale became operational at the landfill. It replaces one in use since the landfill opened in 1974, and complements the new "small load" facility in use since last November.

"It's going to be the nicest dump in the state," said Gary Wilcox, county Solid Waste Commissioner.

With the two additions, landfill users can weigh their vehicle loaded, unload it without going into the "hole," as the landfill is known, and weigh out empty, all without leaving hard surface roads.

The small-load facility serves more than half the landfill users. Located next to the scale, it saves people the half-mile drive over pothole-prone, muddy roads back to the landfill. It consists of 10, 30-cubic-foot capacity bins placed around a platform-like area. Users can back up to the bins, open the gate of the pickup or trunk of the car, and shove the rubbish into it.

"You really don't have to lift anything more than a foot or so to get rid of it," Wilcox said.

"It beats the crap out of trying to drive through the dirt mountain range," said Steve Petersen of Waterloo, who was at the facility Monday dumping material from his old garage.

Petersen said he uses the landfill three or four times a year, and estimated the chance of getting stuck on the muddy road at 1 in 3.

"It's a lot better. You can pretty much back right in. Kind of convenient," agreed Sean Duggan of Waterloo, who lays floors and makes a trip to the landfill once every couple of weeks. "Makes it easier for the little guy."

The small-load facility also increases convenience for the big guys — commercial haulers — because they aren't backed up at the landfill by small load dumpers any longer.

Also, the system helps reduce waste. Since everything is sorted before transporting to the landfill, recyclable materials, such as metal, can be salvaged.

Wilcox said the Dubuque landfill has a similar system, but it is not as large or convenient as Black Hawk County's.

"I think you will start to see other landfills start picking up on it," he said.

STOP 2: THE LITTLE CEDAR AND CORALVILLE FORMATIONS (DEVONIAN) AT BASIC MATERIALS CORPORATION'S PESKE QUARRY, RAYMOND, IOWA

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Cedar Falls, Iowa 50614

INTRODUCTION

During Middle and Late Devonian time, the epicontinental seas over ancient Iowa produced a repetitive sequence of deposits. These Devonian deposits in Iowa and adjacent states formed in an area termed the Midcontinent Carbonate Shelf (Fig. 1). As shown in Figure 1, Inner Shelf Environments were characterized by peritidal (including mudflat deposits, evaporites, breccias, and intraclast conglomerates) and shallow subtidal facies. Thin transgressive marine carbonates also occur. Middle Shelf Environments were dominated by subtidal, open-marine carbonates displaying mud-supported textures. Common deposits of the Middle Shelf setting included carbonate mudstones with fossils and fossil debris, along with fossiliferous wackestones and packstones.

THE CEDAR VALLEY GROUP

The basic stratigraphic framework of Iowa's Devonian Wapsipinicon and Cedar Valley groups is understandable in terms of carbonate T-R cycles (Witzke et al., 1988). Figure 2 shows a qualitative sea-level curve based on interpretations of the depositional environments of Iowa's Devonian formations. A typical T-R cycle in the Cedar Valley Group began with a basal fossiliferous interval that marked open-marine deposition. These transgressive deposits are capped by facies of the regressive or progradational phase of the cycle. Such deposits reflect shallow-marine, restricted-marine, and tidal-flat settings. The regressive deposits are labeled peritidal facies on Figure 3. Peritidal refers to depositional environments in a zone ranging from above the highest storm tides to somewhat below the level of the lowest tides.

The Cedar Valley Group, previously a formation, was elevated to group status by Witzke et al. (1988). Four formations comprise the Cedar Valley Group. In ascending order, the formations are Little Cedar, Coralville, Lithograph City, and Shell Rock (Fig. 3). Each formation corresponds to a T-R cycle of deposition, and each is separated from adjacent formations by a discontinuity or erosional surface.

THE LITTLE CEDAR AND CORALVILLE FORMATIONS AT PESKE QUARRY, RAYMOND, IOWA

We will view the Little Cedar and Coralville formations at Peske Quarry, near Raymond, Iowa (Fig. 4). The Little Cedar and Coralville formations were deposited during T-R cycle IIa. See Figure 2 from Witzke et al. (1988).

Figures 5 and 6 show the stratigraphic section exposed at Peske Quarry. Beds of the Eagle Center Member of the Little Cedar Formation are interpreted as open-marine deposits. The Hinkle Member reflects a shallower, more-restricted, peritidal setting. The Coralville Formation consists of the basal Gizzard Creek Member of open-marine origin and the overlying Iowa City Member, preserving the record of ancient peritidal environments.

A variety of fossils can be collected or observed at this locality (Fig. 5). Stromatolites, the products of sediment trapping, binding, and /or precipitation on the surfaces of cyanobacteria (blue-green algae), are well developed in the Coralville Formation. Structures in unit 3 of the Little Cedar Formation are labeled "wavy stromatolites" on Figure 5. Similar structures were noted in nearby Pint's Quarry by Kettenbrink (1972); he interpreted the "ripple-like" features as the product of soft-sediment deformation. See bed 15 of Figure 7. Examine these structures and see what you think!

Unit 15 in the Coralville Formation (Fig. 5) contains a prominent stromatoporoid biostrome with both hemispherical and digitate stromatoporoids. Stromatoporoids, sponge-like organisms, were important constituents of Iowa's Silurian and Devonian seas, and their remains are common in laterally-extensive blanketlike masses of rock known as biostromes.

Pint's Quarry, no longer in operation, was noteworthy for containing a variety of choice mineral specimens, including handsome crystals and crystal aggregates of fluorite, marcasite, pyrite, and calcite (Anderson and Stinchfield, 1989). Sphalerite and barite, and rare galena provided additional interest. Peske Quarry reveals some calcite-lined vugs, but, overall, it lacks the mineral variety displayed at Pint's Quarry. Figure 7, based on the undergraduate research of Steve Bennett, shows the stratigraphic section at Pint's Quarry with the nomenclature of Kettenbrink (1972) and the revised nomenclature of Witzke et al. (1988).

According to Sherman Lundy, geologist for Basic Materials Corporation, the Peske Quarry is one of the company's primary producers of aggregate. Between 100,000-170,000 tons of rock are produced here in a typical year, with amounts exceeding 200,000 tons during peak periods of road construction.

Units A-G (Fig. 6) are quarried for roadstone, as are other beds lower in the Coralville Formation. Beds in the formation below units A-G produce Class 2 concrete stone. The Little Cedar Formation is not a producing ledge as far as quarry products are concerned, although bed 16 of the Eagle Center Member (Fig. 6) can be made into roadstone.

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Sherman Lundy provided a stratigraphic log and lithologic descriptions for the Peske Quarry. Brian Witzke, Bill Bunker, Sherman Lundy, J. Korpel, and M. Whitsett measured the stratigraphic section at Peske Quarry on April 2, 1996. Their graphic section is used as Figure 5. Steve Bennett's undergraduate research work at U.N.I. provided helpful background. Jim Liljegren's term project on the Peske Quarry for Stratigraphy and Sedimentation in 1995 furnished additional insights. Bunker and Witzke (1992) served as a key source in the preparation of this article.

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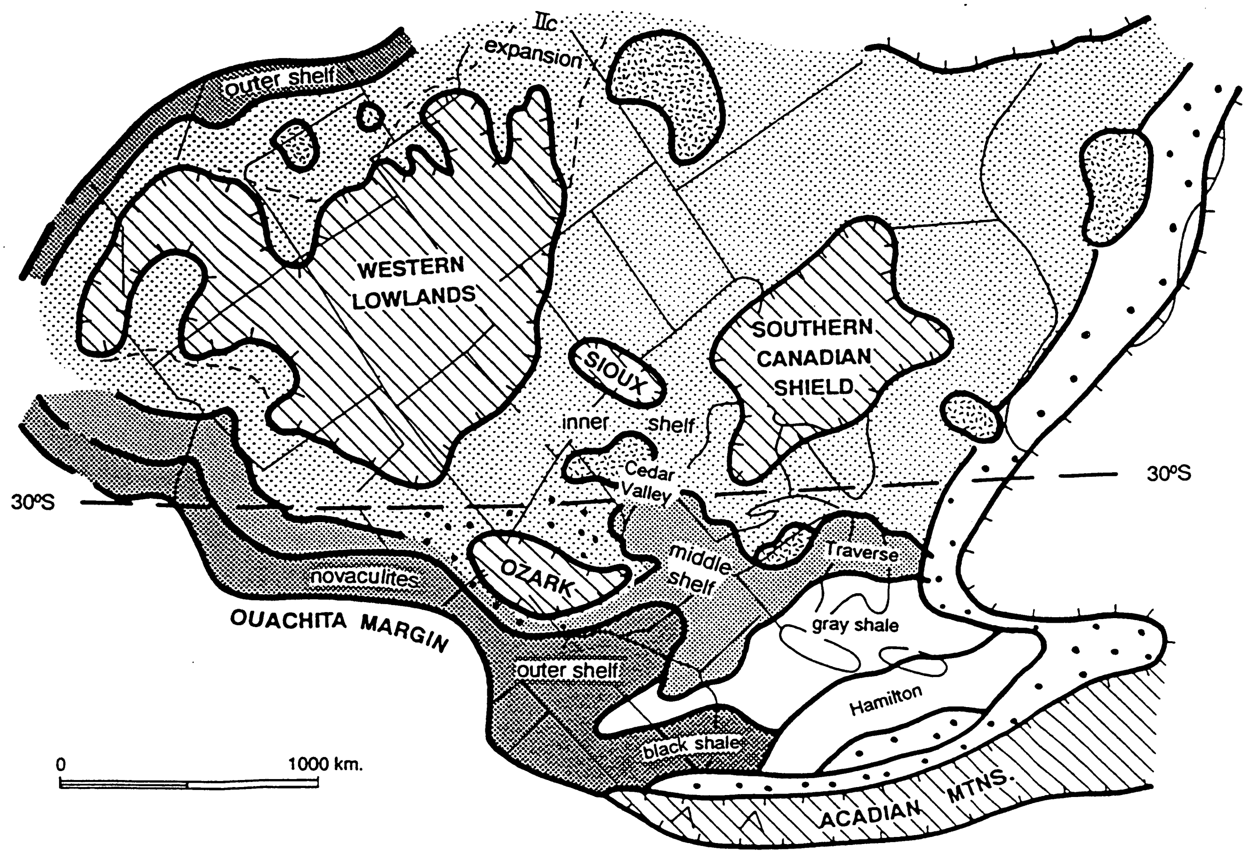


LATE GIVETIAN - EARLY FRASNIAN

Emergent land

Mountains

Eastern-derived clastics

Sandy

Evaporites (gypsum-anhydrite)

Inner shelf environments: peritidal and shallow subtidal facies (including mudflats, evaporites, breccias, and intraclasts); with thin transgressive marine intervals

Middle shelf environments: dominantly subtidal open-marine facies (including skeletal mudstones, wackestones, and packstones; part argillaceous)

Outer shelf environments: starved shale sedimentation; minor thin carbonates; locally phosphatic; novaculites

Figure 1. A paleogeographic map of the Midcontinent Carbonate Shelf during deposition of the Cedar Valley Group. From Bunker and Witzke (1992).

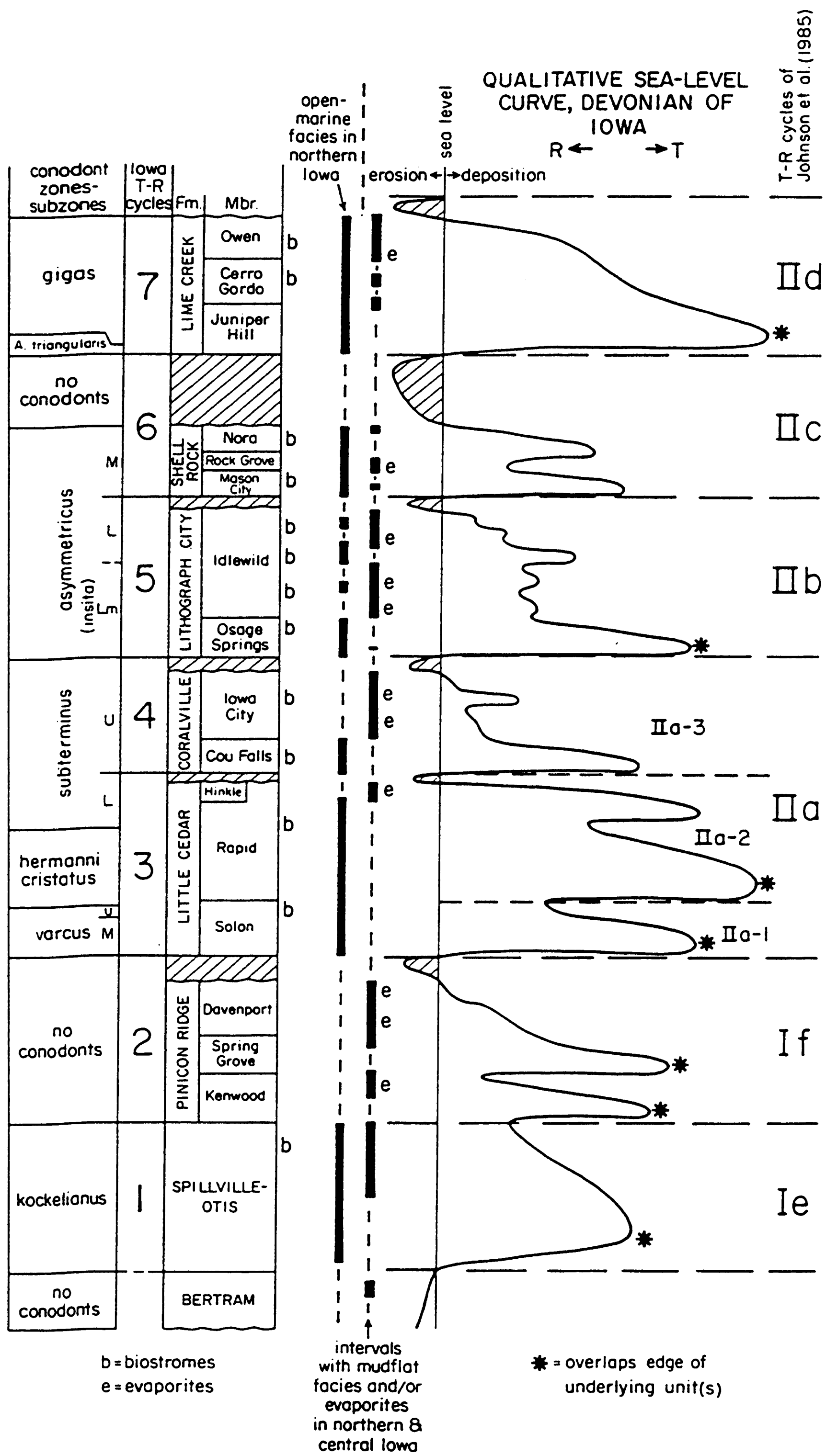


Figure 2. A qualitative sea-level curve interpreted from the Middle and Upper Devonian rock record of Iowa. Each of the four formations of the Cedar Valley Group records a single transgression-regression (T-R) cycle. The Little Cedar and Coralville formations of the Cedar Valley Group are exposed at Peske Quarry, near Raymond, Iowa. From Witzke et al. (1988).

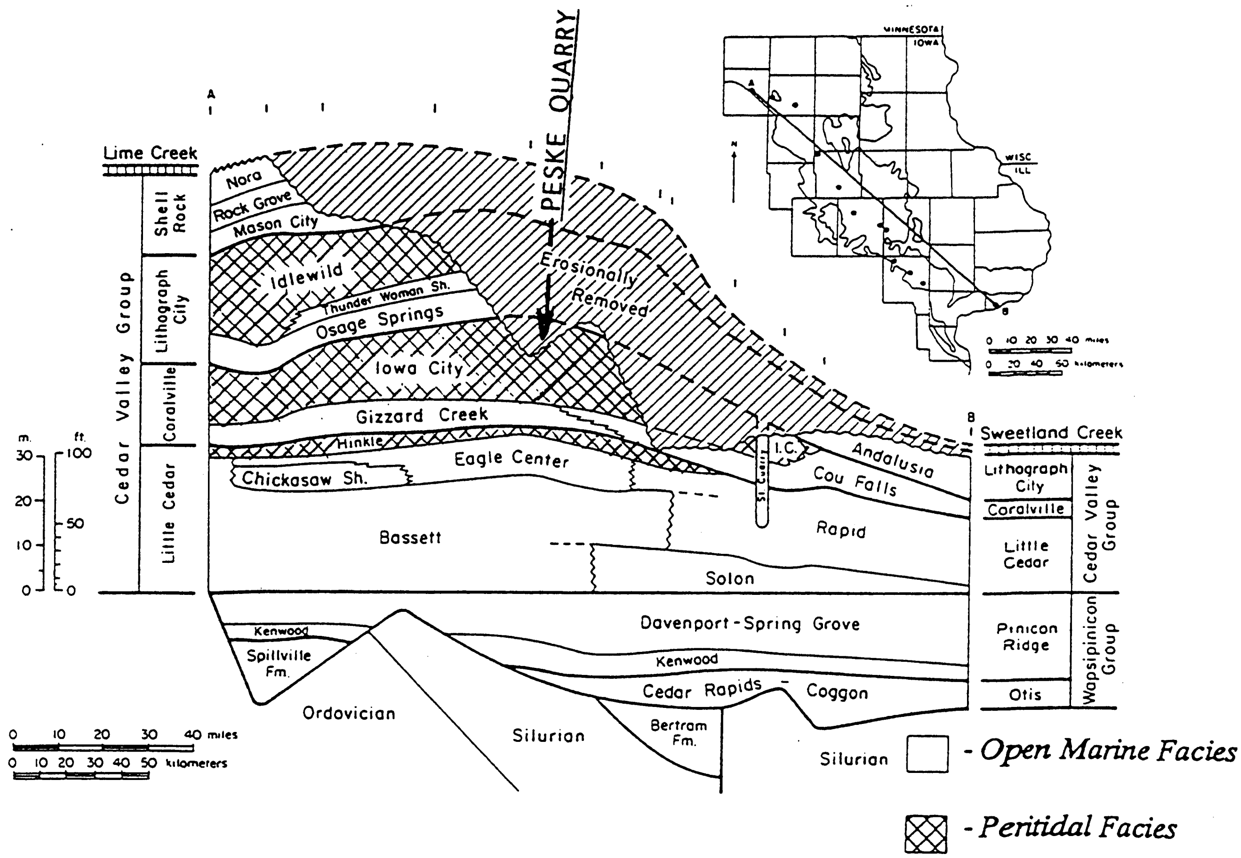


Figure 3. A regional cross-section of the Cedar Valley Group from north-central to east-central Iowa showing the occurrences of transgressive (open-marine) facies and regressive or progradational (peritidal) facies. Formations and members of the Cedar Valley Group are shown. Note the approximate location of Peske Quarry in eastern Black Hawk County with respect to the cross section. The Iowa City and Gizzard Creek members of the Coralville Formation are exposed at Peske Quarry, along with the Hinkle and Eagle Center members of the Little Cedar Formation. Modified from Witzke et al. (1988) and Plocher et al. (1992).

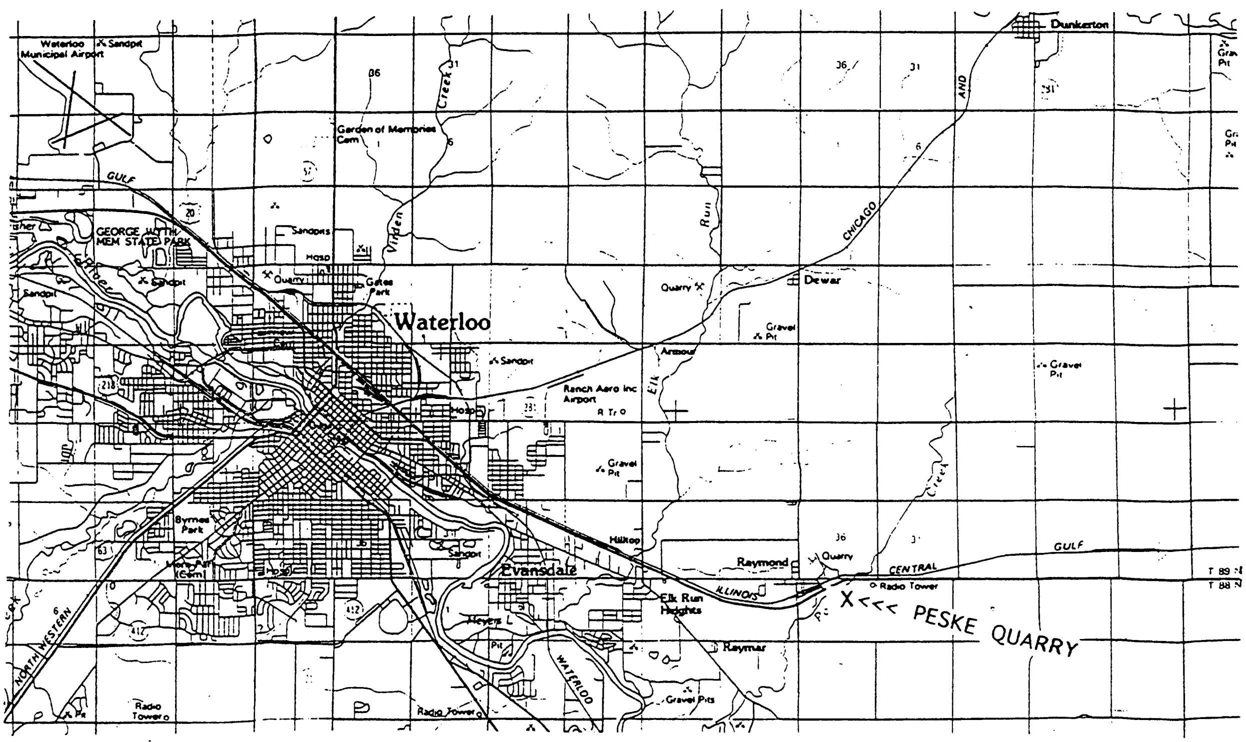


Figure 4. A location map for the Peske Quarry, sec. 2, T. 88 N., R. 12 W., Black Hawk County, Iowa.

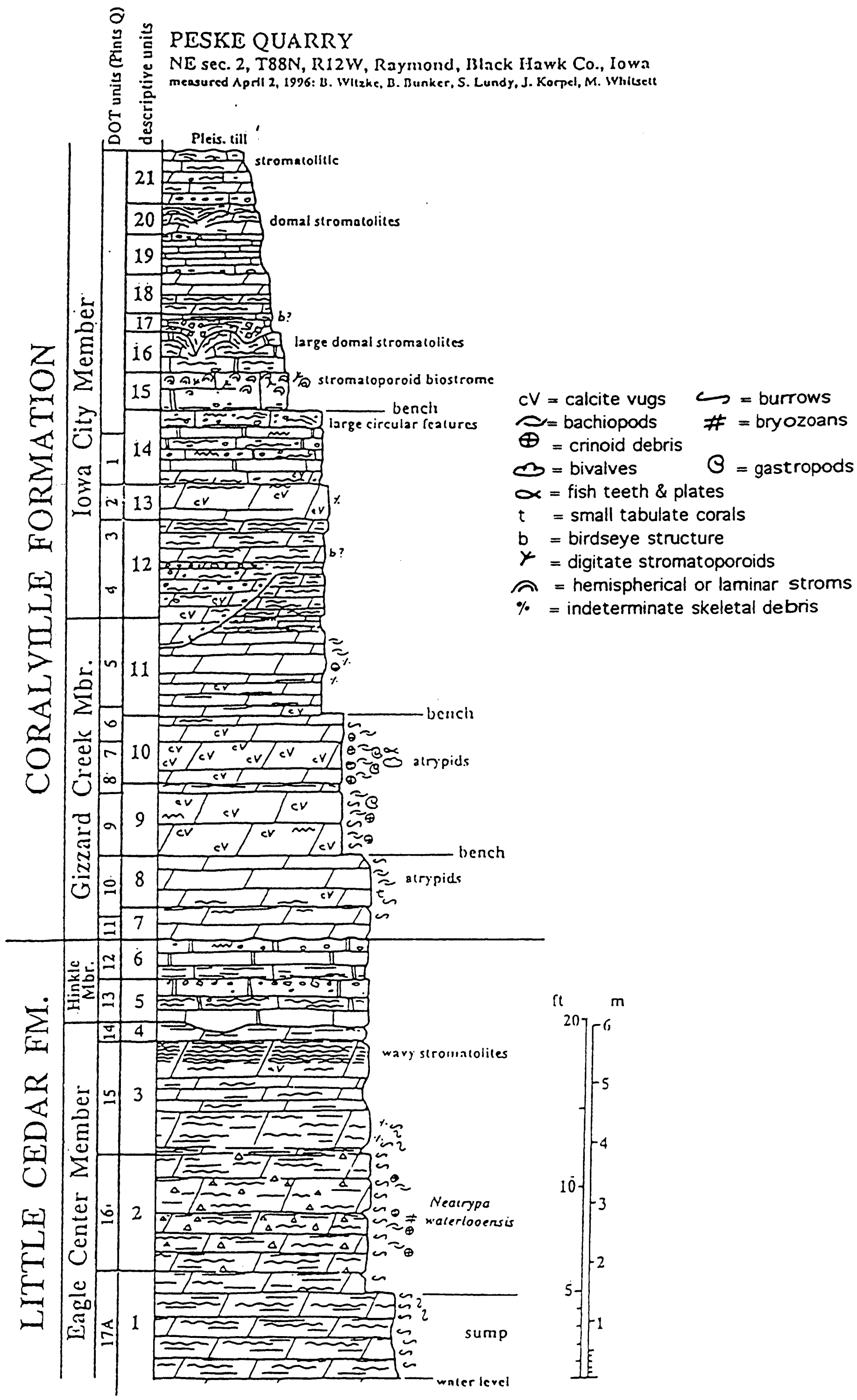


Figure 5. A graphic section of the Coralville and Little Cedar formations at Peske Quarry, near Raymond, Iowa. Stratigraphic section measured on April 2, 1996 by B. Witzke, B. Bunker, S. Lundy, J. Korpel, and M. Whitsett. Standard symbols depict composition and fossil content.

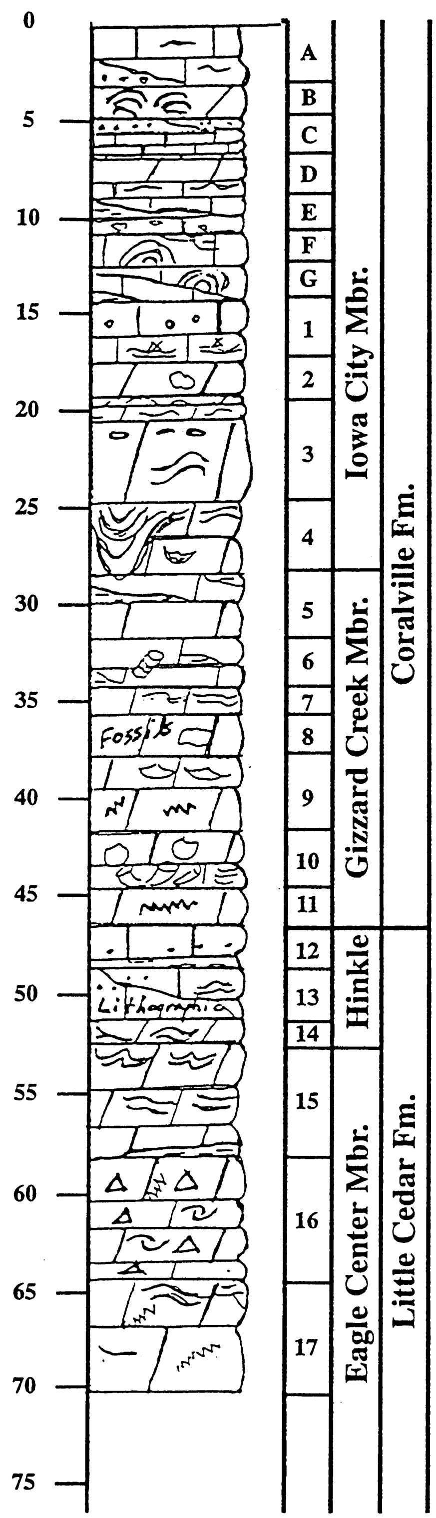


Figure 6. A graphic log of the Peske Quarry. Modified from the work of Sherman Lundy. Location: Sec. 2, T88N, R12W, Black Hawk County, Iowa. (Beds 16 and 17 are located in the sump of the quarry. The beds labeled A-G are above the "DOT" beds beginning with Bed # 1 of nearby Pint's Quarry).

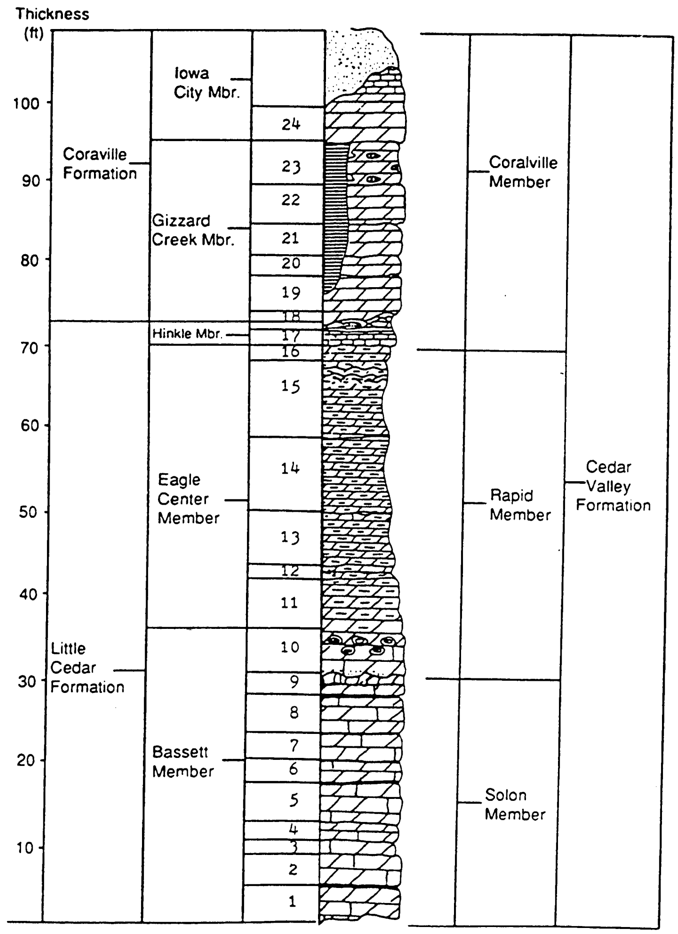


Figure 7. A lithostratigraphic section at Pint's Quarry, Raymond, Iowa. Revised nomenclature of Witzke et al. (1988) at left and earlier nomenclature of Kettenbrink (1972) at right. From Bennett (1988).

DESCRIPTION OF UNITS: PESKE QUARRY, RAYMOND, IOWA

(Modified from Lundy, 1996)

CORALVILLE FORMATION
IOWA CITY MEMBER

Bed		Lithologic Description	Thickness
A:	0-2.95'	**LIMESTONE:** Gray to yellow brown, fine-to- med. grained, thin/faint wavy laminations, dolomitic at top, intraclastic cgl. at base	2.95'
B:	2.95-4.59'	**DOLOMITE:** Yellow-brown, faint laminations in middle of unit, shaley intervals in top 8", large dome-shaped stromatolites	1.64'
C:	4.59-6.72'	**LIMESTONE:** Gray to lt. tan, brecciated and conglomeratic, "flagstone" appearance.	2.13'
D:	6.72-8.92'	**DOLOMITE:** Tan to yellow brown, intraclasts, faint irregular laminations, dolomitic limestone in lower 1.15".	2.20'
E:	8.92-10.4'	**LIMESTONE:** Gray, med. grained, argillaceous, laminated, brecciated, birdseye structure (?).	1.48'
F:	10.4-12.04'	**LIMESTONE:** Light brown, fine gr. to sublithographic, slightly argillaceous, faintly laminated, domed stromatolites.	1.64'
G:	12.04-14.07'	**LIMESTONE:** Fine grained to sublithographic, intraclasts and shale at base, biostrome of stromatoporoids in upper half of bed.	2.03'
1:	14.07-17.25'	**LIMESTONE:** Fine grained to sublithographic, laminated, stylolites in upper part, dolomitic in lower portion.	3.18'
2:	17.25-19.41'	**DOLOMITE:** Med. brown, very-fine grained, faintly laminated near top, calcite as void fills, indeterminate fossil molds.	2.16'
3a:	19.41-20.1'	**DOLOMITE:** With intraclasts and brown calcite "spots".	0.69'
3b:	20.1-24.72'	**DOLOMITE:** Light brown and faintly laminated in lower 2.2', with dark gray mottling and birdseye structure in upper 2.3'.	4.62'
4:	24.75-28.19'	**DOLOMITE:** Fine grained, calcitic and fossiliferous, scattered calcite-filled voids, 2.1' "cut out" at the base.	varies from 1.62-2.

GIZZARD CREEK MEMBER

Bed		Lithologic Description	Thickness
5a:	28.19-29.1'	**DOLOMITE:** Brown, very-fine grained, thin bedded, dark carbonaceous partings in lower portion of bed.	0.91'
5b:	29.1-31.63'	**CALCITIC DOLOMITE** in lower half and **DOLOMITE** in upper half, skeletal fossils, brown "spots", mottling.	2.50'
6:	31.63-34.13'	**DOLOMITE:** Lt. Gray/brown, very-fine grained, scattered calcite-lined vugs, carbonaceous shale partings, crinoidal debris.	2.50'
7:	34.13-35.53'	**DOLOMITE:** Calcitic, fine grained, finely laminated at top, contains small vugs, less fossiliferous than underlying unit.	1.40'
8:	35.53-37.84'	**DOLOMITE:** Calcitic, fine grained, very fossiliferous, calcite vugs.	2.31'
9:	37.84-41.78'	**DOLOMITE:** Lt. brown to brownish gray, dark surface in upper portion of bed, finely crystalline, calcite vugs, fossiliferous with brachiopods and gastropods, burrows.	3.94'
10:	41.78-44.57'	**DOLOMITE:** Lt. brown to gray, fine grained, some voids filled with calcite, fossiliferous with brachiopods and tabulate corals, horizontal burrows.	2.79'
11:	44.57-46.37'	**DOLOMITE:** Lt. Brown/gray to green, dark mottling, fine grained, argillaceous in upper part, fine laminations at top, burrows.	1.80'

LITTLE CEDAR FORMATION
HINKLE MEMBER

Bed		Lithologic Description	Thickness
12:	46.37-48.53'	**LIMESTONE:** Lt. brown, sublithographic, intraclasts, stylolites near top of bed, shale seam at bottom.	2.16'
13:	48.53-51.06'	**LIMESTONE:** Rose/pink to brown, micritic to sublithographic, finely laminated in middle one third of the bed, brecciated toward the top.	2.53'

14: 51.06-52.11' **DOLOMITE:** Lt. Gray/brown, very-fine grained, calcitic, argillaceous partings in upper part, irregular upper surface with relief. .... **1.05'**

EAGLE CITY MEMBER

15: 52.11-58.41' **DOLOMITE**: Lt. brown/gray, fine grained, dark laminations, shaley seam in lower part of the bed, skeletal debris, subvertical burrows, stromatolitic near the top, starved ripples in lower part. .... **6.30'**

16a 58.41-61.62' **DOLOMITE**: Argillaceous, scattered chert nodules, subvertical burrows in lower 1.2' of the bed, wavy irregular laminations in lower part. .... **3.21'**

16b 61.62-64.45' **DOLOMITE**: Brown to brown/gray, slightly calcitic, scattered chert nodules, faint laminations, numerous calcite-filled vugs in lower 2.5', shaley partings near top, brachiopods and other fossils. .... **2.83'**

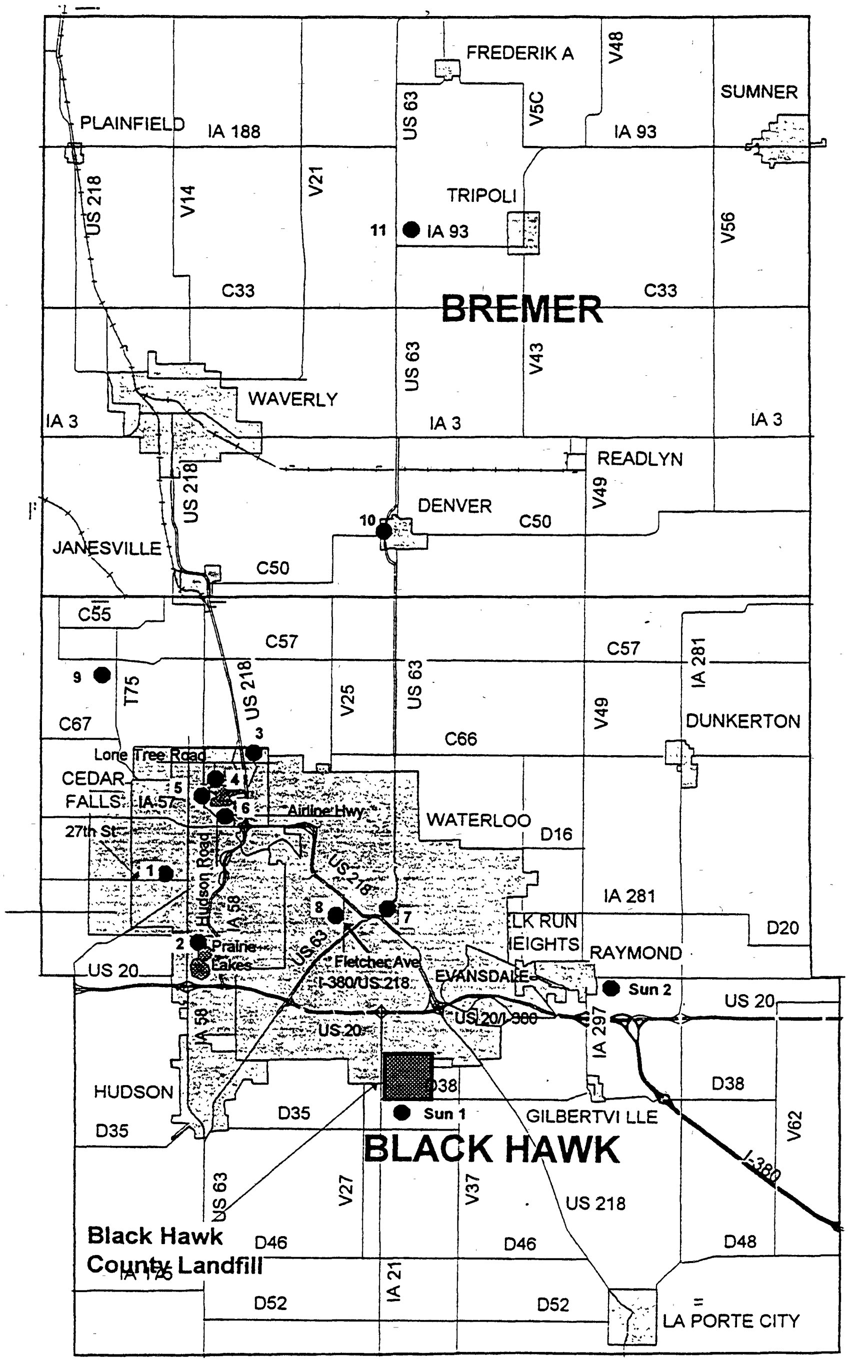
17A1 64.45-65.66' **DOLOMITE**: Lt. Brown, very argillaceous, fine laminations. .... **1.21'**

17A2 65.66-70.09' **DOLOMITE**: Slightly argillaceous and calcitic, irregular laminations, horizontal and vertical burrows. .... **4.43'**

Truth

How the devil do I know
if there are rocks in your field,
plow it and find out.
If the plow strikes something
harder than earth, the point
shatters at a sudden blow
and the tractor jerks sidewise
and dumps you off the seat -
because the spring hitch
isn't set to trip quickly enough
and it never is - probably
you hit a rock. That means
the glacier emptied his pocket
in your field as well as mine,
but the connection with a thing
is the only truth I know of,
so plow it.

James Hearst



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