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## Cooperative Hydrology Study COHYST Hydrostratigraphic Units and Aquifer Characterization Report

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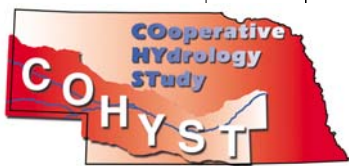
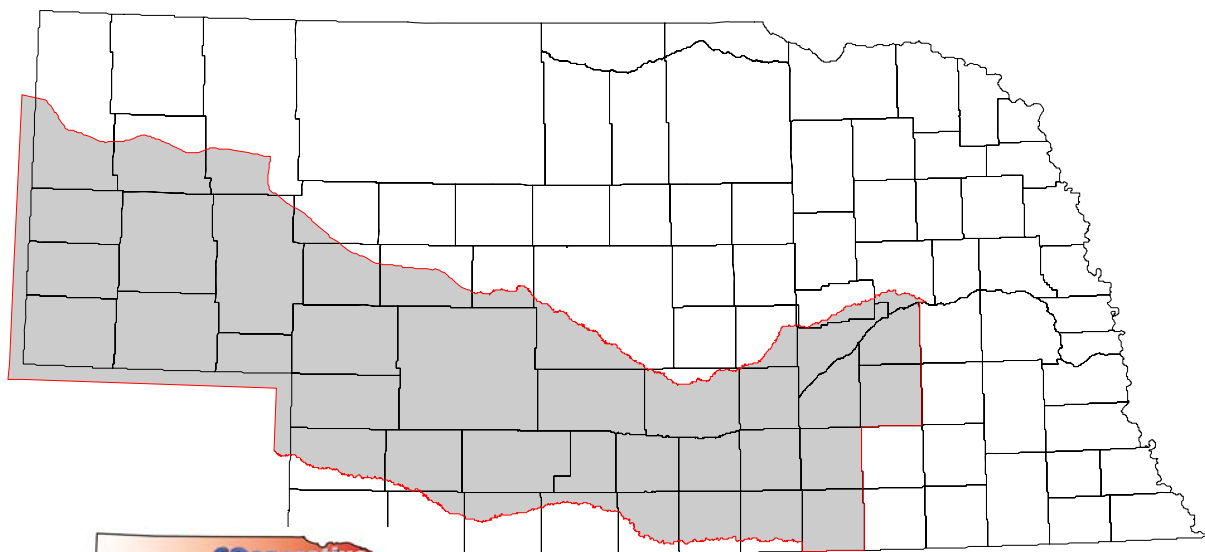
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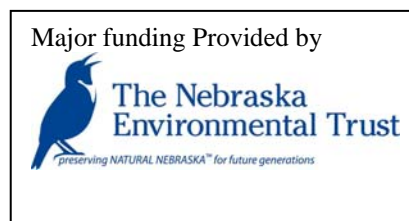
# Cooperative Hydrology Study COHYST Hydrostratigraphic Units and Aquifer Characterization Report

February 24, 2006



COOPERATIVE HYDROLOGY STUDY

JAMES C. CANNIA, DUANE WOODWARD AND  
LARRY D. CAST



## ACKNOWLEDGEMENTS

Special thanks go to a number of individuals who worked on developing the contents of this report. They contributed many man hours of work drilling test holes, reviewing well logs to select Hydrostratigraphic Units, writing computer programs to compute information, and developing GIS datasets. Those individuals include Clint Carney hydrogeologist for NPPD, Steve Peterson hydrogeologist for CNPPID, Richard Luckey hydrologist for USGS, Rich Kern engineer for DNR, Rick Vollertsen GIS specialist for DNR, Jim Goeke Hydrogeologist for UNL Conservation and Survey Division and Steve Sibray Hydrogeologist for UNL Conservation and Survey Division.

## Table of Contents

<b><u>Introduction</u></b> .....	6
Study Purpose.....	6
Study Area .....	6
Great Plains Geology.....	8
Aquifer System.....	17
<b><u>Analyses of Aquifer Structure</u></b> .....	19
Hydrostratigraphic Units of the Aquifer.....	19
Hydrostratigraphic Unit Pick Logic .....	26
<b><u>Information Used for Developing Hydrostratigraphic Units</u></b> .....	27
Conservation and Survey Division Test-Hole Log.....	28
COHYST Test-Hole Information.....	32
DNR well registration database of irrigation well logs.....	36
<b><u>Development of Aquifer Database and Hydrostratigraphic Units</u></b> .....	39
Hydrostratigraphic Database Development.....	39
Hydrostratigraphic Unit Altitude Contour Map Development.....	43
<b><u>Development of Model Layers</u></b> .....	52
Mapping Altitude Values of Hydrostratigraphic Units to Model Grid.....	52
<b><u>Development of Aquifer Properties</u></b> .....	62
Hydraulic Conductivity .....	62
Specific Yield.....	69
<b><u>List of Figures</u></b>	
Figure 1. COHYST Boundary with Nebraska 1995 Water Table Contour Map and Surface Water Features.....	7
Figure 2. Cretaceous age sediments west of Alma, Nebraska. ....	8
Figure 3. Geology of Eagle Rock Scottsbluff National Monument, Nebraska.....	9
Figure 4. Brule Formation, Scottsbluff National Monument, Nebraska .....	10
Figure 5. Brule Formation alluvial channel deposit.....	11
Figure 6. Tertiary Arikaree Group sediments and White River Group contact ...	12
Figure 7. ‘Pipey concretions’ of the Tertiary Arikaree Group .....	13
Figure 8. Tertiary Ogallala Group outcrop.....	14
Figure 9. Tertiary Ogallala sediments.....	15
Figure 10. Pliocene-age gravels north of Big Springs, Nebraska.....	16
Figure 11. Quaternary Alluvium-Tertiary White River Group contact.....	17
Figure 12. Stratigraphic display of geologic and Hydrostratigraphic Units used in COHYST.....	18
Figure 13. Published Nebraska Water Survey Test-Hole Reports by County with test hole locations.....	31
Figure 14. COHYST Test Hole Locations.....	34
Figure 15. COHYST Drilling Program.....	35

Figure 16. Active Registered Irrigation Wells in the COHYST area Through June 2001.....	36
Figure 17. Registered well development over time.....	37
Figure 18. Location of selected wells used to develop Hydrostratigraphic Units.....	40
Figure 19. Base of Hydrostratigraphic Unit 1 Contour Map.....	44
Figure 20. Base of Hydrostratigraphic Unit 2 Contour Map.....	45
Figure 21. Base of Hydrostratigraphic Unit 3-4 Contour Map.....	46
Figure 22. Base of Hydrostratigraphic Unit 5 Contour Map.....	47
Figure 23. Base of Hydrostratigraphic Unit 6 Contour Map.....	48
Figure 24. Base of Hydrostratigraphic Unit 7 Contour Map.....	49
Figure 25. Base of Hydrostratigraphic Unit 8 Contour Map.....	50
Figure 26. Base of Modeled Hydrostratigraphic Units Contour Map.....	51
Figure 27. COHYST Model Units.....	52
Figure 28. Generalized Thickness Map of Hydrostratigraphic Unit 1.....	53
Figure 29. Generalized Thickness Map of Hydrostratigraphic Unit 2.....	54
Figure 30. Generalized Thickness Map of Hydrostratigraphic Unit 3-4.....	55
Figure 31. Generalized Thickness Map of Hydrostratigraphic Unit 5.....	56
Figure 32. Generalized Thickness Map of Hydrostratigraphic Unit 6.....	57
Figure 33. Generalized Thickness Map of Hydrostratigraphic Unit 7.....	58
Figure 34. Fence Diagram of the Western Model Area.....	59
Figure 35. Fence Diagram of the Central Model Area.....	60
Figure 36. Fence Diagram of the Eastern Model Area.....	61
Figure 37. Permeability Contours of Hydrostratigraphic Unit 2.....	63
Figure 38. Permeability Contours of Hydrostratigraphic Unit 3-4.....	66
Figure 39. Permeability Contours of Hydrostratigraphic Unit 5.....	67
Figure 40. Permeability Contours of Hydrostratigraphic Unit 7.....	68

**List of Tables**

Table 1. Stratigraphic Description of geologic and Hydrostratigraphic Units used in COHYST.....	18
Table 2. Test hole 25-B-45.....	20
Table 3. Test hole 1-K-39.....	21
Table 4. Test hole 17-A-49.....	22
Table 5. Test hole 12-B-77.....	25
Table 6. Test-Hole Reports for counties in the COHYST area.....	29
Table 7. Comparison of CSD Test-Hole lithologic log and a near by DNR database lithologic log. ....	41
Table 8. Excerpt from the Hydrostratigraphic database illustrating computation of thickness of Hydrostratigraphic Unit 2.....	42
Table 9. Excerpt of Selected Values from the Aquifer Properties Database.....	65

<b><u>Bibliography</u></b> .....	70
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**Attachments**

Attachment 1. Nebraska Cooperative Hydrology Study Computer Program  
Documentation Geoparm – Hydraulic Conductivity from  
Well Logs.....75  
Attachment 2. Layers to Models.....96

# Hydrostratigraphic Units Report for COHYST

## Introduction

### **Study Purpose**

The Cooperative Hydrology Study (COHYST) is a geohydrologic study of surface and groundwater resources in the Platte River Basin of Nebraska upstream from Columbus, Nebraska. Information relating to COHYST and the products produced by it are found at the website <http://cohyst.dnr.state.ne.us/>. COHYST was started in early 1998 to develop scientifically supportable hydrologic databases, analyses, models, and other information which, when completed, will:

1. Assist Nebraska to meet obligation under a separate three-state **Cooperative Agreement (CA)**. (Governors of Wyoming, Colorado, and Nebraska, and the Secretary of the Interior, 1997) – for more information, see <http://www.platteriver.org/>
2. Assist Nebraska's Natural Resources Districts along the Platte River in providing appropriate regulation and management.
3. Provide Nebraskans with a basis to develop policy and procedures related to groundwater and surface water.
4. Help Nebraskans analyze proposed activities of the **CA** and/or other water management programs in Nebraska.

### **Study Area**

The COHYST study area illustrated with the 1995 groundwater table altitudes (Figure 1) covers 29,300 square miles and extends from the Republican River and Frenchman Creek on the south to the Loup River, South Loup River, and a groundwater divide on the north. The eastern boundary is a selected boundary that follows county lines but was located sufficiently east that model boundary condition assumptions about groundwater flow across this boundary are likely to have little effect on the flow of the Platte River upstream of Columbus. The western and southwestern boundaries also are selected boundaries, and were placed 6 miles inside Colorado and Wyoming. These boundaries are sufficiently far from Nebraska that assumptions regarding groundwater flow across these boundaries will have minimal effect on the study results east of the state line. Additionally, the southern boundary along the Nebraska Panhandle in Colorado nearly follows a known groundwater flow line so little north or south trending water is likely to cross this boundary.

Figure 1



## Great Plains Geology

The High Plains aquifer (Weeks and others, 1988) underlies nearly all of the COHYST study area and consists of parts of the Brule Formation, the Arikaree Group, the Ogallala Group, and Quaternary deposits (Table 1). All of Nebraska and the entire COHYST study area lie within the Great Plains physiographic province as defined by Fenneman (1931). The aquifers, which are the focus of this study, are part of the High Plains aquifer system. The area within the COHYST boundary and within the stratigraphic time frame of this study's Hydrostratigraphic Units has not undergone major structural deformation. Faulting and formational deformation is of limited extent but does occur in Nebraska and has affected the geologic formations within parts of the study area. The mountain-building events west of Nebraska had major impacts on the deposition and erosional history of the state. In more recent geologic times continental and the corresponding alpine glaciations have contributed greatly to the depositional and erosional history of Nebraska.

Cretaceous age (undifferentiated) sediments and the Tertiary age White River Group (Brule and Chadron Formations) are considered to be the base of the aquifer system for this study. The Cretaceous bedrock materials are of marine origin and were deposited in a shallow sea occupying central North America. Figure 2 shows an outcrop of cretaceous age shale and limestone deposits of the Niobrara formation in central Nebraska.

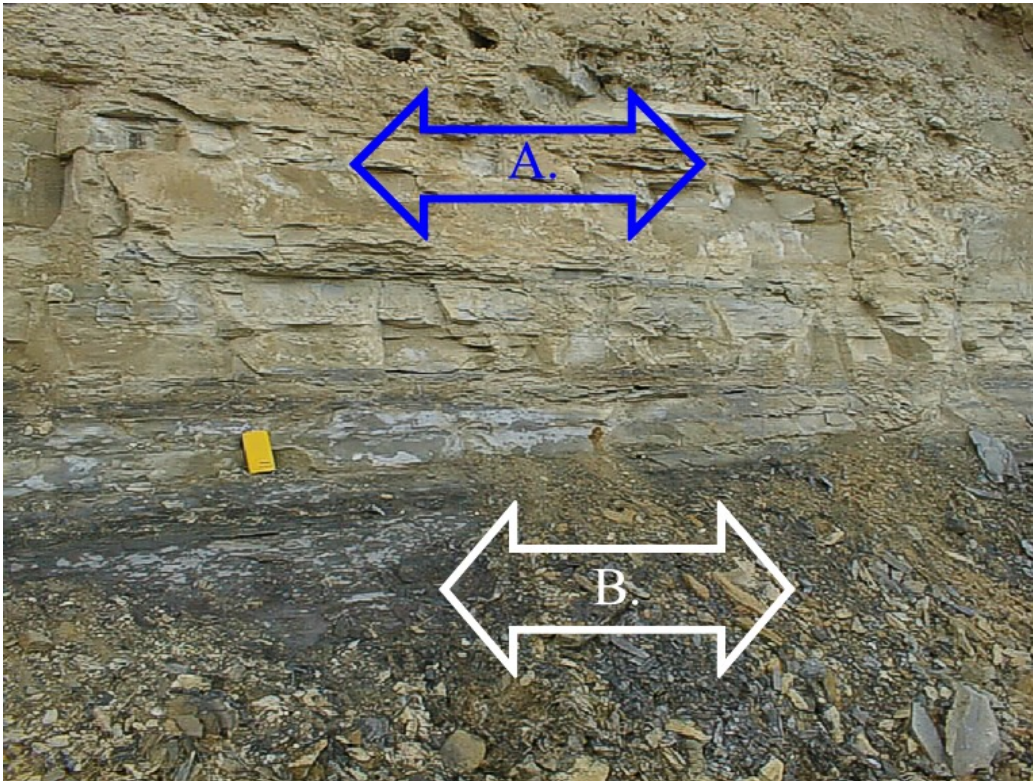


Figure 2      A. Niobrara Limestone  
                  B. Niobrara Shale

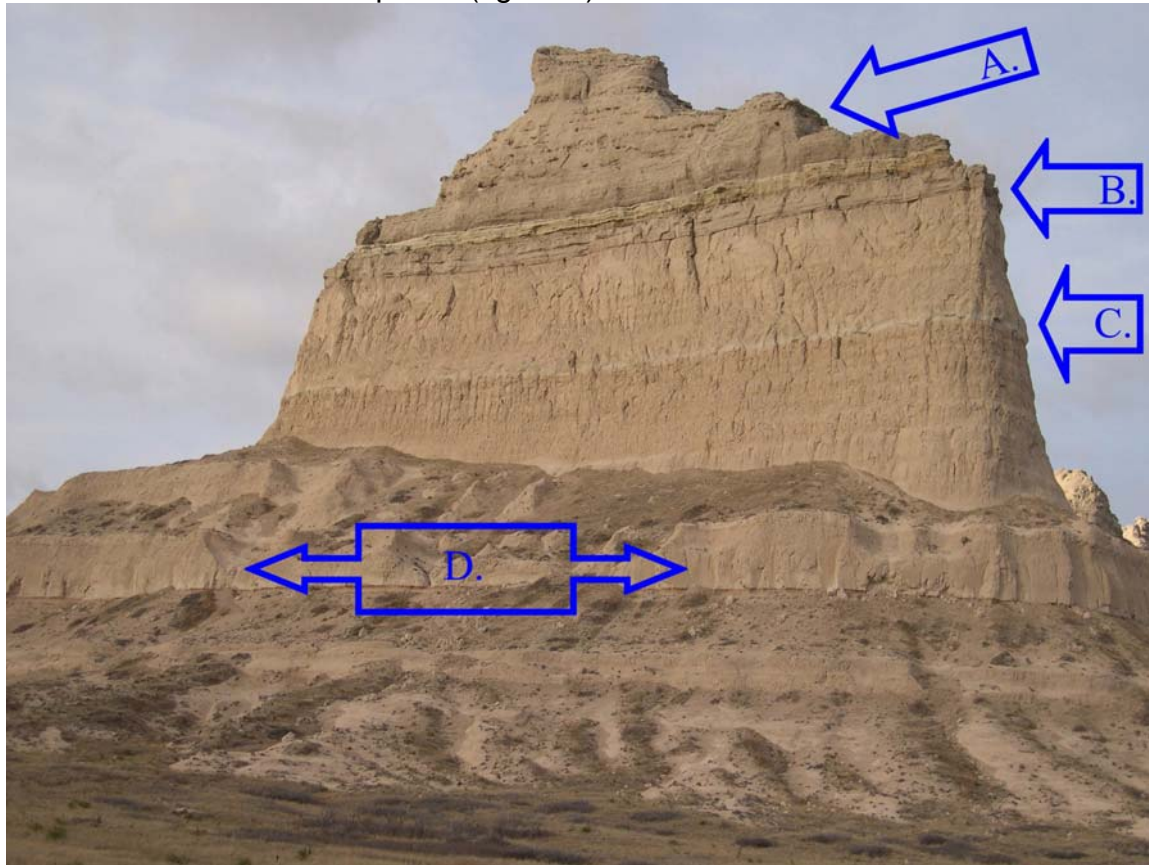
Photo taken of working face of quarry ~1 mile south and ~1 mile west of Alma, NE, facing south.

The active mountain building to the west, known as the Laramide orogeny began near the end of Cretaceous time.

The Laramide orogeny resulted in periods of erosion, deposition and stability (EDS cycles) that gives unique character to the formations of Cenozoic age.

Contemporaneous with the mountain building to the west were periods of enormous volcanic eruptions which provided massive volumes of ash which blanketed large parts of the study area. These eruptions continued periodically through the Cenozoic, but were of greater frequency during the Oligocene and Miocene. The main source areas for the ash were located in present day Nevada and southwestern Colorado.

The White River Group, which includes the Chadron and Brule formations of early to middle Oligocene age are eolian deposits of primarily ash and direct ash-fall interbedded with fluvial deposits (figure 3).

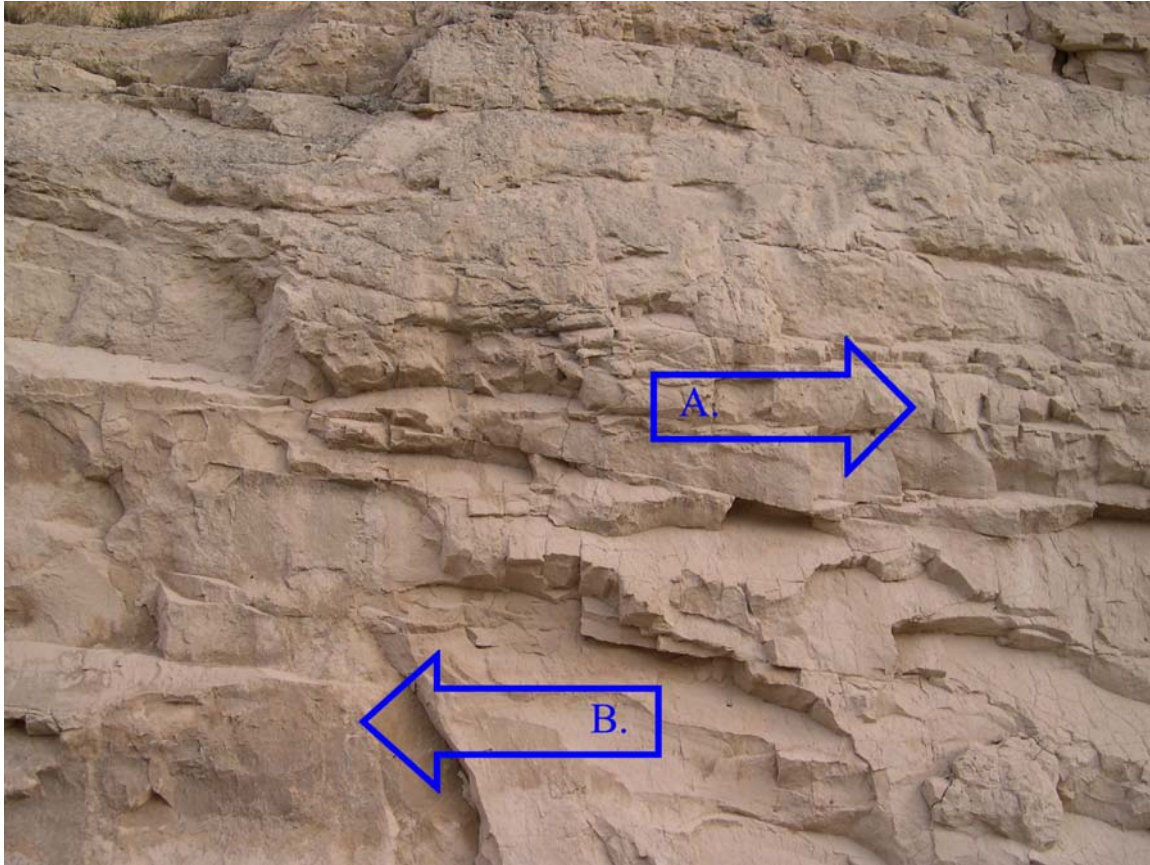


**Figure 3**      **A. Tertiary Arikaree Formation**  
                  **B. Erosional unconformity**  
                  **C. Tertiary Brule Formation**  
                  **D. Upper ash bed of the Brule Formation**

Photo taken of Eagle Rock north of highway 92 within the Scottsbluff National Monument, ~1/4 mile west of park headquarters.

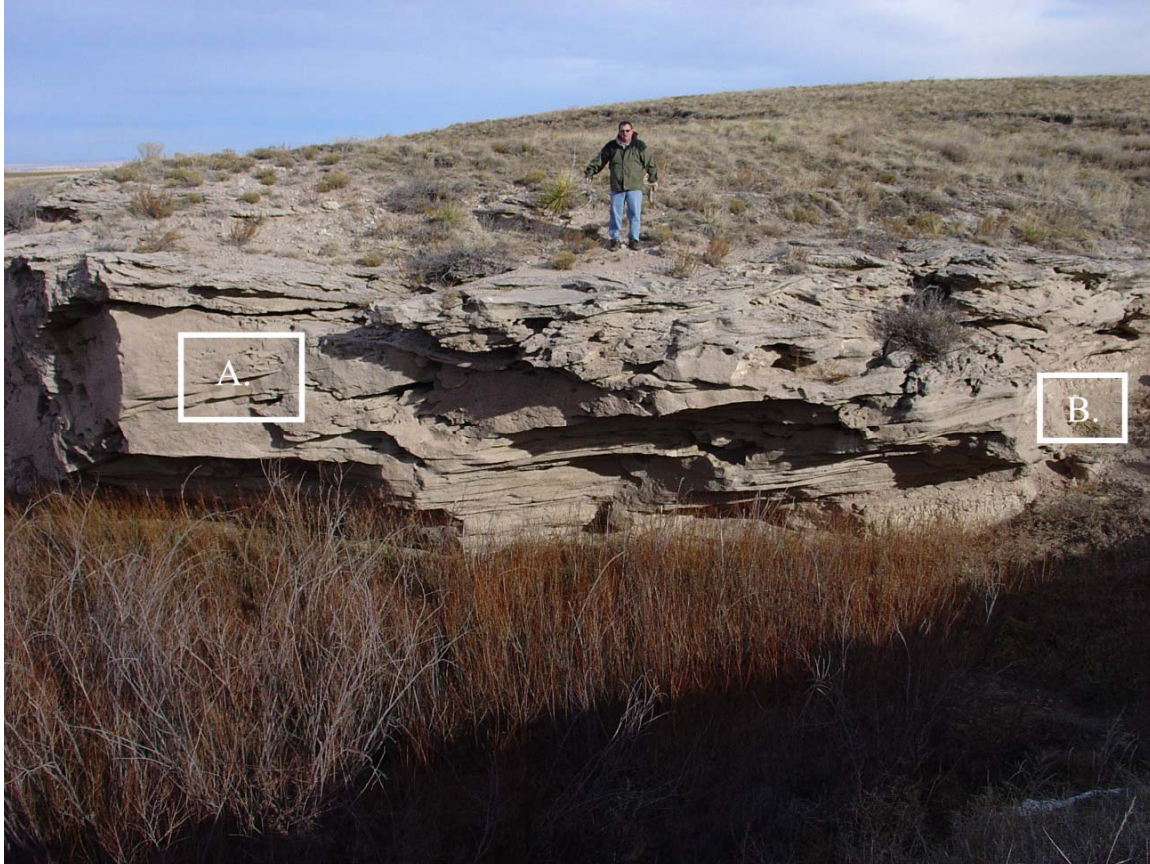
Most of these formations are considered an aquiclude, which is the main reason for their selection as the basal Hydrostratigraphic Units for this study. However, the exception to this is where the Brule Formation is fractured or has alluvial deposits that are saturated and unconfined (figure 4). The alluvial deposits of the Brule formation are

of limited extent and are not easily mapped. Figure 5 shows a rare outcrop of a Brule alluvial channel.



**Figure 4**      **A. Tertiary Brule fractures**  
                  **B. Unfractured Tertiary Brule**

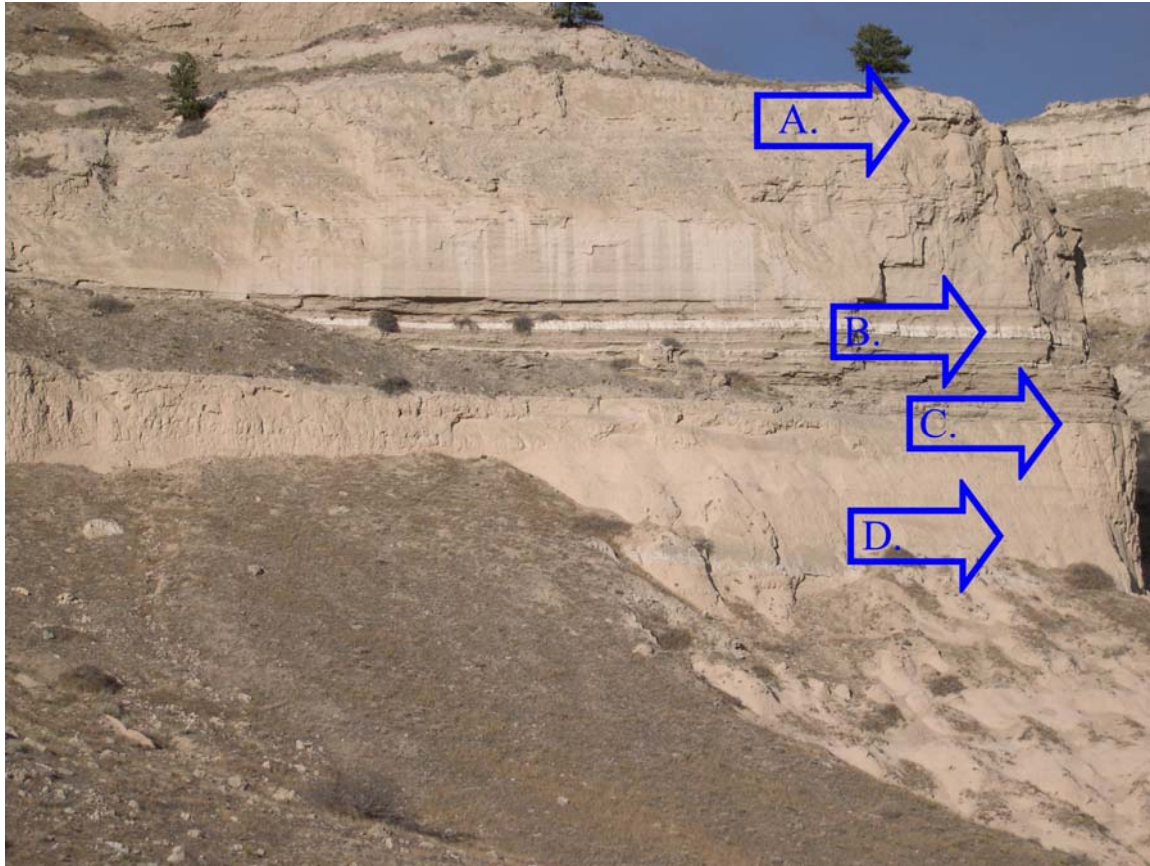
**Photo taken along summit road between tunnels 1 and 2, Scottsbluff National Monument, facing east.**



**Figure 5**      **A. Tertiary Brule sandstone and conglomerate channel deposit**  
                  **B. Unfractured Tertiary Brule**

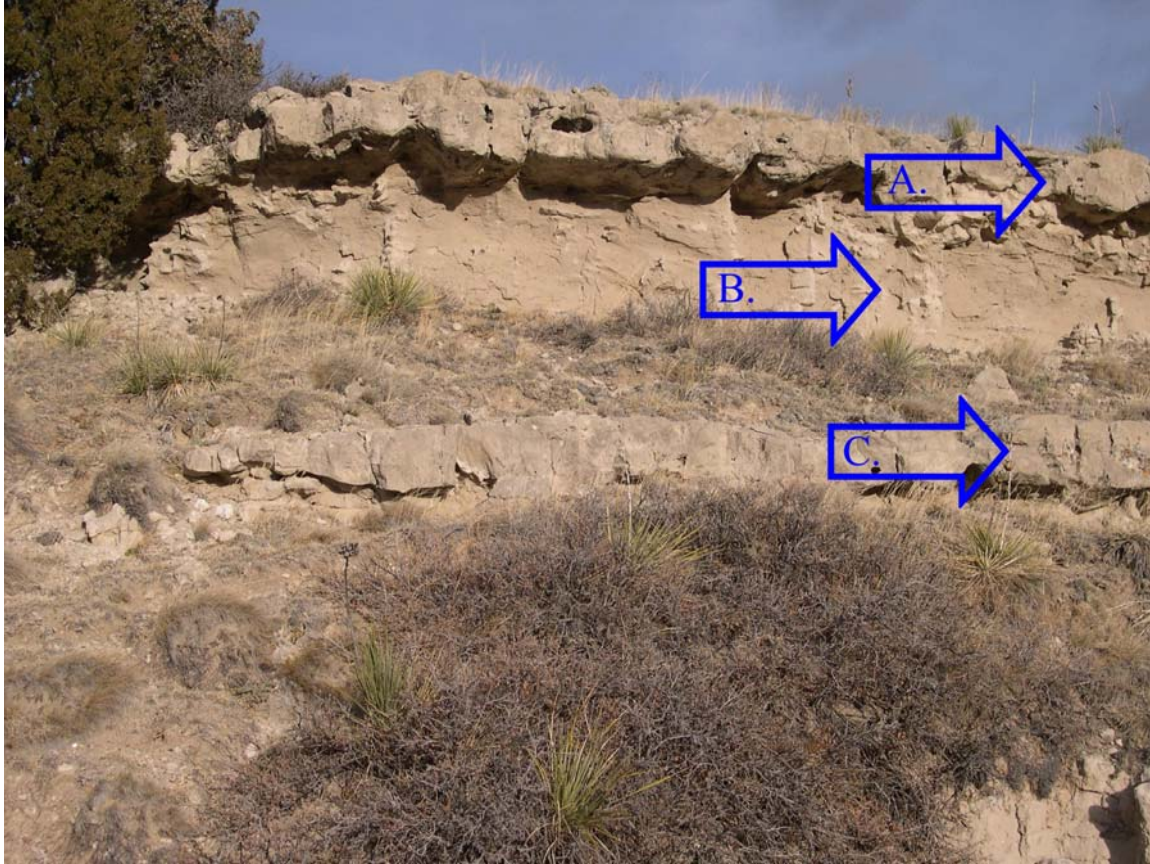
**Photo taken 5 miles south of Gering, NE on Highway 71 and 1 mile east on county road, facing northeast.**

The Tertiary Arikaree Group is between middle Oligocene to early Miocene in age and lies unconformably upon the Brule formation. This is an erosional unconformity. This group is dominated by fluvial deposition of continental sediments in the lower part of the group and a combination of eolian and fluvial deposition in the upper part of the group. Continued uplift in the west caused erosion of the White River Group and creation of large valleys across western Nebraska. These valleys were filled with fine-grained sediments from reworked older volcanic deposits, eolian/fluvial deposits and concurrent volcanic deposits. Numerous but less extensive ash fall deposits occur in much of the upper Arikaree Group (Figure 6).



**Figure 6**      **A. Tertiary Arikaree ‘pipey concretions’**  
**B. Ash fall deposit within the Tertiary Arikaree**  
**C. Erosional unconformity between the Tertiary Arikaree Group and Tertiary White River Group Brule Formation**  
**D. Upper ash of the Tertiary White River Group Brule Formation**  
**Photo taken along summit road before tunnel 1, Scottsbluff National Monument, facing north.**

Sandstones called ‘pipey concretions’ (Figure 6 & 7) are present throughout much of the middle to late age Arikaree group sediments and are responsible for much of the upland-valley landscapes seen throughout the western modeling area. These concretions are much more resistive to erosion than the sand and siltstones that make up the rest of the formation. This allows the high escarpments along the river valleys of the western model area to develop. These escarpments can be 200 to greater than 500 feet higher than the surrounding valleys.



**Figure 7**      **A. Tertiary Arikaree ‘pipey concretions’**  
                  **B. Invertebrate burrow casts**  
                  **C Tertiary Arikaree ‘pipey concretions’**

**Photo taken approximately ¼ mile from summit parking lot, along summit road, Scottsbluff National Monument, facing east.**

Renewed uplift of the Rocky Mountains resulted in an active and fairly long period of erosion and valley formation across Nebraska and is characteristic of the Ogallala Group which occupies middle Miocene to the beginning of Pliocene time. The period of deposition that followed is associated with the Ogallala Group. This period of paleo-valley filling produced complex valley/alluvial depositional environments. A wide range of varying depositional environments consisting of high energy streams to quiet shallow lakes existed through out the area. The Ogallala Group varies greatly both horizontally and vertically in sediment size and character over short distances (figure 8).



**Figure 8**      **A. Tertiary Ogallala sandstone**  
                  **B. Tertiary Ogallala silt and sand**  
                  **C Tertiary Ogallala sandstone**

**Photo taken in Gosper County along county road, facing west.**

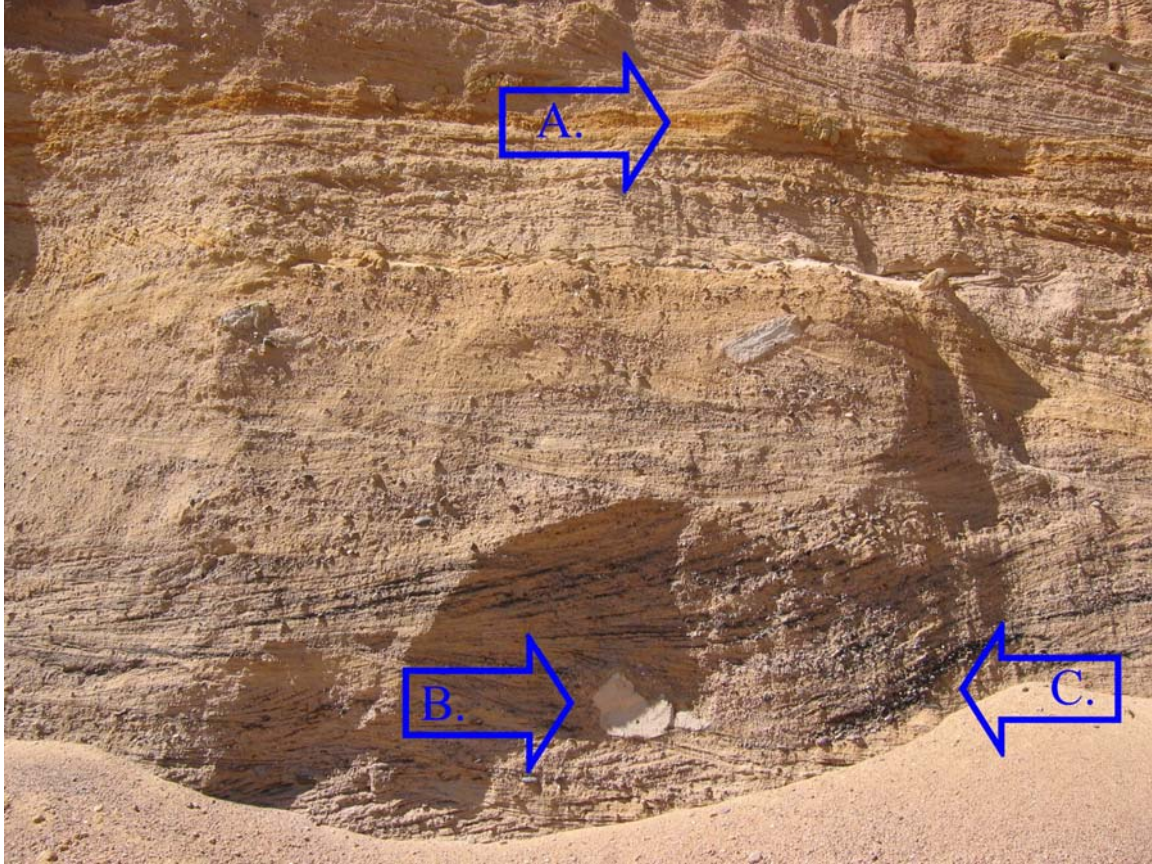
These high-energy gravel-filled stream deposits (Figure 9) of western Nebraska were transported and converged into coalescing stream deposits over much of central and eastern Nebraska.



**Figure 9** Cross bedded, fluvial, coarse grained sediments of the Tertiary Ogallala  
Photo taken near Kingsley Dam, Keith County Nebraska, facing north.

During the Pliocene, continued Rocky Mountain uplift occurred, with the resultant erosion creating an unconformity containing numerous valleys, which also extended into present day Wyoming and Colorado, which were subsequently filled with sediments derived there. These Pliocene valley-fill deposits make up the Broadwater formation (figure 10). These deposits tend to be channel deposits in a few areas of the Nebraska panhandle. The channels trend to the east where they coalesce and become wide spread north beneath the sand hills.

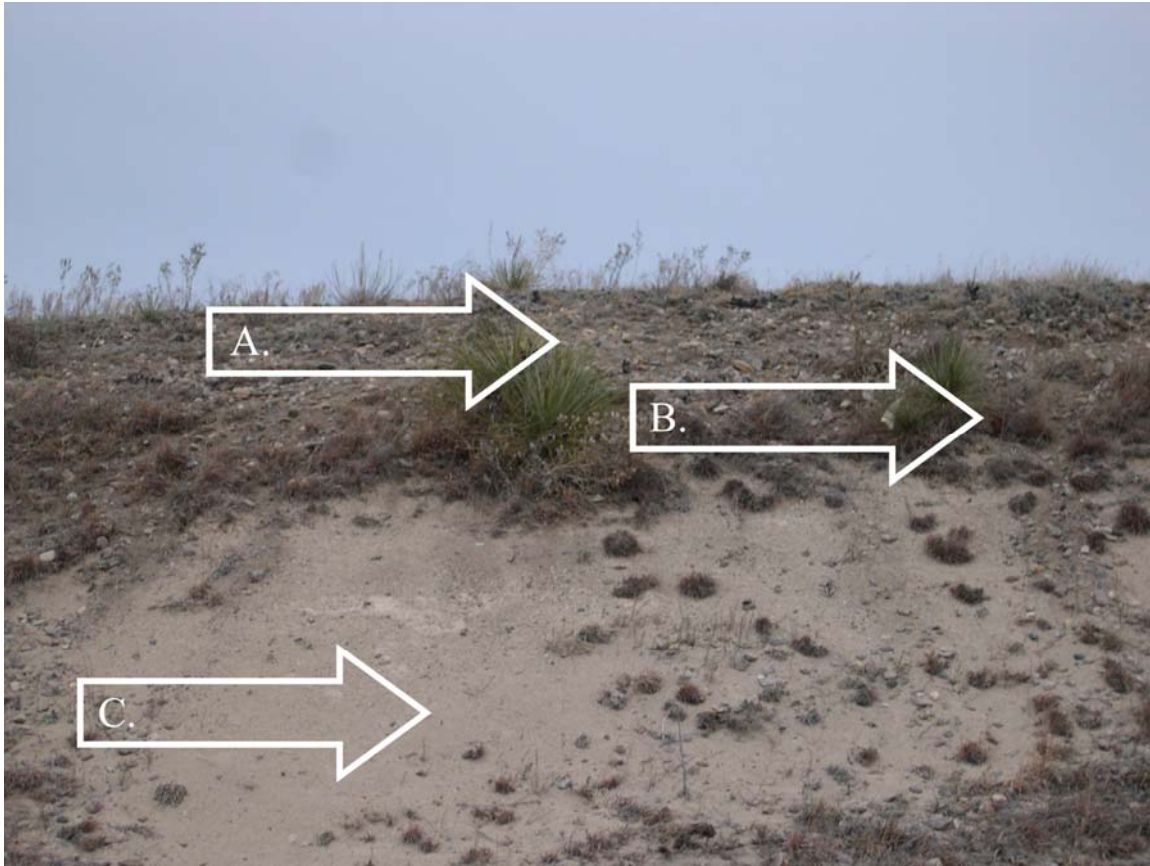




**Figure 10.**     **A. Iron stained sediments**  
                  **B. Manganese stained sediments**  
                  **C. Siltstone clasts ~1.5 feet in diameter.**

**Cross bedded, fluvial, coarse grained sediments of the Pliocene Broadwater Formation. Photo taken ~ 1.5 miles north of Big Springs Nebraska facing west.**

The major episodes of Pleistocene glaciations were the primary formative factors in surface and unconsolidated subsurface deposits present in the COHYST area. The lowered sea levels associated with continual ice sheet advances resulted in stream down cutting cycles, the subsequent retreats of the ice sheet and consequent sea level rises were times of stream/valley aggradation. The melt water from the Rocky Mountain glaciations transported coarse-grained sediments from Colorado and Wyoming and eroded material from the Ogallala group. These materials form the vast sand and gravel deposits of central Nebraska and river valleys and tablelands of western Nebraska. Figure 11 shows the erosional unconformity between the quaternary alluvial sediment of the North Platte river basin and the Tertiary White River Group Brule Formation siltstone.



**Figure 11**      **A. Quaternary Alluvium. Coarse grained sand and gravel with pebbles**  
                  **B. Erosional unconformity**  
                  **C Tertiary White River Group Brule Formation**

**Photo taken ~ 1.5 miles east of Henry, Nebraska along highway 26, facing north.**

The continental glacial advances into eastern Nebraska and their outwash drainages modified the west-to-east drainage patterns of existing streams into the southeastern orientation seen today. Deposits of fine sand, silt, and clay accumulated in the outer portions of the valleys and in uplands. Widespread occurrence of eolian deposits, loess, and dune sand cover much of the study area. Other areas are generally covered with the locally derived soils.

### **Aquifer System**

The High Plains aquifer (Weeks and others, 1988) underlies nearly all of the COHYST study area and consists of parts of the Brule Formation, the Arikaree Group, the Ogallala Group, and Quaternary deposits (Table 1). Previous studies generally have treated the vertical extent of the High Plains aquifer as a single Unit. COHYST has investigated the hydrologic importance of the various layers within the High Plains aquifer by comparing single and multilayer flow models of the groundwater system. This report describes the Hydrostratigraphic Units and aquifer properties that are used by COHYST and defines their relationship to geologic units that make up the High Plains aquifer.

Table 1 Figure 12.

## Analyses of Aquifer Structure

### Hydrostratigraphic Units

COHYST divides the High Plains aquifer into eight Hydrostratigraphic Units and divides the confining Hydrostratigraphic Units beneath the aquifer into two additional Hydrostratigraphic Units. The ten Hydrostratigraphic Units are described in table 1 and are shown in Figure 12.

The Hydrostratigraphic Units are geologic units that have been grouped based on hydraulic properties such as water storage capacity and permeability. These Hydrostratigraphic Units generally conform to the associated geologic age but for model purposes they can cross geologic time boundaries when similar types of material are in contact with each other. The Hydrostratigraphic Units are numbered from youngest to oldest sediments present in the study area, with HU1 being quaternary in age and HU 10 of Cretaceous age.

The Hydrostratigraphic Units 1-3 are of Quaternary or Tertiary age. These Hydrostratigraphic Units are most important in the eastern one-third of the COHYST area and in the river valleys through out the rest of the study area. The combined thickness of these Hydrostratigraphic Units exceeds 300 feet in much of Hamilton, Polk, and York Counties. The Hydrostratigraphic Units may be thin or absent in much of the western part of the COHYST area. Hydrostratigraphic Units 1 and 2 are aerially more extensive than Hydrostratigraphic Unit 3. Hydrostratigraphic Unit 1 generally consists of silt, but may contain some fine sand or clay. Where Hydrostratigraphic Unit 1 is comprised of mostly silt, it is thickest south of the Platte River in the southeast corner of Lincoln and southwest corner of Dawson counties. Where Hydrostratigraphic Unit 1 is comprised mostly of fine grain sand it reaches its maximum thickness in Grant, Arthur, McPherson, Logan and Custer Counties (Figure 28). Hydrostratigraphic Unit 2 directly underlies Hydrostratigraphic Unit 1 and generally consists of sand and gravel, although it may contain layers of finer material. Hydrostratigraphic Unit 2 generally transmits much more water than either Hydrostratigraphic Unit 1 or Hydrostratigraphic Unit 3. Hydrostratigraphic Unit 2 reaches maximum thickness in Adams, Clay, Polk and York Counties (Figure 29) where the thickness can exceed 200 feet. Thickness of 100 feet or greater is common north of the North Platte and Platte rivers in Garden, Arthur, McPherson, Lincoln, Logan, Custer, and Hall counties. Similar thickness is present in Phelps, Harlan, Kearney, Franklin, Hall, Adams, Webster, Clay, Hamilton, Polk and York Counties south of the Platte River. Only in the narrow confines of the North Platte River valley does Hydrostratigraphic Unit 2 exceed 100-150 feet in thickness within the central panhandle region of the COHYST area, the exception to this is the previously mentioned central part of Garden County. Hydrostratigraphic Unit 3, where it exists, directly underlies Hydrostratigraphic Unit 2 and generally consists of silt, but it may contain some fine sand or clay. Hydrostratigraphic Unit 3 is thickest in the eastern part of the COHYST area in Hamilton, Polk and York Counties. In localized areas the thickness can exceed 250 feet (Figure 30). The log from Test-Hole #25-B-45 in Table 2 shows a thick section of Hydrostratigraphic Units 1-3 associated with Quaternary gravel in York County; Hydrostratigraphic Units 4-9 are absent in this test hole. The log from

Test-Hole #1-K-39 in Table 3 shows a typical section of Hydrostratigraphic Units 1-5 in Buffalo County; Hydrostratigraphic Units 6-9 is absent in this test hole.

Table 2. Test-Hole 25-B-45

<b>10N 01W 22DDDA Test Hole #25-B-45 York County</b>			
Location: NE SE SE SE sec. 22, T. 10 N., R. 1 W., approximately 430 feet north and 9 feet west of southeast corner.			
Ground altitude: 1,540.0 ft. (t). (Utica SW 7.5 min. quadrangle).			
Depth to water: Unknown. Test hole caved at 39.5 ft. (9-7-45).			
	Depth, in feet		Hydrostratigraphic Unit
	From	To	
<b>Quaternary System, undifferentiated:</b>			1
Road fill	0.0	2.0	
Silt, clayey, sandy, dark brown, in part reddish brown	2.0	4.0	
Sand and gravel, silty; fine sand to coarse gravel with some pebbles	4.0	7.0	
Silt, sandy, light gray to greenish gray	7.0	9.0	
Sand, fine to medium with some coarse	9.0	11.0	
Sand, gravelly, medium sand to medium gravel with some coarse gravel (20 percent gravel); sand is fine to very coarse and contains 5 percent gravel below 15 ft; contains 15 percent gravel below 20 ft	11.0	25.0	2
Sand and gravel; fine sand to medium gravel with some coarse gravel (50 percent gravel); contains 70 percent gravel from 30 to 50 ft	25.0	50.0	
Sand, gravelly, fine sand to fine gravel (10 percent gravel); contains 30 percent gravel from 55 to 60 ft; contains 15 percent gravel below 60 ft	50.0	72.0	
Clay, silty, light gray to light brown	72.0	79.0	
Sand, fine to medium	79.0	81.0	
Silt, moderately clayey, light greenish gray	81.0	84.0	
Sand, fine to coarse with some very coarse	84.0	90.0	
Silt, slightly clayey, sandy, light greenish gray with a brown tint, sand is fine; contains some medium brown silty clay below 98.5 ft	90.0	99.5	
Sand, fine to medium	99.5	104.0	
Silt, clayey, medium gray with a green tint	104.0	119.5	
Sand, silty, sand is very fine to fine with some coarse sand to fine gravel; contains some rounded clay grains	119.5	130.0	
Silt, clayey, medium gray with some dark gray; contains some shell fragments; contains a trace of wood fragments below 145 ft; contains a sand lens from 145.5 to 146 ft	130.0	150.0	
Sand, silty, sand is fine to medium	150.0	152.0	
Silt, slightly clayey, medium gray; contains some shell fragments	152.0	157.0	
Sand, fine to very coarse with a trace of fine gravel	157.0	163.0	
Sand, gravelly, medium sand to medium gravel with some coarse gravel (30 percent gravel)	163.0	170.0	
Sand and gravel; medium sand to medium gravel with some coarse gravel (50 percent gravel)	170.0	180.0	
Sand, gravelly, medium sand to coarse gravel; contains some limestone grains (40 percent gravel); slightly coarser textured from 185 to 190 ft; contains 10 percent gravel from 190 to 195 and from 200 to 210 ft; contains 40 percent gravel below 210 ft	180.0	220.0	
Sand and gravel; medium sand to coarse gravel (60 percent gravel); contains some limestone grains	220.0	231.5	
Silt, slightly clayey, slightly calcareous, coarse textured, medium dark brownish gray; moderately clayey, moderately calcareous, light gray below 234 ft	231.5	244.0	3
Gravel; principally shell fragments	244.0	247.0	
<b>Cretaceous System - Upper Cretaceous Series - Colorado Group: Carlile Formation:</b>			10
Limestone, grayish brown, fossiliferous	247.0	251.0	
<b>Cretaceous System - Upper Cretaceous Series - Colorado Group: Greenhorn Formation:</b>			
Limestone, dark grayish brown, shaly, silty; contains light gray limestone layer from 257.5 to 258 ft	251.0	259.5	
Limestone, light gray	259.5	260.0	

Table 3. Test-Hole 1-K-39

<b>8N 16W 02DBDA Test Hole #1-K-39 Buffalo County</b>			
Location: NE SE NW SE sec 2-8N-16W (30 ft N and 50 ft E of intersection of 16th Street and 6th Avenue)			
Ground altitude: 2149 ft (t) Kearney 7.5 minute quadrangle			
Depth to water: Not recorded			
	Depth, in feet		Hydrostratigraphic Unit
	From	To	
<b>Quaternary System, undifferentiated:</b>			
Soil, very dark brown	0.0	5.0	1
Silt, clayey to gravelly, yellow-brown	5.0	8.0	
Sand and gravel, coarse, a few pebbles	8.0	15.0	
Sand and gravel, finer than above	15.0	25.0	2
Sand and gravel, fine to medium gravel	25.0	45.0	
Silt, light to dark brown; mostly light brown below 55 ft; common concretions below 80 ft; lighter in color below 85.6 ft, probably calcareous; hard layer 94.7 to 95 ft	45.0	95.0	3
Tertiary System - Miocene Series - Ogallala Group:			
Marl, chalky, yellow	95.0	98.0	4
Sand, clayey, whitish to very light gray	98.0	111.0	
Sandstone, soft, very light gray	111.0	127.0	
Sand, silty, very light greenish gray	127.0	143.0	5
Sandstone, silty, white to very light greenish gray, sand mostly fine, calcareous, some hard layers	143.0	197.0	
<b>Cretaceous System - Upper Cretaceous Series - Montana Group - Pierre Formation:</b>			
Shale, black	197.0	207.0	10

The Hydrostratigraphic Units 4-6 consist of Tertiary age sediments of the Ogallala Group. These Hydrostratigraphic Units occur in most of the COHYST area except for the eastern and northwestern parts (Table 1). The combined thickness of Hydrostratigraphic Units 4-6 exceeds 500 feet in many locations, particularly in the western one-half of the COHYST area. Hydrostratigraphic Unit 5 is aerially more extensive than either Hydrostratigraphic Unit 4 or Hydrostratigraphic Unit 6. Hydrostratigraphic Unit 4, where it exists, generally consists of silt, but may contain some fine sand or clay. Hydrostratigraphic Unit 4 has hydrologic properties similar to Hydrostratigraphic Unit 3, but was separated from Hydrostratigraphic Unit 3 because some maps may depict the top of Hydrostratigraphic Unit 4, which corresponds to the top of the Ogallala Group, and such maps can be used to verify COHYST maps of the top of Hydrostratigraphic Unit 4. Hydrostratigraphic Unit 5 directly underlies Hydrostratigraphic Unit 4 and generally consists of sand and gravel, sandstone and siltstone and may contain layers of finer material. Hydrostratigraphic Unit 5 is thickest along the northern COHYST boundary from Arthur to Sheridan Counties where its thickness exceeds 500 feet in places (Figure 31). Hydrostratigraphic Unit 6, where it exists, directly underlies Hydrostratigraphic Unit 5 and generally consists of silt, but may contain some fine sand or clay. Hydrostratigraphic Unit 6 is areally extensive only in Lincoln, McPherson, Logan, Dawson and Custer Counties (Figure 32). It tends to be thin and of local extent in the rest of the COHYST area. The log from Test-Hole #14-S-

82 in Table 4 shows a typical section of Hydrostratigraphic Units 1-6 and 9 in Keith County; Hydrostratigraphic Units 3, 7, and 8 are absent in this test hole.

Table 4. Test-Hole 17-A-49

<b>14N 40W 33DDDD Test Hole #17-A-49 Keith County</b>				
Location: SE SE SE SE sec. 33, T. 14 N., R. 40 W., approximately 5 ft. north and 47 ft. west of southeast corner.				
Ground altitude: 3,617 ft. (t). (Brule NW 7.5 min. quadrangle)				
Depth to water: Unknown. (7-17-49)				
	Depth, in feet		Hydrostratigraphic Unit	
	From	To		
<b>Quaternary System, undifferentiated:</b>				
Road fill: slightly calcareous	0.0	1.5	1	
Soil: silt, grayish black	1.5	3.0		
Silt, slightly clayey, slightly calcareous, light-brown	3.0	7.0		
Sand, silty, slightly calcareous, light tan-brown; texture of sand is very fine	7.0	10.0		
Silt, slightly calcareous, light tan-brown; non-calcareous below 30 ft; dark-buff and brownish tan from 90 to 95 ft; light reddish brown below 95 ft	10.0	117.0		
<b>Quaternary System and Tertiary System - Pliocene Series:</b>				
Sand, slightly calcareous, grayish brown and pink; texture grades from very fine to medium sand	117.0	120.0	2	
Sand, silty, moderately calcareous, white and brown; slightly more calcareous below 125 ft	120.0	135.0		
Sand, moderately calcareous, grayish brown; texture grades from very fine to very coarse sand; contains some limy nodules	135.0	140.0		
Sand and gravel, brown, pink and tan; texture grades from fine sand to fine gravel; contains about 40 percent gravel with a few silt layers	140.0	150.0		
Sand, grayish brown; texture grades from very fine to coarse sand	150.0	152.0		
Silt, reddish brown	152.0	155.0		
Silt, sandy, brown-buff	155.0	160.0		
Sand and gravel, yellow, pink and tan; contains about 40 percent gravel; contains about 20 percent gravel below 170 ft, and about 50 percent gravel below 190 ft; finer texture below 200 ft	160.0	203.0		
<b>Tertiary System - Miocene Series - Ogallala Group: Ash Hollow Formation:</b>				
Silt, sandy, brownish buff	203.0	212.5		4
Silt, slightly sandy, very calcareous, white	212.5	214.0		
Silt, sandy, moderately calcareous; contains some limy nodules	214.0	217.5		
Sand, greenish tan; texture grades from very fine to coarse sand	217.5	227.5		
Silt, slightly clayey, reddish brown	227.5	230.0		
Silt, reddish brown; slightly sandy below 235 ft	230.0	240.0		
Silt, sandy, light-brown to brown	240.0	247.5		
Sand, grayish brown-tan; texture grades from very fine to medium sand; contains some coarse sand and limy nodules below 250 ft	247.5	251.5		
Silt, slightly sandy, dark-gray; slightly calcareous, light-brown and contains limy layers below 252 ft	251.5	260.0		
Silt to siltstone, moderately calcareous, white; contains some clay fragments	260.0	263.0		
Silt, sandy, moderately calcareous, reddish brown; contains some brown clay fragments	263.0	270.0	5	
Silt, slightly sandy, slightly calcareous, grayish brown and tan; contains some brown clay fragments.	270.0	280.0		
Silt, very sandy, to sand, very silty, moderately calcareous, white; contains very fine to medium sand	280.0	290.0		

Sand, yellow, pink, and tan; texture grades from very fine to very coarse sand with some fine gravel; contains some limy nodules below 300 ft	290.0	305.0	
Sand, silty, slightly calcareous, light brown-tan; texture grades from very fine to coarse sand; grayish light-brown below 320 ft	305.0	330.0	
Sand, slightly silty, slightly calcareous, reddish brown-gray; texture grades from very fine to medium sand; contains some limy nodules; coarser below 335 ft	330.0	340.0	
Sand, brownish gray; texture grades from very fine to medium sand; contains limy silt layers; greenish below 345 ft	340.0	353.8	
Sand, very calcareous, white; texture grades from very fine to coarse sand; contains some limy layers	353.8	369.5	5
Silt, slightly clayey to sandy, moderately calcareous, olive-green	369.5	370.0	
Silt to sandstone, slightly calcareous, brownish green; texture grades from very fine to fine sand; contains some hard layers below 375 ft	370.0	380.0	
Silt, sandy, very calcareous, white	380.0	390.0	
Silt, slightly sandy, very calcareous, white; interbedded hard layers with a trace of light green sandstone; more sandy below 400 ft	390.0	410.0	6
Silt, sandy, very calcareous, white; contains some marl layers	410.0	420.0	
Silt, clayey, slightly calcareous, light olive green; contains some limy layers; brownish green below 423 ft	420.0	428.0	
<b>Tertiary System - Oligocene Series - White River Group: Brule Formation:</b>			
Silt, slightly to moderately clayey, reddish brown	428.0	450.0	9



Hydrostratigraphic Unit 7 consists of Tertiary age sediments of the Arikaree Group (Table 1). This Hydrostratigraphic Unit exists only in the western part of the COHYST area and is the source of water for many of the irrigation wells in southern Box Butte County. Hydrostratigraphic Unit 7 generally consists of very fine to fine-grained sandstone, but also may contain siltstone. The Hydrostratigraphic Unit has greatest thickness in southern Sioux, Box Butte and Sheridan Counties (Figure 33). Locally, Hydrostratigraphic Unit 7 may contain conglomerate, gravel, sand and ash. Test-Hole #12-B-77 (Table 5) located in T26N, R55W, Section 18, Sioux County penetrated more than 500 feet of Hydrostratigraphic Unit 7.

Hydrostratigraphic Unit 8 is that part of the Tertiary Brule Formation of the White River Group (Table. 1) that is capable of yielding large quantities of water to wells. The Brule Formation yields large quantities of water only where it is fractured or consists of channel deposits of sand or gravel in hydrologic connection with overlying saturated Hydrostratigraphic Units. Water yielding fractures are in the upper part of the Brule Formation, typically less than 120 feet from the upper surface of the formation. Coarse alluvial channel deposits may occur deeper in the formation but do not yield water in large amounts due to the lack of hydrologic connection with upper water-bearing Hydrostratigraphic Units. It is difficult to predict where the Brule Formation will yield water, but saturated useable portions of the formation are frequently encountered in the vicinity of Pumpkin Creek, Lodge Pole Creek, Sidney Draw and parts of the North Platte River valley (Figure 25).

Hydrostratigraphic Unit 9 consists of that part of the Brule Formation (Table 1) that do not yield water to wells and the Tertiary age Chadron Formation of the White River Group. Hydrostratigraphic Unit 9 generally consists of silt, siltstone, clay, and claystone. It forms the impermeable base of aquifer over most of the western two-thirds of the COHYST area. The Unit is most prevalent in Banner, Morrill, and Scottsbluff Counties where it can be up to 500 feet thick.

Table 5. Test-Hole 12-B-77

**26N 55W 18CDCD  
Test Hole #12-B-77  
Sioux County**

Location: SE SW SE SW sec. 18, T. 26 N., R. 55 W., approximately 290 ft north and 1820 ft east of southwest corner of section.  
Ground altitude: 4,983 ft (t). (Chalk Buttes NE 7.5 min. quadrangle).  
Depth to water: 379 ft (August 18, 1977)

	Depth, in feet		Hydro-stratigraphic Unit
	From	To	
<b>Tertiary System - Miocene Series - Ogallala Group: Sheep Creek Formation (?):</b>			
Silt, clayey, sandy, very fine to fine sand, interbedded with lime cemented sandstone, moderate to very calcareous siliceous root casts	0.0	15.0	4
<b>Tertiary System - Miocene and Oligocene Series - Arikaree Group - Harrison and Monroe</b>			
<b>Creek Formations, undivided:</b>			
Sandstone, very fine to fine, very silty, friable, volcanoclastic, pale yellow to light gray 14.8 to 30 ft, siliceous root casts 35 to 45 ft, mostly very fine sand with lesser amounts of fine sand, 74 to 105 ft less silty	15.0	105.0	
Sandstone, very fine to fine, slightly silty in parts, well sorted, some limy zones, 115 to 120 ft abundant siliceous root casts	105.0	200.0	
As above with more limy zones and higher silt content in parts, light gray	200.0	294.2	7
Sandstone, very fine to fine, traces of medium sand, very silty, moderate to very calcareous, white to pale brown	294.2	305.8	
Sandstone, very fine to fine, slightly silty, medium to coarse sand from 420 to 428 ft, slightly calcareous	305.8	420.0	
<b>Tertiary System - Oligocene Series - Arikaree Group - unnamed Unit (formerly Gering Formation):</b>			
Sandstone to sand; very fine to fine; medium to coarse sand 450 to 450 ft, poor sorting	420.0	450.0	
Sandstone, very fine to medium, poor sorting, medium to coarse sand from 486 to 500 ft, slight to moderately calcareous	450.0	500.0	
Sand, very fine to very coarse, slightly silty in parts, poorly sorted, more coarse sand from 532 to 538.1 ft, some calcareous zones	500.0	538.1	
Siltstone, very sandy, very fine to fine sand, very calcareous, white to light yellowish brown	538.1	560.0	
<b>Tertiary System - Oligocene Series - White River Group - Brule Formation, Whitney Member:</b>			
Siltstone, very calcareous, very pale brown to light yellowish-brown	560.0	600.0	9

Hydrostratigraphic Unit 10 consists of marine shale, chalk, limestone, siltstone, and sandstone of Cretaceous age (Table 1). Where sandstones are in contact with the High Plains aquifer, they may exchange small amounts of water with the aquifer, but this only happens in isolated areas near the western and eastern COHYST boundaries and the volumes of water involved are small compared to flow across the boundary. Hydrostratigraphic Unit 10 is treated as an impermeable base of aquifer in the COHYST models.

## Hydrostratigraphic Unit Pick Logic

The 10 Hydrostratigraphic Units defined are selected by two major criteria:

(1) The grain size and permeability were the primary characteristics for selection of Hydrostratigraphic Units 1, 2, 3, 4, 5, 6, and 8.

Hydrostratigraphic Units 1, 3, 4, and 6 are divisions where silts, clays, and siltstone comprise the dominant material and typically have low permeability. Hydrostratigraphic Units 2, 5, and 8 are coarser grained and have corresponding higher permeability. Hydrostratigraphic Units of this group may have similar characteristics but are in different geologic formations.

(2) Geologic formation status is the sole basis for the assignment to Hydrostratigraphic Units 3-4, 7, 9, and 10. For example, Hydrostratigraphic Unit 7 is assigned entirely as the Arikaree Group, without consideration of permeability or grain size characteristics.

Hydrostratigraphic Unit 1 is Pleistocene; primarily silt, clay, fine and medium sand. Thin (1-3') beds of coarse sand can be present within the Hydrostratigraphic Unit. Dune sand is included with Hydrostratigraphic Unit 1. In some areas the Hydrostratigraphic Unit rests directly on Hydrostratigraphic Units 4 through 10. When Hydrostratigraphic Unit 2 is the underlying Hydrostratigraphic Unit, the base of Hydrostratigraphic Unit one was selected as the first occurrence of fine to coarse sand or coarser material. This identifies a marked depositional change from an eolian or low energy fluvial environment to a fluvial sequence (Hydrostratigraphic Unit 2) where sand and gravel are dominant sediment size.

The top of this higher energy depositional environment is the beginning of Hydrostratigraphic Unit 2. This Unit can be present upon all Units within the study area. The sand and gravel deposits of the Pliocene age Broadwater Formation in west central Nebraska is included with Hydrostratigraphic Unit 2. The bottom of Hydrostratigraphic Unit 2 is defined as when the highly permeable sand and gravel end at a contact with Pleistocene silts (Hydrostratigraphic Unit 3), fine sand and clay or Miocene-aged (Ogallala Group) or older deposits (Hydrostratigraphic Units 4-10). Hydrostratigraphic Unit 3 is the final sequence of Pleistocene sediments and has much fine grain sediment such as clay, silt and fine sand. It has intermittent occurrence on a regional level and ends at the contact with one of Hydrostratigraphic Units 4-10; this is a geologic age horizon. When Hydrostratigraphic Unit 2 was absent no effort was made to delineate Hydrostratigraphic Unit 1 from 3; all material was included with Hydrostratigraphic Unit 1. At some isolated locations, a thin (<5') bed of coarse grain sediment such as

medium to coarse sand ,fine to coarse gravel and occasionally pebbles to cobbles occurs at the base of Hydrostratigraphic Unit 3 and is included in the Unit.

Hydrostratigraphic Unit 4 is defined as material consisting of fine grained sediment occurring in the upper portion of the Ogallala Group. It includes materials such as silt, siltstone, clay, claystone, lime, limestone, caliche, marl, highly clayey sand, etc. It may include thin Hydrostratigraphic Units of fine to coarse sand or sandstone if they represented a small part of the overall sequence. Hydrostratigraphic Unit 4 is not continuous regionally, but when combined with the occurrence of Hydrostratigraphic Unit 3, the two Units create an extensive zone of low permeability.

Hydrostratigraphic Unit 5, the more permeable zone of the Ogallala Group, begins at the start of the sandy phase or phases of the Ogallala Group begin; where sand, silty sand, sandstone, sand and gravel predominate. The base of Hydrostratigraphic Unit 5 is the contact point with any of Hydrostratigraphic Units 6 through 10. The contact with Hydrostratigraphic Units 7 through 10 is one of geologic Hydrostratigraphic Unit difference, while the Hydrostratigraphic Unit 5/6 contact is based solely on the physical difference of the material as both are within the Ogallala Group.

Hydrostratigraphic Unit 6 consists of silt, clay, siltstone or claystone and has relatively little coarse grain sediment. The base of Hydrostratigraphic Unit 6 is defined by its contact with any of the Hydrostratigraphic Units 7 through 10.

Hydrostratigraphic Unit 7 represents the Arikaree Group, thus both top and bottom of this Hydrostratigraphic Unit are a geologic age/Hydrostratigraphic Unit horizons.

Hydrostratigraphic Unit 8 is made up of either fractured zones of limited occurrence, found in the upper surface of the Brule Formation or fluvial channel deposits found throughout. This is a physical condition identified by well drillers and is based on intervals of fracturing detected while drilling. The fracture zones are located beneath valleys in the panhandle of Nebraska.

Hydrostratigraphic Unit 9 consists of the remainder of the White River Group. The top of Hydrostratigraphic Unit 9 is the beginning of unfractured Brule Formation. Where the Chadron Formation directly underlies the Brule Formation, it is included within Hydrostratigraphic Unit 9. The base of Hydrostratigraphic Unit 9 is the contact of the Brule and/or Chadron Formations with the Cretaceous aged geologic units.

Hydrostratigraphic Unit 10 is the undifferentiated Cretaceous bedrock. This surface is in conjunction with Hydrostratigraphic Unit 9 and is considered the base of the aquifer.

### **Information Used for Developing the Hydrostratigraphic Units**

Evaluation of Conservation and Survey Division Test-Hole log books in conjunction with the Department of Natural Resources well registration database and published surficial and subsurface geologic maps provided information needed to determine the extent and shape of the 10 Hydrostratigraphic Units. Published reports on the geology of the study area were also considered. This data was compiled in both a database of well logs and maps which is accessible at the COHYST website.

Approximately 67,000 well logs from various sources were reviewed for quality and content to determine if they met minimum standards for inclusion in the database. Site location, land surface altitude, clarity of lithologic descriptions, depth drilled, and groups/formations penetrated and existences of geophysical logs were the types of information included in the process. A total 6494 records were accepted for analysis.

Proper site location descriptions were the primary concern when evaluating whether or not to add a well log to the database. All sites in the COHYST database include County, Township, Range, Section and quarter section. Some sites had precision down to 2.5 acres, and/or footage from section corner. If global positioning system locations were available they were included as direct inputs to the X-Y coordinates of the database. All of the records in the Conservation and Survey Division Test-Hole logbooks had high precision locations. These locations followed an established protocol for location, which included measured distances from section corners. The precision of locations within the DNR well registration database varies, but the locations included in the COHYST database were considered acceptable. Surficial geologic maps were digitized for use in determining the location of geologic formation outcrops.

Land surface altitudes were determined for each well log location by calculating an altitude from USGS 30 meter DEMs for the COHYST area. Altitudes for all sites are included in the COHYST database. A contour map of land surface altitude at 100-foot intervals was created from the 1:24, 00 topographic maps for the COHYST area. This map was used to determine altitude for the outcrop areas.

Clarity of the lithologic description is the next most important criteria considered for selecting well logs for the COHYST database. The lithologic descriptions of the Conservation and Survey Division Test-Hole log books were the most precise and contained the highest quality descriptions available for the study area. These records include detailed descriptions of grain size, sorting, cementation, mineralogy, color, fossils and geologic formations penetrated. Some of these logs have a geophysical log of some combination of resistivity, spontaneous potential, and natural gamma. The lithologic descriptions of well logs from the DNR database ranged in quality from very good to very poor.

Total depth drilled and geologic formations penetrated were the last criteria to be evaluated for inclusion in the database. Lithologic logs from wells and test holes that penetrated into the White River Group or Cretaceous Hydrostratigraphic Units selected for the models were the most valuable to this process. Those logs that penetrated more than one geologic formation were the next most useful. Those that were completed in one formation without completely penetrating it were least effective in creating the hydrogeologic layers.

### **Conservation and Survey Test-hole Logs**

In 1930, the Conservation and Survey Division(CSD) of the University of Nebraska and the U.S. Geological Survey began a cooperative study of groundwater in Nebraska. An integral part of the study was the drilling of test holes, which has continued up to the present time (2002). As part of the COHYST study, the Conservation and Survey Division has published Test-Hole logbooks for all 43 Nebraska counties in the COHYST

area. Creation of the Test-hole Log Books consists of compiling all data for each test-hole, studying drill cutting and logs, reviewing test-hole locations and altitudes, doing other research to define geological parameters, and publishing a log book. Table 6 gives information for Test-Hole logbooks for each county in the COHYST area. Figure 13 shows the location of the entire test holes used in the COHYST study.

Table 6. Test-Hole Reports for counties in the COHYST area.

County	Test-Hole Report Number	Author(s)	Latest Date Published	Number of Logs
Adams	1	P. B. Wigley	2001	25
Arthur	3	R. F. Diffendal, Jr. and J. W. Goeke	2000	45
Banner	4	F. A. Smith	2000	32
Box Butte	7	F. A. Smith	2000	55
Buffalo	10	V. H. Dreeszen	2000	119
Chase	15	V. H. Dreeszen	2000	45
Cheyenne	17	R. F. Diffendal, Jr.	2000	198
Clay	18	R. R. Burchett and F. A. Smith	1994	20
Custer	21	L. D. Cast	2004	69
Dawson	24	F. A. Smith	1999	57
Deuel	25	R. F. Diffendal, Jr.	1999	62
Franklin	31	R. R. Burchett and S. E. Summerside	1997	85
Frontier	32	D. A. Eversoll	2000	54
Furnas	33	F. A. Smith	1998	245
Garden	35	F. A. Smith and J. B. Swinehart	2000	47
Gosper	37	L. D. Cast	2000	34
Grant		Unpublished	--	--
Hall	40	V. H. Dreeszen	1999	75
Hamilton	41	P. B. Wigley	1999	20
Harlan	42	R. R. Burchett and S. E. Summerside	1998	94
Hayes	43	D. A. Eversoll	2000	42
Hitchcock	44	D. A. Eversoll	2004	119
Howard	47	V. H. Dreeszen	1999	54
Kearney	50	S. E. Summerside	1999	27
Keith	51	R. F. Diffendal, Jr. and J. W. Goeke	2004	81
Kimball	53	F. A. Smith	2000	79
Lincoln	56	J. W. Goeke	2004	133
Logan	57	P. B. Wigley	2000	6

McPherson	60	J. W. Goeke	2004	32
Merrick	61	F. A. Smith	1999	22
Morrill	62	V. L. Souders and J. B. Swinehart	2000	73
Nance	63	R. R. Burchett and F. A. Smith	1992	14
Nuckolls	65	S.E. Summerside	2003	56
Perkins	68	V. H. Dreeszen	2000	24
Phelps	69	S. E. Summerside	1999	31
Platte	71	R. R. Burchett and S. E. Summerside	1998	89
Polk	72	R. R. Burchett and F. A. Smith	1996	31
Red Willow	73	D. A. Eversoll	2003	172
Scotts Bluff	79	S. S. Sibray and F. A. Smith	2000	49
Sheridan	--	Unpublished	--	5
Sioux	--	Unpublished	--	8
Webster	91	S. E. Summerside	2004	110
York	93	F. A. Smith	2000	28

Based on the need for additional geologic data in several areas within the COHYST study area a test hole drilling effort was conducted by the COHYST effort in cooperation with CSD and the local Natural resources Districts. The North Platte NRD has also worked with CSD to drill over 300 additional test holes in 4 counties in the Panhandle. These additional logs were also reviewed and published by CSD for the COHYST study.

Figure 13.



## COHYST Test-Hole Information

The new drilling program provided additional understanding of critical areas within the model Hydrostratigraphic Units and suggested where future work is needed. It also provides infrastructure for the Natural Resources Districts to collect both water quantity and quality information into the foreseeable future.

Figure 14 shows the location of these sites. All Test-Hole locations were completed to bedrock and lithologic logs were taken using the CSD protocols. Special thanks to Jim Goeke and Steve Sibray of CSD who donated their time and effort to training COHYST personnel and actual logging many of these sites. Lithologic and geophysical logs were made of the each borehole at all sites (Figure 15). Each site was located using survey grade GPS surveys provided by Department of Natural Resources survey division. Samples were taken at distinctive breaks in lithology and every 5 feet where Units were similar. All samples taken during drilling for the lithologic logs are housed at the Conservation and Survey Division office in Lincoln, Nebraska and will be analyzed in greater detail in their laboratory.

20 new test holes totaling 1490 feet of lithologic and geophysical logs were completed in the eastern part of the COHYST area. Within Webster County, 17 sites were drilled, 9 of which were completed as monitoring wells. Test-holes were drilled in Webster County to investigate whether the upland alluvial aquifer was connected to Republican River valley alluvial deposits. Two test-holes were drilled in Nuckolls County to add information: one was completed as a monitoring well. Custer County had three new test holes; all completed with monitoring wells. Monitoring wells were normal installed in the test holes that were drilled and screened at a level well into the principal aquifer (Ogallala, Quaternary Sand & Gravel, fractured Brule, etc). Multi-level wells required a second or third hole to be drilled.

A total of 14 test holes were completed within the central part of the COHYST area with 7620 feet of geologic log. Thirteen of these sites have monitoring wells. Arthur County had one new test hole and it was completed with a monitoring well. Four test holes were completed in Keith County and all test-hole received monitoring wells. Lincoln County has four test-holes with monitoring wells, three of which have multi-level wells. Perkins County has one test hole and no monitoring well. McPherson County has one site with a multi-level monitoring well. Many of these sites were done in cooperation with the USGS High Plains National Water Quality Assessment program.

The Western model Hydrostratigraphic Unit completed 14 test holes amounting to 3975 feet of geologic log and multiple monitoring wells. Garden County has 8 test holes with multiple monitoring wells installed. Two test holes were installed in the Northern part of the county. These two test holes went to a total depth of 860 and 820 feet respectively. Six sites went in along Blue Creek just north of the bedrock high through which the creek has eroded. This is a complicated area both geologically and hydrologically. Groundwater gradients in excess of 60 feet per mile exist in this area. Gradients of this magnitude were indicated by the COHYST model but were not verified until the test-hole drilling and monitoring well installation was complete. Multi-level wells were installed throughout this area in an effort to better understand the groundwater-surface water relationship of the area.

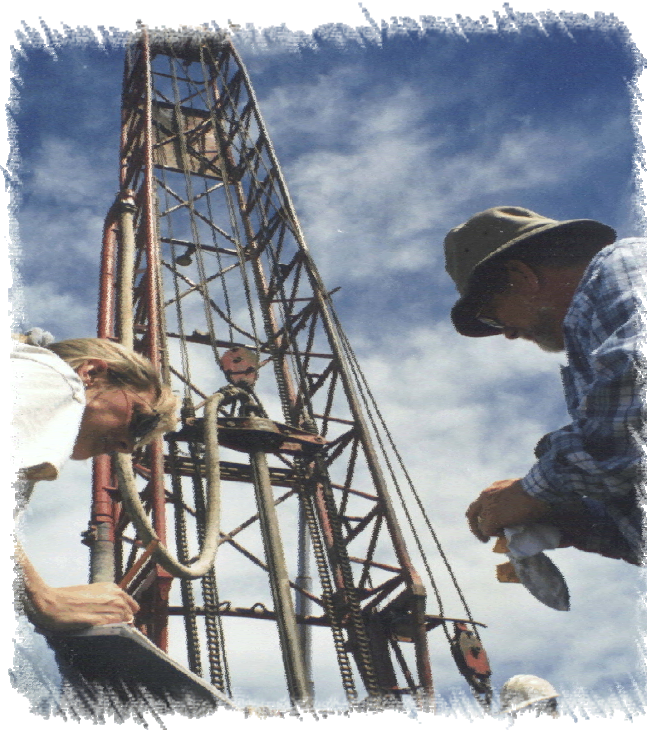
Cheyenne County has 6 sites with 6 monitoring wells with total test-hole footage of 2920 feet. The connection of the Lodge pole Creek alluvium to the Tertiary Ogallala and Brule formations in the vicinity of the City of Sidney was the primary purpose of installing wells in this area. A secondary consideration was to trace Tertiary Ogallala paleo-channels which trends southwest to northeast in Kimball and Cheyenne Counties.

Figure 14.

Figure 15. COHYST Drilling Program



Reviewing a sample for logging



Drilling and logging work in Western Model Area



Geophysical Logging a Test-hole



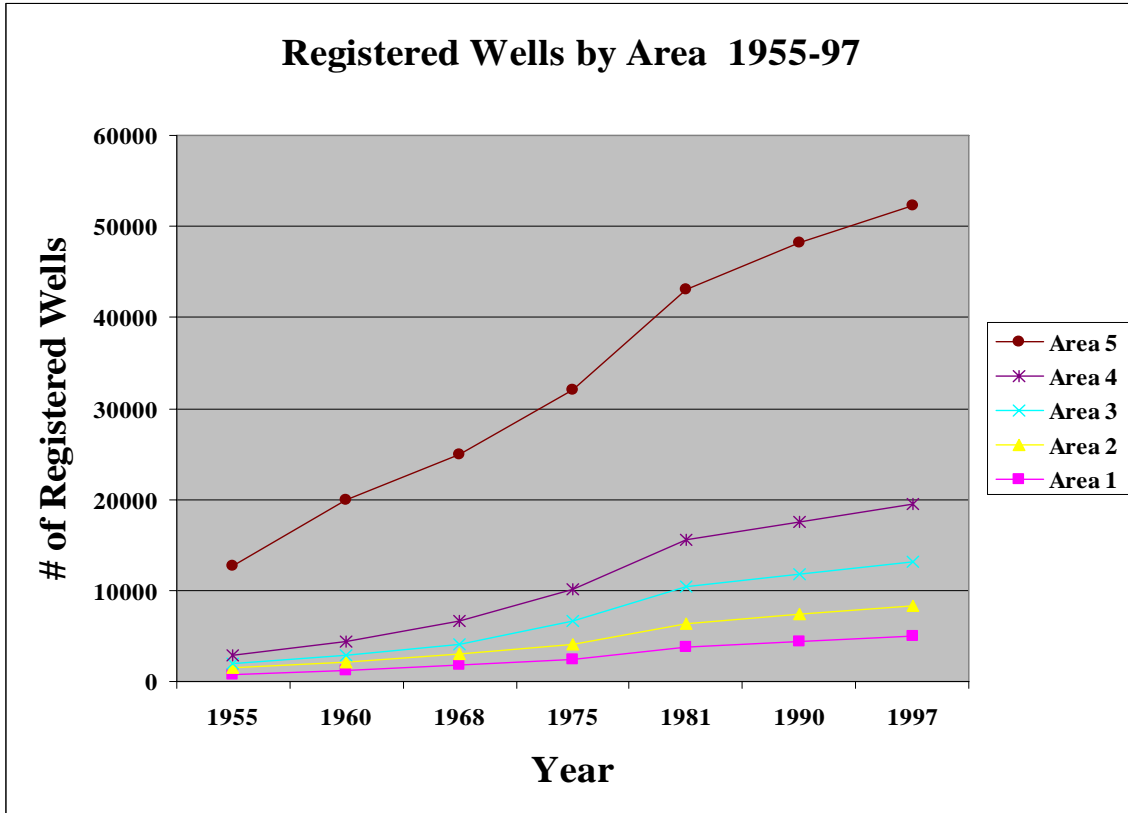
Where is the next drill stem?

## **DNR well registration database of irrigation well logs**

In 1950's the State of Nebraska enacted legislation requiring large capacity wells to be registered. The Nebraska Department of Natural Resources NDNR is the agency that receives and handles the registration process. Past and current registration filings are placed in a database by the NDNR, which is accessible by Internet.

Figure 16 shows the active registered irrigation wells in the COHYST area through June 2001. Also shown are the active irrigation wells that do or do not have a lithologic log. Figure 17 shows registered well development between 1955 and 1997 for the areas depicted in the attached map.

Figure 16



Areas of Registered Well Development

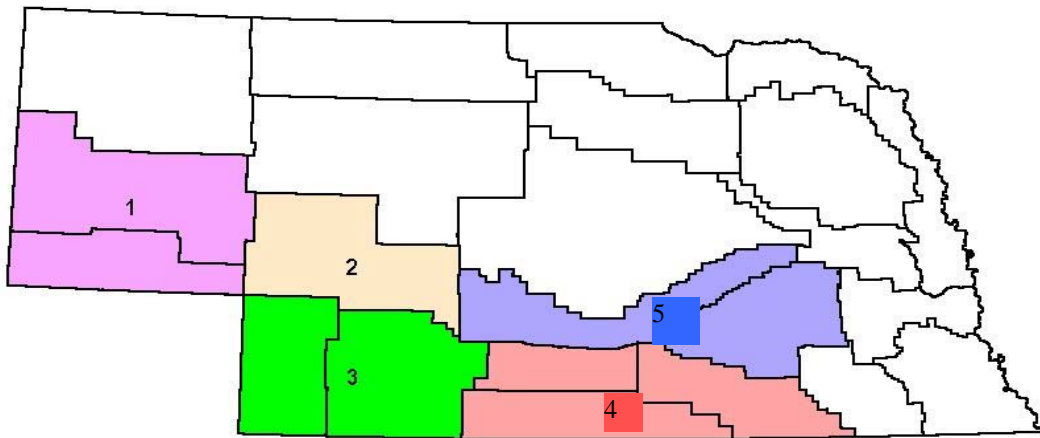


Figure 17

## **Development of Aquifer Database and Hydrostratigraphic Units**

### **Hydrostratigraphic Database Development**

Maps for each Hydrostratigraphic Unit for the COHYST models were constructed using the Hydrostratigraphic database, outcrop maps and geologic reports. A complete copy of the Hydrostratigraphic database may be found on the COHYST website. Initial work consisted of plotting all selected wells as a GIS layer (Figure 18) using the COHYST boundary as the limits of the map. The next step was making Hydrostratigraphic Unit picks from the lithologic records of the database and determining both a top and bottom altitude for the appropriate Hydrostratigraphic Unit. The geologic formation picks were provided as a part of the Conservation and Survey Division Test-Hole log books. These sites were the anchor locations for characterizing the adjacent DNR registered well logs. Table 7 shows a comparison of a Conservation and Survey Division Test-Hole lithologic log and a near by DNR database lithologic log. Both logs were used in the development of the Hydrostratigraphic Units and are part of the Hydrostratigraphic database.

Maps depicting the areas in which the Hydrostratigraphic Unit existed were compiled based on whether a Hydrostratigraphic Unit existed at a particular site. An excerpt from the Hydrostratigraphic database is attached as Table 8 and shows how the thickness was calculated for Hydrostratigraphic Unit 2 at particular well sites. Positive values in the table are altitude picks of top or bottom of the various formations. Negative values are the altitudes of the depth of drilling for borings that did not completely penetrate the particular formation. Formations that do not exist at a site have a zero thickness. Figures 20 through 25 have Hydrostratigraphic Unit existence polygons displayed as shaded areas for Hydrostratigraphic Units 2 thru 8. These areas were drawn and digitized by hand using the information provided by the database and the knowledge of the depositional environment and geology of the Hydrostratigraphic Units. GIS layers in the form of Arc View shape files were the final products of this effort. The existence shape files may be found on the COHYST website.



Figure 18.

Table 7

Table 8

## Hydrostratigraphic Unit Contour Map Development

Maps of altitude of the bottom of each Hydrostratigraphic Unit were created within the existence polygons, by hand contouring information from the Hydrostratigraphic database and the surficial geologic maps of the area. Additional data in the form of oil and gas logs provided additional information in the western model area when there was insufficient information from either the CSD Test-Hole log books or the DNR registered well database. Information from published geologic reports was also considered. Contours were created using 100-foot contour intervals and altitudes are expressed as altitude above mean sea level. Surficial geologic maps and land surface altitudes were used to match the subsurface contours with the outcrop altitudes of the area. Surficial geologic maps were very useful in completing the maps in the western model area because of many of the geologic units are exposed at the surface. The contour maps were digitized and stored in Arc View shape file format. Figures 19 through 25 show the contour maps and existence polygons for each Hydrostratigraphic Unit. They are available at the COHYST website. The base of the Model Aquifer map shown in Figure 26 was developed the same way and used to compare with base of aquifer maps previously developed for the High Plains aquifer. This contour map was developed using the Hydrostratigraphic Unit database altitudes for the top of the Brule Formation and Undifferentiated Cretaceous formation based on the areas shown on the map. Limited visual comparisons show good similarity the 1979 CSD base of aquifer map and comparisons with other base of aquifer maps like USGS High Plains RASA still need to be completed.

Figure 19

Figure 20

Figure 21

Figure 22



Figure 23

Figure 24

Figure 25

Figure 26

## Development of Model Layers

### Mapping altitude values of Hydrostratigraphic Units to model grid

The altitude contour maps of the bottom of each Hydrostratigraphic Unit were turned into grid data sets for each model layer. Model layer grid data sets were developed on cell centered nodes for the 1 mile model grid for each COHYST Model area (Figure 27). Attachment 2 (end of document) gives detailed steps of this process. These outputs were directly imported into the GMS (Groundwater Modeling System) modeling software as model layer datasets. The model layer datasets are on the COHYST Website.

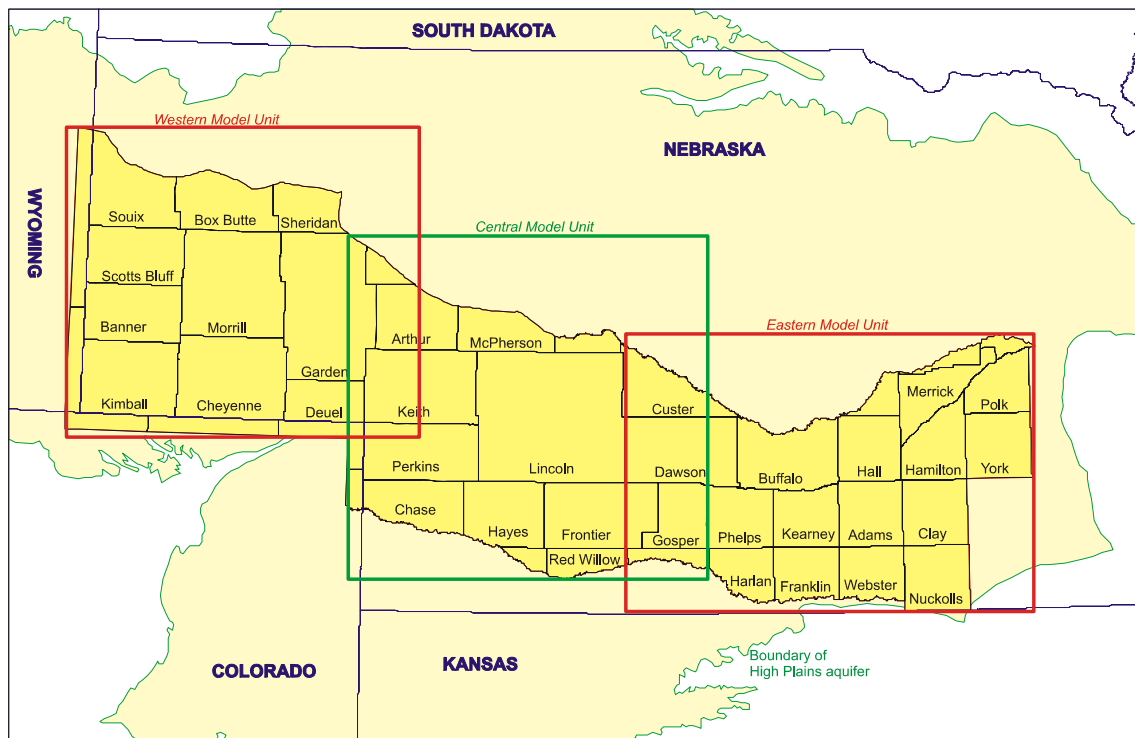


Figure 27. COHYST Model Areas

GIS software was used to calculate the difference between the top and bottom of the Hydrostratigraphic Units to produce thickness maps for each Hydrostratigraphic Unit. These values were then displayed at each grid cell location. Generalized thickness maps of each Hydrostratigraphic Unit were generated by contouring these points in GIS software. Figures 28 through 33 illustrate the generalized thickness maps for the Hydrostratigraphic Units. Fence diagrams of the individual model areas were generated and are presented as Figures 34,35,and 36. These fence diagrams were created by the GMS software for each model unit. The diagrams depict in a general way the aquifer layers used in the MODFLOW models.

Figure 28

Figure 29

Figure 30



Figure 31

Figure 32

Figure 33

Figure 34

Figure 35

Figure 36

## **Development of Aquifer Properties**

### **Hydraulic conductivity**

Two methods for selecting hydraulic conductivity values for the model inputs were explored for suitability for model input. Hydraulic conductivity values from aquifer tests were determined to be the less desirable alternative to a lithologic characterization method for determining equivalent conductivity. Aquifer test results were not continuous across the study area, nor were there enough completed to characterize the Hydrostratigraphic Units. The equivalent hydraulic conductivity values for the model inputs were estimated based upon work at the University of Nebraska Conservation and Survey by E.C. Reed and R. Piskin . They assigned permeability values to various unconsolidated materials based on grain size, particle size, degree of sorting, and silt content. This work has been used by several authors as the basis for estimating hydraulic conductivity of the sedimentary deposits of Nebraska.

The work by Piskin and Reed does not include consolidated lithologic units (sandstone, siltstone, claystone, etc.). Oral communication with Vince Dreeszen, Professor Emeritus of UNL Conservation and Survey Division and informal written notes of Lynn Johnson (USBR geologist) indicated both reduced conductivity values by 50% of the conductivity values established for unconsolidated material when the material was consolidated or cemented. If the material was identified as sandstone with no grain size given, the material was assigned a value of 30 ft/day. No differentiations were made between the sandstones of the Ogallala and the Arikaree Hydrostratigraphic Units.

The Geoparm program developed by Rich Kern of NDNR automated the methods used to assign hydraulic conductivity and specific yield values to the Hydrostratigraphic Unit (see Attachment 1). The average conductivity value was obtained by assigning a value to the material as defined by Piskin and Reed for each discrete interval of a test-hole and within the Hydrostratigraphic Unit. This was done for all test-holes shown in (Figure 13). Then multiplying that value by the thickness of the discrete intervals within the Hydrostratigraphic Unit, summing these computed values, and then dividing by the thickness of the entire Hydrostratigraphic Unit. This procedure was uniformly applied for all Hydrostratigraphic Units. The average value of the Hydrostratigraphic Unit in the test-hole was used to create hydraulic conductivity contours for layers 2, 5 and 7. Hydraulic conductivity contours were not created for the Hydrostratigraphic Units 1, 3-4, 6 and 8 because the range of values were did not vary enough to contour. An average value for hydraulic conductivity was determined for these Hydrostratigraphic Units.

Hydrostratigraphic Unit 1 is generally unsaturated and composed primarily of fine-grained materials, i.e. silt, clay, fine sand, etc. The calculated average value for Hydrostratigraphic Unit 1 on all test-holes was used as one "k" throughout the study area. Hydrostratigraphic Units 6-10 were not contoured and the same averaging procedure was used as per Hydrostratigraphic Unit 1.

The hydraulic conductivity contours of Hydrostratigraphic Unit 2 (Figure 37) was subdivided into 5 groups; 25-49, 50-74, 75-99, 100-124, and 125+ft/day. During the 1940's the Conservation and Survey Division developed a standardized method for obtaining and describing materials encountered by a test-hole. Prior to this time considerable variance in material descriptions occurred primarily in

Figure 37



The coarse grained sand and gravel. The pre 1940 test-holes undisciplined descriptions resulted in extremely high (200+ft/day) “k” values for those holes, which were considered by this study to be unusual. Consequently the maximum rule was established that set the last classification division to 125+ft/day.

The hydraulic conductivity contours of Hydrostratigraphic Unit 3-4 (Figure 38) was subdivided into 3 groups; 1-10, 11-20, and 21-30 ft/day.

The hydraulic conductivity contours of Hydrostratigraphic Unit 5 (Figure 39) were subdivided into 4 groups; 1-24, 25-49, 50-100, and 100+ ft/day. The non-uniform conductivity range was implemented based on the abundance of “k” values less than 49 in comparison to the higher values.

The hydraulic conductivity map for Hydrostratigraphic Unit 7 (Figure 40) exists only in the Western area and was subdivided into 2 groups: 0.1-10 and 11-20.

Table 9 is an excerpt of selected values from the Aquifer Properties Database. This database can be found on the COHYST website as a Arc-View GIS shapefile.

Table 9

Figure 38

Figure 39

Figure 40

## **Specific Yield**

A.I. Johnson (1967) compiled specific yield data for various materials in USGS water supply paper 1662-d. These values were modified by Peckenpaugh and Dugan (1983) in USGS water resources report 83-4219 and assigned to the compilation of materials described by Piskin and Reed. Peckenpaugh and Dugan's assigned values were used to determine the average specific yield of each individual Hydrostratigraphic Unit and then the average was assigned as the representative value of the entire Hydrostratigraphic Unit throughout the study area. Using the same process as used to estimate hydraulic conductivity the Geoparm program estimated the specific yield by test-hole (see Attachment 1). The estimated values are contained in Aquifer Properties Database and Arc-View GIS shapefile.

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# Attachments

## Attachment 1

Nebraska Cooperative Hydrology Study  
Computer Program Documentation  
Geoparm – Hydraulic Conductivity and Storage Coefficient from Well Logs  
Rich Kern <sup>1</sup> P.E.

The purpose of this program is to assist in the assignment of a hydraulic conductivity value (feet per day) and specific yield to each geologic layer based on the lithologic material, texture description, silt content and sorting modifiers.

### Results

The out put of this program is a series of files showing the legal description, land surface elevation at the well log and then a series of lines (one for each lithology) showing the top, bottom, thickness, derived hydraulic conductivity and specific yield values, and the recognized phrases from each lithology that were used to derived the HC ad SY values. The name of each output file is the name of the testhole it is representing along with a “.out” extension.

### Process

The general process is to first read in a file that defines hydraulic conductivity (HC) and specific yield (SY) values based on pre-defined lithologic material descriptions and various modifiers. These hydraulic conductivity and specific yield values are derived from an unpublished and undated report by E. C. Reed and R. Piskin, Conservation and Survey Division, University of Nebraska. Then each well log is read in and compared to the pre-defined descriptions As well log description phrases are matched with phrases in the Reed and Piskin report, values are assigned to each lithologic layer and written to an output file.

### Advantages of this process

In other modeling studies, researchers have relied primarily on aquifer tests to determine the hydrogeologic characteristics. While these are considered pretty accurate, they are relatively expensive and sparsely located. Although the results actually only apply to a single point location or relatively small area, they are usually extrapolated to a large area. Consequently, there is usually not a lot of actual data available to determine parameters over a large expansive model area such as the COHYST study.

Through the development of this process, testhole logs can be used to determine the hydrogeologic characteristics of the aquifer. While these are still just point locations and

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representative of an even smaller area than the aquifer tests, there are a much larger number of points available. There were nearly 3000 logs available for analysis in the COHYST area so should represent the model area much more densely than aquifer tests.

### **Disadvantages of this process**

In some ways, it might be a disadvantage to have so much data available to determine the hydrogeologic characteristics of the aquifer. With so much information, it could be difficult to review all of it to ensure interpretations from all the derived information are valid. This was counteracted by plotting the results against results from previous studies to determine any inconsistencies. Also, contouring the data helps to flag any data that may not be consistent with surrounding data points. The data used to determine the derived values could then be reviewed to see if any interpretations were incorrect.

Another disadvantage of this process is that the testhole logs were not always entirely consistent. As will be explained later in the discussion, this process is dependent on the GeoParm program being able to recognize exact key phrases in the logs. If there were typos in the data, recognitions that should have been made might have failed and incorrect interpretations could have been made. Plotting the results as described in the previous paragraph should be able to locate any gross errors but more subtle errors might still go unnoticed. However, it was assumed that just having this vast volume of data available would mask any subtle errors so when spread over the entire modeling effort, the consequences would be balanced out and prove to be insignificant.

### **Programs, Input and Output Files**

#### **GeoParm**

There is only one program associated with this procedure. GeoParm has two main processes and several sub-processes within each of the primary steps.

The first main process involves reading and storing the table derived from the Reed and Piskin information and the modifier data associated with it. The table below shows the estimated hydraulic conductivities from the Reed and Piskin paper as it was published in "Hydrogeology of Parts of the Twin Platte and Middle Republican Natural Resources Districts, Southwestern Nebraska" by J. W. Goeke, J. M. Peckenpaugh, R. E. Cady, and J. T. Dugan, Nebraska Water Survey Paper No. 70, April 1992, published through the Conservation and Survey Division, Institute of Agriculture and natural Resources, University of Nebraska-Lincoln.

Grain-size class or range (from description of saturated sediments)	Hydraulic conductivity, in feet per day <sup>(a)</sup>					
	Degree of sorting			Silt content		
	Poor	Moderate	Well	Slight	Moderate	High
Clay and silt:						
Clay.....				1.0		
Silt, slightly clayey.....				10.0		
Silt, moderately clayey.....				8.0		
Silt, very clayey.....				4.0		
Silt; loess; sandy silt.....				15.0		
Sand and gravel <sup>(b)</sup> :						
Very fine sand.....	13	20	27	23	19	13
Very fine to fine sand.....	27	27		24	20	13
Very fine to medium sand.....	36	41-47		32	27	21
Very fine to coarse sand.....	48			40	31	24
Very fine to very coarse sand.....	59			51	40	29
Very fine sand to fine gravel.....	76			67	52	38
Very fine sand to medium gravel.....	99			80	66	49
Very fine sand to coarse gravel.....	128			107	86	64
Fine sand.....	27	40	53	33	27	20
Fine to medium sand.....	53	67		48	39	30
Fine to coarse sand.....	57	67-72		53	43	32
Fine to very coarse sand.....	70			60	47	35
Fine sand to fine gravel.....	88			74	59	44
Fine sand to medium gravel.....	114			94	75	57
Fine sand to coarse gravel.....	145			107	87	72
Medium sand.....	67	80	94	64	51	40
Medium to coarse sand.....	74	94		72	57	42
Medium to very coarse sand.....	84	98-111		71	61	49
Medium sand to fine gravel.....	103			84	68	52
Medium sand to medium gravel.....	131			114	82	66
Medium sand to coarse gravel.....	164			134	108	82
Coarse sand.....	80	107	134	94	74	53
Coarse to very coarse sand.....	94	134		94	75	57
Coarse sand to fine gravel.....	116	136-156		107	88	68
Coarse sand to medium gravel.....	147			114	94	74
Coarse sand to coarse gravel.....	184			134	100	92
Very coarse sand.....	107	147	187	114	94	74
Very coarse sand to fine gravel.....	134	214		120	104	87
Very coarse sand to medium gravel.....	170	199-277		147	123	99
Very coarse sand to coarse gravel.....	207			160	132	104
Fine gravel.....	160	214	267	227	140	107
Fine to medium gravel.....	201	334		201	167	134
Fine to coarse gravel.....	245	289-334		234	189	144
Medium gravel:	241	321	401	241	201	160
Medium to coarse gravel.....	294	468		294	243	191
Coarse gravel.....	334	468	602	334	284	234

<sup>(a)</sup> Hydraulic conductivity values are from an unpublished and undated paper by E.C. Reed and R. Piskin, Conservation and Survey Division, University of Nebraska.

<sup>(b)</sup> Reduce hydraulic conductivity by 10 percent if grains are subangular.

The actual data used in this program was modified from Reed and Piskin to fit the needs of this program. Additionally, SY data was obtained, and added to the input file, from Larry Cast based on his years of experience as a geologist with the Bureau of Reclamation. A detailed description of that input file and the changes made are included below in the discussion on the program inputs.

After the descriptive phrases have been read in and stored, the loop of reading and processing each testhole log begins. There are several sub-steps to this loop involving cleaning up the input data, matching the log descriptions to phrases in the Reed and Piskin report, assigning the HC and SY, modifying the outputs as necessary, and writing the output.

All of the testhole logs to be processed have to be in one folder with the extension of “.asc”. This input data is derived from the UNL Conservation and Survey Division Test-Hole Log Word Perfect® files. The files were read into Microsoft® Word and saved as MS-DOS Text with Layout (\*.asc) format. This is an ASCII format that retains the “look” of the Word Perfect files so the columns and spacing are maintained

The initial step is to open the first input “.asc” file and the output “.out” file. The first part of each file will have the same format. The file name for each “.asc” and “.out” file begins with the ID of the testhole log and will be a name like “01A58.asc” for example. With the input file open, the first line is read. This contains the legal description of the test-hole log. The legal description format is not always consistent so it must be parsed to find the township, range, direction, section, and quarter section information. The direction must be either “E” for east or “W” for west. Next the ground elevation is retrieved from the input file. This is also not in a consistent format so it must also be located within the input file. Both the legal location and the ground elevation are then output to the “.out” file for later use. The first record of the lithology information must next be located because this format is also not consistent. Once found, the next task is to cycle through each record to determine the appropriate HC and SY values.

The format of the description for each lithology is not consistent from file to file so an attempt is made by the program to “clean up” each record. For instance, sometimes in the lithology description, a “-“ is used to separate items and other times two spaces are used. Both of these are converted into one space in the program. Also used to separate items are “;”, “:”, and “,”. These are all converted into “,” for consistency and ease of parsing. Sometimes “road fill” is the first phrase on the first record. This is stripped out, as well as the word “soil”. After each description is “cleaned up” it is stored along with the starting and ending depths from land surface for each layer until the entire file is read in, parsed and stored.

The last step for each file is to actually search each layer for each of the recognized material types. If no recognized material is found, a dialog box pops up to ask the user what HC to assign this layer. Only silt, gravel, sandstone, sand and gravel, and sand have texture or gradation information. If further texture or gradation qualifiers are available for that material a search is made for that additional qualifier. If found, the associated HC is assigned and if not, the standard default value is assigned to this layer. Another search is made for additional sorting phrases. Finally another search for final material modifiers is made on the record and, the HC is modified by the appropriate factor. This modifier is based on silt content and inter-bedded layer information. The entire log is parsed this way and a HC value is assigned for every layer.

The SY is assigned in the same manner except there are no ranges of data based on sorting as there are for HC values. SY values are still modified based on gradation information as are the HC values. This will all become more clear below in the discussion of the input and output files where examples can be used to display the process and results.

The hydraulic conductivities assigned by this program to each material, texture, and Modifier are based on standard values presented by Reed and Piskin. The scaling of standard HC values over the range of modifiers was suggested by Mr. Larry Cast, based on many years of experience in evaluating well log stratigraphy. The standard values and scaling factors should be confirmed by any user. The storage coefficients assigned by GeoParm were obtained from Mr. Larry Cast and apply to unconfined aquifers only, based on standard specific yields of the materials.

Below is the documented source code for GeoParm.

```
' The purpose of this program is to assist in the assignment of a hydraulic
' conductivity value (feet per day) and specific yield to each geologic
' layer based on the lithological material, texture description, silt
' content, and sorting modifiers.
'
' The general process is to first read in a file that defines hydraulic
' conductivity (HC) and specific yield (SY) values based on pre-defined
' lithological material descriptions and various modifiers. These are stored
' for later use. Then each well log is read in and compared to the pre-defined
' descriptions. As matches are found, hydraulic conductivity and specific
' yield values based on an unpublished and undated report by E. C. Reed and
' R. Piskin, Conservation and Survey Division, University of Nebraska are
' assigned to each lithological layer and written to an output file.
'
' Variable Dictionary
'
' bb - location of " " (double blanks) in log description
' c - location of "," (comma) in an elevation value
' cc - location of various spurious characters in log description
' Defaultx - Default Hydraulic Conductivity if no modifier is found
' DefaultxSY - Default Specific Yield if no modifier is found
' Desc$ - testhole lithology description
' e$ - ground elevation taken from testhole log
' eend - end of the word "elevation" in a line
' est - location in a line for the word "elevation"
' Fact - Factor to multiply basic Hydraulic Conductivity value based modifier
' Factor - temporary value for multiplier factor
' fil$ - file name and also testhole number
' flin$ - Legal Description read in from testhole log
' FromFeet - Top of lithology
' grp$ - lithologic group such as gravel, sandstone, sand, etc.
' HC - assigned Hydraulic Conductivity
' hit - identifier to save in index of the material description group
' irow - counter used to keep track of grain-size descriptions as they are
' being read in
' j - index to cycle through log descriptions
' k - index to cycle through For...Next loops
' l - index to use as counter for modifiers
' m - index to cycle through groups for recognizable material in descriptions
' LastFile - variable to keep track of last file processed. If processing
' is interrupted, it will be restart based on this number
' lg - ignore - this is no longer used
' lin$ - temporary variable used when reading input data from files
' MCode$ - Search code used to define which type of search algorithm to use
' for that group
' MDefault$ - default HC for that group
' MDefaultYS$ - default SY for that group
' MDesc$ - grain-size description
' MHCM$ - HC for moderately sorted material based on grain-size description
' MHCP$ - HC for poorly sorted material based on grain-size description
' MHCW$ - HC for well sorted material based on grain-size description
' MEnd$ - counter of last record of a grain-size description
' MNo$ - number of grain-size descriptions for that group
' ModMax - Maximum number of modifiers
' Mods - Modifier phrase
' MStart$ - counter of first record of a grain-size description
' MSY$ - SY based on grain-size description
```



```
' n - index to cycle through modifiers in each block
' NewDesc - Found description from group
' NewMat - Found material from the Material Listbox
' NewMod - Found modifier description
' No - number of modifiers in each block
' Prompt$ - Prompt to describe interim results for Inputbox
' qqqq$ - quarter-section description
' Reply$ - temporary variable used while waiting for response
' RStart$ - restart number if other than LastFile
' SC - assigned Specific Conductance
' Sort$ - variable used to save the degree of sorting in lithology
' sp - location of the space character in the legal description
' t1, t2, t3, t4 - location of tab characters in an input line (this would
' not have been necessary had I known about the "split"
' function when I wrote this program).
' t$ - tab character
' Title$ - Title for interim results Indexbox
' ToFeet - bottom of lithology
```

```
Private Sub Form_Load()
```

```
'This is the primary subroutine that does most of the work of the program.
'It reads in the table of materials for the logs to be compared to and
'assigns HC and SY values. It also allows for the operator to assign
'values when matches are not found automatically.
```

```
Dim mods(30) As String, Fact(30) As Single
Dim NewMat As String, NewDesc As String, NewMod As String
Show
t$ = Chr$(9)
```

```
'Read in reduction modifiers
```

```
Open "modify.txt" For Input As #1
For k = 1 To 2
Input #1, No, Factor
For n = 1 To No
l = l + 1
Input #1, lin$
mods$(l) = lin$
Fact(l) = Factor
Next
Next
```

```
'Read in material, search style code, # of codes, default
```

```
ModMax = l
Input #1, lin$
irow = 0
Do Until EOF(1)
Line Input #1, lin$
t1 = InStr(lin$, t$)
t2 = InStr(t1 + 1, lin$, t$)
t3 = InStr(t2 + 1, lin$, t$)
t4 = InStr(t3 + 1, lin$, t$)
grp$ = Left$(lin$, t1 - 1)
MCode$ = Mid$(lin$, t1 + 1, t2 - t1 - 1)
MNo$ = Mid$(lin$, t2 + 1, t3 - t2 - 1)
MDefault$ = Mid$(lin$, t3 + 1, t4 - t3 - 1)
MDefaultSY$ = Mid$(lin$, t4 + 1)
MStart$ = Format(irow)
MEnd$ = Format(irow + Val(MNo$) - 1)
irow = irow + Val(MNo$)
IstMat.AddItem (grp$)
IstMCode.AddItem (MCode$)
IstMDefault.AddItem (MDefault$)
IstMDefaultSY.AddItem (MDefaultSY$)
IstMStart.AddItem (MStart$)
IstMEnd.AddItem (MEnd$)
For k = 1 To Val(MNo$)
```

```
'Read in description, hydraulic conductivity for various sorting conditions and
```

'specific yield

```
Line Input #1, lin$
t1 = InStr(lin$, t$)
t2 = InStr(t1 + 1, lin$, t$)
t3 = InStr(t2 + 1, lin$, t$)
t4 = InStr(t3 + 1, lin$, t$)
MDesc$ = Left$(lin$, t1 - 1)
lstMDesc.AddItem (MDesc$)
MHCP$ = Mid$(lin$, t1 + 1, t2 - t1 - 1)
lstMHCP.AddItem (MHCP$)
MHCM$ = Mid$(lin$, t2 + 1, t3 - t2 - 1)
lstMHCM.AddItem (MHCM$)
MHCW$ = Mid$(lin$, t3 + 1, t4 - t3 - 1)
lstMHCW.AddItem (MHCW$)
MSY$ = Mid$(lin$, t4 + 1)
lstMSY.AddItem (MSY$)
Next
Line Input #1, lin$
Loop
Close
If dirList.ListIndex + 1 <> dirList.ListCount Then dirList.ListIndex = dirList.ListIndex + 1
filList.Path = dirList.List(dirList.ListIndex)
```

'Check for next file to process. This is used in case processing had previously  
'been interrupted. The LastFile variable keeps track of the last testhole  
'log that had been completed

```
Open "LastFile.RAK" For Input As #4
Input #4, LastFile
Close #4
RStart$ = Format(LastFile)
RStart$ = InputBox("What File Number do you want to start with?", , RStart$)
LastFile = Val(RStart$)
l = 0
lg = Val(RStart$)
```

'Start main cycle of processing testhole logs

```
For k = LastFile To filList.ListCount - 1
```

'Get next testhole log file name

```
fil$ = Left$(filList.List(k), Len(filList.List(k)) - 3)
```

'Open input and output files

```
Open dirList.List(dirList.ListIndex) + "\" + fil$ + ".asc" For Input As #1
Open dirList.List(dirList.ListIndex) + "\" + fil$ + ".out" For Output As #2
Debug.Print fil$; " ";
txtProcessing = Format(k) + ", " + Left(fil$, Len(fil$) - 1)
```

'Read the legal description

```
Line Input #1, flin$
lg = lg + 1
```

'Get Ground Elevation

```
Do Until InStr(lin$, "levation:") > 0
Line Input #1, lin$
Loop
est = InStr(lin$, "levation:")
eend = InStr(est + 13, lin$, " ")
e$ = Trim(Mid$(lin$, est + 9, eend - est - 9))
c = InStr(e$, ",")
If c > 0 Then e$ = Left$(e$, c - 1) + Mid$(e$, c + 1)
```

'Check the legal description to see if the form is correct.

```
sp = 0
Do Until sp > 0
```

```

sp = InStr(11, flin$, " ")
If (sp - 11) > 6 Or sp = 0 Then
    flin$ = InputBox("This Legal Description does not appear to be correct", "Legal Description Correction", flin$)
End If
sp = InStr(11, flin$, " ")
Loop

```

'Print TRDSQQQQ, file sequence #, and ground elevation. The file sequence #  
'was used initially in this process but its functionality was later dropped  
'so should be ignored. It no longer has any use but was left in because other  
'post-processing programs expected that value to be present.

```

qqqq$ = Mid$(flin$, 11, sp - 11)
Print #2, Format(Ig, "000000"); " "; Left$(flin$, 2); Mid$(flin$, 4, 7); " "; qqqq$; Spc(12)
Print #2, Format(Ig, "000000"); " "; e$

```

'Find Start of testhole log

```

Do Until InStr(lin$, "Depth, in feet") > 0
    Line Input #1, lin$
Loop
Line Input #1, lin$
Desc$ = ""
ToFeet = 9999

```

'Loop through lines until a complete description is read in for each lithology

```

Do Until EOF(1)
    DoEvents

```

'Some lines do not have lithology descriptions so are discarded

```

Do
    Line Input #1, lin$
Loop Until Left$(lin$, 3) = " " Or EOF(1)

```

'Find the top and bottom of each lithology

```

If InStr(Mid$(lin$, 57), ".") > 0 Then
    FromFeet = Val(Mid$(lin$, 57, 8))
    ToFeet = Val(Mid$(lin$, 64))
    lin$ = Trim$(Left$(lin$, 55))
    Do Until Right$(lin$, 1) <> "."
        lin$ = Left$(lin$, Len(lin$) - 1)
    Loop
End If

```

'Clean up line for consistency

```

If Right$(Desc$, 1) <> "-" Then
    Desc$ = Desc$ + " " + LCase$(Trim$(lin$))
Else
    Desc$ = Left$(Desc$, Len(Desc$) - 1)
    Desc$ = Desc$ + Trim$(lin$)
End If
Do Until Left$(Desc$, 1) <> " "
    Desc$ = Mid$(Desc$, 2)
Loop

```

'Convert "-" to " "

```

cc = InStr(Desc$, "-")
Do Until cc = 0
    Desc$ = Left$(Desc$, cc - 1) + " " + Mid$(Desc$, cc + 1)
    cc = InStr(Desc$, "-")
Loop

```

'Convert " " to " "

```

bb = InStr(Desc$, " ")
Do Until bb = 0
    Desc$ = Left$(Desc$, bb - 1) + Mid$(Desc$, bb + 1)

```

```

    bb = InStr(Desc$, " ")
Loop

'Convert ";" to ","
cc = InStr(Desc$, ";")
Do Until cc = 0
    Desc$ = Left$(Desc$, cc - 1) + "," + Mid$(Desc$, cc + 1)
    cc = InStr(Desc$, ";")
Loop

'Convert ":" to ","
cc = InStr(Desc$, ":")
Do Until cc = 0
    Desc$ = Left$(Desc$, cc - 1) + "," + Mid$(Desc$, cc + 1)
    cc = InStr(Desc$, ":")
Loop
RecheckSoil:

'Get rid of "soil"
If Left$(Desc$, 4) = "soil" Then
    Desc$ = Trim$(Mid$(Desc$, 6))
    If Left$(Desc$, 4) = "and " Then
        Desc$ = Mid$(Desc$, 5)
    End If
End If

'Get rid of "Road fill"
If InStr(LCase$(Desc$), "road") > 0 Then
    rd = InStr(LCase$(Desc$), "road")
    blink = InStr(rd + 6, Desc$, " ")
    If blink > 0 Then
        Desc$ = Trim$(Mid$(Desc$, blink))
    Else
        Desc$ = ""
    End If
    If InStr(Desc$, "and ") > 0 Then
        Desc$ = Mid$(Desc$, 5)
        GoTo RecheckSoil
    End If
End If

'Store description, top and bottom in list boxes for later parsing
If ToFeet <> 9999 Then
    IstStart.AddItem (Format(FromFeet))
    IstEnd.AddItem (Format(ToFeet))
    IstDesc.AddItem LCase$((Trim$(Desc$))) + ","
    IstHC.AddItem ""
    IstSC.AddItem ""
    IstNewMat.AddItem ""
    IstNewDesc.AddItem ""
    IstNewMod.AddItem ""
    IstSort.AddItem ""
    Desc$ = ""
    ToFeet = 9999
End If
Loop
Close #1

'After all data from testhole log has been read in and stored, recycle through
'descriptions to parse for known material types

For j = 0 To IstDesc.ListCount - 1
    IstDesc.ListIndex = j
    Desc$ = IstDesc.List(j)
    c = InStr(Desc$, ",")
    Mat$ = Trim$(Left$(Desc$, c - 1))
    For m = 0 To IstMat.ListCount - 1

```

'Initialize Variables to blank

```
NewMat = ""  
NewDesc = ""  
NewMod = ""
```

'MCode\$ identifies the search code method for each material

```
MCode$ = IstMCode.List(m)  
Select Case MCode$
```

'If MCode=0 then material in description must match the recognized material  
'in input file exactly

```
Case "0"  
If Mat$ = IstMat.List(m) Then  
NewMat = IstMat.List(m)  
GoTo Match  
End If
```

'If MCode=2 then material in description must start with the recognized  
'material in input file but anything can follow

```
Case "2"  
In = Len(IstMat.List(m))  
If Left$(Mat$, In) = IstMat.List(m) Then  
NewMat = IstMat.List(m)  
GoTo Match  
End If
```

'If MCode=3 then the recognized material in input file must be found in the  
'description but anything can precede that material and anything can follow

```
Case "3"  
If InStr(Mat$, IstMat.List(m)) > 0 Then  
NewMat = IstMat.List(m)  
GoTo Match  
End If
```

'If MCode=anything else, then both the material and the search text must be  
'found in the description

```
Case Else  
If InStr(Mat$, IstMat.List(m)) > 0 And InStr(Mat$, MCode$) > 0 Then  
NewMat = IstMat.List(m) + " and " + MCode$  
GoTo Match  
End If  
End Select
```

'If no match is found, keep searching. If match is found, check for texture  
'description

```
GoTo Nomatch  
Match:
```

'A matching material type has been found so look for the texture and sorting

```
MStart = IstMStart.List(m)  
MEnd = IstMEnd.List(m)  
If Val(MEnd) > Val(MStart) Then  
For i = Val(MStart) To Val(MEnd)  
If InStr(Desc$, IstMDesc.List(i)) > 0 Then
```

'Texture found now check for sorting. If sorting information is not found, assume  
'"moderately sorted".

```
If InStr(Desc$, "poorly sorted") > 0 Then  
Sort$ = "poorly"  
HC = IstMHCP.List(i)  
Elseif InStr(Desc$, "well sorted") > 0 Then  
Sort$ = "well"  
HC = IstMHCW.List(i)  
Elseif InStr(Desc$, "moderately sorted") > 0 Then  
Sort$ = "moderately"
```

```

        HC = IstMHCM.List(i)
    Else
        HC = IstMHCM.List(i)
    End If
    NewDesc = IstMDesc.List(i)
    hit = m
    SC = IstMSY.List(i)
    GoTo CheckMod
End If
Next
Else

```

'No texture modifiers available so use defaults

```

    HC = IstMDefault.List(m)
    SC = IstMDefaultSY.List(m)
    hit = m
    GoTo CheckMod
End If

```

'Material type found but no texture found. Ask to use default or change to another value. Sometimes texture is actually present in log but typos make it so they can't be recognized by program.

```

If NewMat <> "silt" Then
    Prompt$ = "Found " + Mat$ + Chr$(13) + Chr$(10) + "but no Modifier" + Chr$(13) + Chr$(10) + "LINE = " + Desc$
    Title$ = "Use what for HC"
    Defaultx = IstMDefault.List(m)
    DefaultxSY = IstMDefaultSY.List(m)
    If InStr(Desc$, "poorly sorted") > 0 Then
        Sort$ = "poorly"
        If m = 1 Then
            Defaultx = 241
        ElseIf m = 4 Then
            Defaultx = 67
        End If
    End If
End If

```

'Set default values for text prompt when textures not found

```

Reply$ = ""
txtReply = ""
txtMsgBox = Prompt$
txtDefault = Defaultx
txtDefaultSY = DefaultxSY

```

'Wait for response from user to either accept defaults or change them

```

GetReply Reply$

```

'Set a flag to identify in the output file if non-standard values were entered

```

If txtReply <> Defaultx Then
    NewDesc = "modified"
Else
    NewDesc = ""
End If

```

'Use informat from user response. These may either be the default values or user-supplied numbers

```

    HC = txtReply
    SC = txtReplySY

```

'Reset variables for next use

```

txtReply = ""
txtReplySY = ""
txtMsgBox = ""
txtDefault = ""
txtDefaultSY = ""
hit = m

```

'If "silt" is found, use defaults

```
Else
  HC = IstMDefault.List(m)
  SC = IstMDefaultSY.List(m)
  hit = m
End If
GoTo CheckMod
```

Nomatch:  
Next

'No material type found. Ask to use default or change to another value

```
Prompt$ = "Found No Match" + Chr$(13) + Chr$(10) + "LINE = " + Desc$
Title$ = "Select Cancel to Quit Program"
Defaultx = "1"
DefaultxSY = "1"
```

```
Reply$ = ""
txtReply = ""
txtMsgBox = Prompt$
txtDefault = Defaultx
txtDefaultSY = DefaultxSY
GetReply Reply$
If txtReply <> Defaultx Then
  NewMat = "modified"
Else
  NewMat = ""
End If
HC = txtReply
SC = txtReplySY
txtReply = ""
txtReplySY = ""
txtMsgBox = ""
txtDefault = ""
txtDefaultSY = ""
hit = 0
```

CheckMod:

'Check gravel, sandstone, sand&gravel, and sand for parameter description modifiers

```
If hit > 0 And hit < 5 Then
  For m = 1 To ModMax
```

'If modifier is found, reduce HC by the modification factor of either .75  
'or .5

```
  If InStr(Desc$, mods(m)) > 0 Then
    NewMod = mods(m)
    HC = HC * Fact(m)
  Exit For
End If
Next
End If
```

'Store HC, SC, Material, Texture, Modifier, and Sorting for later output

```
IstHC.List(j) = HC
IstSC.List(j) = SC
IstNewMat.List(j) = NewMat
IstNewDesc.List(j) = NewDesc
IstNewMod.List(j) = NewMod
IstSort.List(j) = Sort$
Sort$ = ""
Next
```

'Cycle through all stored values and output to file

```
For m = 0 To IstHC.ListCount - 1
```

```

Print #2, Format(IstStart.List(m)); ", "; Format(IstEnd.List(m)); ", "; Format$(Val(Format(IstEnd.List(m) - IstStart.List(m), "0.0"))); ", ";
Format(IstHC.List(m)); ", "; Format(IstSC.List(m)); ", "; Chr$(34); IstNewMat.List(m); Chr$(34); ", "; Chr$(34); IstNewDesc.List(m);
Chr$(34); ", "; Chr$(34); IstNewMod.List(m); Chr$(34); ", "; Chr$(34); IstSort.List(m); Chr$(34)

```

'Make sure the top elevation not lower than bottom elevation. If so, show warning message

```

If IstEnd.List(m) - IstStart.List(m) < 0 Then
    Reply$ = MsgBox("This layer has a negative thickness" + Chr$(13) + Chr$(10) + "...oops..." + Chr$(13) + Chr$(10) + "Write
down the Input File name (from the box above the Exit button) so corrections can be made at a later time.")
End If
Next
Close #2

```

'Clear listboxes for use with next testhole log

```

IstStart.Clear
IstEnd.Clear
IstDesc.Clear
IstHC.Clear
IstSC.Clear
IstNewMat.Clear
IstNewDesc.Clear
IstNewMod.Clear
IstSort.Clear

```

'save file number of last log processed in case processing is interrupted

```

Open "LastFile.RAK" For Output As #4
Print #4, k
Close #4
Next
End
End Sub

```

'This subroutine causes the program to wait for a response from the user to either accept the supplied HC and SY defaults or change the values to what they feel is appropriate

```

Private Sub GetReply(Reply$)
    cmdOK.SetFocus
    Do Until txtReply <> ""
        DoEvents
    Loop
End Sub

```

'Exit program

```

Private Sub cmdExit_Click()
    End
End Sub

```

'Sets flag so program knows it has values to use for either default HC and SY or user has supplied new values

```

Private Sub cmdOK_Click()
    txtReplySY = txtDefaultSY
    txtReply = txtDefault
End Sub

```

## Modify.txt

One of the input files used with GeoParm is Modify.txt. This file contains the data associate with the Reed and Piskin report, the SY data obtained from Larry Cast, and the sets of modifiers based on silt content and parameters. This input file is shown below and the description of this file is below this input file.



11 0.75

slightly indurated  
 slightly silty  
 interbedded  
 in part silty and clayey  
 in part slightly silty  
 very slightly silty  
 in part silty  
 cemented in part  
 moderately consolidated  
 slightly clayey  
 in part consolidated

7 0.50

moderately silty  
 very silty  
 silty to slightly clayey  
 silty to in part clayey  
 clayey  
 silty  
 marly

-----					
silt	2	5	8	8	
slightly clayey		10	10	10	10
moderately clayey	8	8	8	8	8
very clayey	4	4	4	4	3
loess	15	15	15	15	
sandy silt	15	15	15	15	
-----					
gravel	0	6	321	23	
fine to coarse	245	311	311	334	23.5
fine to medium	201	334	334	334	24
fine	160	214	267	25	
medium to coarse	294	468	468	468	22.5
medium	241	321	321	23	
coarse	334	468	602	22	
-----					
sandstone	3	13	30	30	21
very fine to coarse	30	30	30	30	20
very fine-coarse	30	30	30	30	20
very fine to medium	15	15	15	15	20
very fine-medium	15	15	15	15	20
very fine to fine	5	5	5	5	10
very fine-fine	5	5	5	5	10
very fine	2	2	2	1	
fine to coarse	30	30	30	30	21
fine to medium	25	25	25	25	21
fine	10	10	10	20	
medium to coarse	35	35	35	35	21
medium	30	30	30	21	
coarse	40	40	40	21	
-----					
sand	grave	15	131	26.7	
very fine sand to coarse	grave	128	128	128	20.9
very fine sand to medium	grave	99	99	99	20.8
very fine sand to fine	grave	76	76	76	20.7
fine sand to coarse	grave	145	145	145	25.5
fine sand to medium	grave	114	114	114	25
fine sand to fine	grave	88	88	88	24
medium sand to coarse	grave	164	164	164	26.9
medium sand to medium	grave	131	131	131	26.7
medium sand to fine	grave	103	103	103	26.5
coarse sand to coarse	grave	184	184	184	26
coarse sand to medium	grave	147	147	147	26.5
coarse sand to fine	grave	116	146	156	26.7
very coarse sand to coarse	grave	207	207	207	25.1
very coarse sand to medium	grave	170	213	227	25.3
very coarse sand to fine	grave	134	214	214	25.5
-----					
sand	2	15	80	26	
very fine to very coarse		59	59	59	20.6
very fine to coarse	48	48	48	48	20.5

very fine to medium	36	44	47	20.4	
very fine to fine	27	27	27	20.2	
very fine	13	20	20		
fine to very coarse	70	70	70	23	
fine to coarse	57	69	72	22	
fine to medium	53	67	67	21.5	
fine	27	40	53	21	
medium to very coarse		84	104	111	26.3
medium to coarse	74	94	94	26.1	
medium	67	80	94	26	
coarse to very coarse		94	134	134	27
coarse	80	107	134	27	
very coarse	107	147	187	25.9	
-----					
loess	2	0	1	1	
-----					
loam	2	0	1	1	
-----					
clay	2	0	1	1	
-----					
clay	2	0	1	1	
-----					
shale	2	0	0	.1	
-----					
chalk	2	0	0	1	
-----					
	0	0	1	1	
-----					
till	2	0	0	1	
-----					
limestone	2	0	0	1	
-----					
marl	2	0	0	.1	
-----					
bentonite	2	0	0	1	
-----					
ash	2	0	5	4	
-----					
peat	2	0	1	1	
-----					
quartzite	2	0	0	.1	
-----					

There are actually several different types of data in this input file. The first block of data represents modifiers based on silt content and other parameters. The first line says there are 11 descriptions that may be found in the testhole logs that would cause the HC values to be multiplied by 0.75. There are 8 more lines similar to this where the first one indicates there are 7 lines and if those phrases are found, the HC values will be multiplied by 0.50.

The next part of this input file identifies the materials that are recognized by the program and how various textures are used to assign values. Gravel is shown in the table below and will be used to explain how most of the remainder of the input file is used.

## Texture Descriptions for Gravel and Corresponding Standard HC and SY Values

Material	Search Code	No.	Gradation Texture Description	HC based on degree of sorting			SY
				Poor	Moderate	Well	
Gravel	0	6			321		23.0
			fine to coarse	245	311	334	23.5
			fine to medium	201	334	334	24.0
			fine	160	214	267	25.0
			medium to coarse	294	468	468	22.5
			medium	241	321	321	23.0
			coarse	334	468	602	22.0

The first line shows the lithologic material, a “search code”, the number of texture descriptions that will follow, and the HC and SY values that will be suggested if a texture description is not found. Units of HC in the program are ft/day while SY is dimensionless. The rest of the lines in the table are the recognized gradation textures and the corresponding standard assigned HC, based on degree of sorting, if that texture is found for the respective material and the SY value as well.

The “search code” can be either “0”, “2”, “3”, or “any text”. The explanation below describes how the data is searched based on the search code assigned to each material.

“0” = Material in description must match the recognized material in input file exactly.

“2” = Material in description must start with the recognized material in input file but anything can follow.

“3” = The recognized material in input file must be found in the description but anything can precede that material and anything can follow.

“any text” = Both the material and the search text must be found in the description. The only use of this in this program is in the case of “sand and gravel”. Because of a “quirk” in the data this is referred to as “sand and grave”. That quirk dates back to the days when typewriters were used to type up all this data where an “l” (the small letter L) and a “1” (the numeral one) were frequently used interchangeably since they looked identical. It was found that gravel was frequently found with a number as the last character so just searching for “grave” took care of that problem.

After the “search code”, the next digit in this example is “6” and it represents the number of additional phrases that may be found in the testhole file to describe the material. The last two numbers are 321 and 23.0. These numbers are what will be assigned for HC and SY if no additional descriptive phrases are found in the testhole description.

The next 6 lines represent additional phrases that may be used to describe the amount of gradation in the sample. The more coarse material found in a layer, the larger the HC value to be assigned. Conversely, the more gradation from fine to coarse the material is in a layer, the smaller the SY value to be assigned. If none of these phrases are found, the default values are selected.

The first three numbers after each gradation description are the HC values based on the degree of sorting in the layer. The phrases that need to be found in the description are either “poorly sorted” or “well sorted”. If neither of those phrases is found, “moderately sorted” is assumed and the appropriate HC value is assigned.

The final value in each of the last 6 lines is SY. The degree of sorting will not affect SY but material gradation will.

### **XXXX.asc**

This set of input files is the actual testhole logs and the XXXX is used to signify that the first part of this name changes based on the name of the testhole. The actual original file formats were Word Perfect files and were then saved as an ASCII space-delimited format for use with this program.

Over 3000 testhole logs were analyzed but the naming convention was not entirely consistent in the original data. Sometimes there were leading zeroes in the name, sometimes there were embedded dashes and sometimes the county ID number was part of the file name. The only thing completely consistent was the extension always had a “.asc” and only testhole logs in the processing folder had that extension so GeoParm could distinguish the ASCII testhole logs from all other input files for COHYST.

Even within the testhole log, the various input items were not consistent from one testhole log to another but the differences could be programmed around. The primary parts of interest from this file are the lithology descriptions and the thickness of each layer but there are other parts that must be parsed as well. Below is a sample “.asc” file to be used as an example for explaining what information is obtained from each log. The name of this sample log is “12b77.083.asc”.

1 26N 55W 18C DCD 12-B-77  
2 Test Hole #12-B-77 (E-log)  
3 (26-55-18cdcd)  
4 Sioux County  
5  
6 Location: SE SW SE SW sec. 18, T. 26 N., R. 55 W., approximately 290  
7 ft north and 1820 ft east of southwest corner of section.  
8 Ground elevation: 4,983 ft (t). (Chalk Buttes NE 7.5 min. quadrangle).  
9 Depth to water: 379 ft (August 18, 1977).  
10 Depth, in feet  
11 From To  
12 Tertiary System - Miocene Series - Ogallala Group:  
13 Sheep Creek Formation(?):  
14 Silt, clayey, sandy, very fine to fine sand, inter-  
15 bedded with lime cemented sandstone, moderate to  
16 very calcareous siliceous root casts..... 0.0 15.0  
17 Tertiary System - Miocene and Oligocene Series - Arikaree Group:  
18 Harrison and Monroe Creek Formations, undivided:  
19 Sandstone, very fine to fine, very silty, friable,  
20 volcanoclastic, pale yellow to light gray 14.8 to  
21 30 ft, siliceous root casts 35 to 45 ft, mostly  
22 very fine sand with lesser amounts of fine sand,  
23 74 to 105 ft less silty..... 15.0 105.0  
24 Sandstone, very fine to fine, slightly silty in  
25 parts, well sorted, some limy zones, 115 to 120  
26 ft abundant siliceous root casts..... 105.0 200.0  
27 As above with more limy zones and higher silt con-  
28 tent in parts, light gray..... 200.0 294.2  
29 Sandstone, very fine to fine, traces of medium sand,  
30 very silty, moderate to very calcareous, white to  
31 pale brown..... 294.2 305.8  
32 Sandstone, very fine to fine, slightly silty, medium  
33 to coarse sand from 420 to 428 ft, slightly cal-  
34 careous..... 305.8 420.0  
35 Tertiary System - Oligocene Series - Arikaree Group:  
36 unnamed unit (formerly Gering Formation):  
37 Sandstone to sand; very fine to fine; medium to  
38 coarse sand 450 to 450 ft, poor sorting..... 420.0 450.0  
39 Sandstone, very fine to medium, poor sorting, medium  
40 to coarse sand from 486 to 500 ft, slight to mod-  
41 erately calcareous..... 450.0 500.0  
42 Sand, very fine to very coarse, slightly silty in  
43 parts, poorly sorted, more coarse sand from 532  
44 to 538.1 ft, some calcareous zones..... 500.0 538.1  
45 Siltstone, very sandy, very fine to fine sand,  
46 very calcareous, white to light yellowish brown... 538.1 560.0  
47 Tertiary System - Oligocene Series - White River Group:  
48 Brule Formation, Whitney Member:  
49 Siltstone, very calcareous, very pale brown to light  
50 yellowish-brown..... 560.0 600.0

The line numbers followed by a space shown in the first three columns above are not actually in the file but have been added for the following explanation.

The first line of each log contains the legal description and the log id. Many times the log id is in a slightly different format than what is indicated by the log filename, however the log filename is what was used as the identifier so the log id as it was shown inside the file was discarded. The legal description was retrieved from the file and written to the output file. (The output file format will be discussed following this input file format discussion.)

The next three lines contain the testhole log id again (in still a different format), the legal location (another format) and the county name. None of this are needed so are simply read and discarded. A blank line typically follows and is also discarded. Additional location information is on the next one or two lines but this is ignored as well.

Line 8 in this example shows the ground elevation at the log. This is retrieved and saved to the output as a later check on the validity of the location of the log. The “Depth to water” is on the next line but since that was just a one time reading at the time of drilling, it was not considered useful for our purpose so was discarded. Heading information for “Depth, in feet” – “From” and “To” are on the next two lines. These were used in the program to find where the actual lithologic descriptions began so after the ground elevation line was found, the file was read until the “Depth, in feet” was located in the file. Then one more line was read and the remainder of the file was assumed to be lithologic description data.

There is usually some Series and Group information (lines 12, 13, 17, 18, 35, 36, 47, and 48 in this example) separating the lithologies. This is flagged by those key words and that information is ignored in GeoParm.

Lines that are indented more than one character are the lithologies so that is used as the flag to indicate them. Many times the description takes more than one line but they always end with a series of dot trailers followed by the From and To depths of that lithology.

In the example above, the first lithology starts on line 14 and continues through line 16. It is a “silt” layer starting at land surface (the From depth is 0.0) and has a thickness of 15 feet (the To depth is 15.0). As described in the Modify.txt input file description above, silt uses a “2” search code so once that material has been identified, the program searches for the other gradation or texture descriptions of “slightly clayey”, “moderately clayey”, “very clayey”, “loess”, or “sandy silt”. Since none of these are found, the default value of 8 and 8 would be used for the HC and SY values. You might note in this example that “clayey” is found which would be similar to “moderately clayey” that has the same HC and SY values.

The next lithology starts on line 19 and goes to 23 for a depth from 15 feet down to 105 feet. This is a “sandstone” material with a gradation of “very fine to fine” so when you look up the values for this material from Modify.txt, you get 5 and 10 for HC and SY. It also has a further descriptive modifier of “very silty” so the Modify.txt file indicates the previous HC value should be multiplied by 0.50 for a final value of 2.5.

The following lithology is also “sandstone”, “very fine to fine” but this also shows that it is “well sorted”. In this case, well sorted and moderately sorted are the same so the starting value is 5 for HC and again 10 for SY. This time a modifier of “slightly silty” is found which means the HC value is multiplied by 0.75 so the final value written to the file is 3.75.

The primary material shown in lines 27 to 28 is described as “As above with more limy zones and higher silt content in parts”. Obviously this is not recognized by the program so no value can automatically be assigned by GeoParm. Consequently, an input box pops up to the operator showing description found so they can determine what the best HC and SY values should be assigned to it. In this case, the operator used the previous values of 3.75 and 10 for HC and SY.

The remainder of this input testhole log is very similar to the lithologies described above and will not be further discussed in detail. There is a sand layer and a couple of siltstone layers (this is considered the same as silt for the purposes of this program). The general process is the same where GeoParm reads in an entire layer, attempts to identify the main material and find any gradation or texture description that might follow. Then any sorting information is parsed for and finally any modifier info is searched for.

**XXXX.out**

This is the main set of output files generated by GeoParm. The XXXX is the same as described above and represents the testhole log id. Below is an example that corresponds to the input file, "12b77.083.asc", described above. This output file is named "12b77.083.out". There are three separate types of output lines and will be described below the example file.

```
000008 26 55W 18 CDCD
000008 4983
0,15,15,8,8,"silt", "", "", ""
15,105,90,2.5,10,"sandstone","very fine to fine","very silty", ""
105,200,95,3.75,10,"sandstone","very fine to fine","slightly silty","well"
200,294.2,94.2,3.75,10,"modified", "", "", ""
294.2,305.8,11.6,2.5,10,"sandstone","very fine to fine","very silty", ""
305.8,420,114.2,3.75,10,"sandstone","very fine to fine","slightly silty", ""
420,450,30,5,10,"sandstone","very fine to fine", "", ""
450,500,50,15,20,"sandstone","very fine to medium", "", ""
500,538.1,38.1,44.25,20.6,"sand","very fine to very coarse","slightly silty","poorly"
538.1,560,21.9,8,8,"silt", "", "", ""
560,600,40,8,8,"silt", "", "", ""
```

The first line of output contains the legal description as found in the XXXX.asc input file. There is also a six-digit id followed by a blank at the beginning of this first line. This id was created as a result of an earlier version of GeoParm but is no longer used. It was left in the file because other subsequent programs expected that id to be present even though the use of it was eventually written out of all programs.

The next line also has this same id and is followed by the ground elevation from the original log. The remainder of the file shows the result of parsing and evaluating the lithologic data from the input log.

The format of the remainder of the file is all the same and is comma-quote delimited. The first three numbers are the top, bottom and thickness of each individual lithology. Here is the information from the input file used to produce the fifth line of this sample output file used as an example for the remainder of the discussion:

	Depth, in feet	
	From	To
Sandstone, very fine to fine, slightly silty in parts, well sorted, some limy zones, 115 to 120 ft abundant siliceous root casts.....	105.0	200.0

The top of that layer is 105 feet below land surface and the bottom extends down to 200 feet while the thickness is 95 feet. The next two numbers are the final assigned HC and SY, 3.75 and 10 respectively.

The remainder of each line shows the recognized parts of each line. If any of the output values appear to be inconsistent with known values, the information used to determine the final output is available for review to determine if there was any recognition error during the parsing process.

The next item shows the primary material in this lithology as “sandstone” and is followed by the gradation/texture information that was found in the lithology description, “very fine to fine”. “slightly silty” is the modifier and this line indicates that sorting of the material was “well”.

There is one other line that deserves special description and that is the line starting with 200 in the output file. To the right of the numbers is the word “modified”. This indicates none of the key material phrases were found on that layer so the program operator had to modify the standard data from the “Modify.txt” file.



## Attachment 2

**This attachment outlines the steps performed with GIS to convert mapped Hydrostratigraphic Unit (HU) contours into model node elevations for each model layer and modeling unit.**

### Step 1.

Convert HU contour b's layer from Shapefile to Arc/Info coverage

Arc command

Arcshape <Shapefile name> <Coverage name>

### Step 2.

Convert HU contour coverage's to Grid layers

Arc command

Topogrid < grid name> <cell size>

### Step 3.

Check grid layers for consistency: 1-foot minimum difference between layers.

Starting with land surface elevation.

A new b-1 grid layer will be created to reflect a 1-foot difference between land surface elevations and the b-1 grid layer. Then each b's grid layer will be checked for 1-foot difference between grid layer below. All new b's grid layers will reflect a 1-foot difference between layers.

### Step 4.

Create data set for GMS modeling program, with new b's grid layers (corrected 1 foot difference) for Eastern Model Area, Central Model Area, and Western Model Area.

Using Arc/Grid command

setwindow and aggregate:

Grid data set layers are generated for each model area by layers.

### Step 5.

Create input ascii file for GMS Model program.

Using Arc command

gridascii

Grid data set layers are converted to ascii file to be used as input file for GMS