COLORADO GEOLOGICAL SURVEY

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MEMORANDUM

TO: Brian Macpherson, Decision Support System Specialist
Colorado Water Conservation Board

FROM: Lesley Sebol, Colorado Geological Survey

DATE: June 25, 2020

SUBJECT: Fiscal Year-end Progress Summary for POGGI, PDAA, 202000002036, Statewide Mapping of Quaternary Alluvium

INTRODUCTION

The Colorado Geological Survey (CGS) was provided the above referenced Colorado Water Conservation Board (CWCB) Severance Tax Operational Fund grant for fiscal year FY19-20 for developing a digital statewide Quaternary alluvium (Qal) ArcGIS product. This memorandum constitutes the year-end report for the effort documenting the methodology of how this statewide Qal product was developed. The final product will be incorporated into the web-based Groundwater Atlas of Colorado that the CGS completed in 2020 as a digital resource with downloadable GIS files.

BACKGROUND

While developing the Groundwater Atlas of Colorado, it was recognized that there was limited detailed GIS data for the extent of Quaternary alluvium in Colorado. the only statewide product was mapped at a scale of 1:250,000 which is too coarse a scale for many uses. Existing data at a finer scale existed as a patchwork of various sources and scales.

While Qal mapping existed for the Colorado Decision Support System (CDSS) Division 1 - South Platte, similar data was not readily available for the other six CDSS divisions. Data also existed from various CGS 1:24,000 quadrangle mapping efforts throughout Colorado, and at

1:50,000 scale from the completed County Geology and Groundwater Resources projects (Douglas, Park, Chaffee, Mesa, and Elbert Counties). Additionally, the CGS had recently digitized a small section of alluvium along the Lower Arkansas River, near the state line. These various data were used to assist with generation of the statewide alluvium GIS mapping at the 1:50,000 scale. Lidar, where flown in Colorado, was used as a base for the mapping effort. Otherwise, NAIP imagery or the State digital elevation model (DEM) at a scale of 10 meters or better was used. Thus, this statewide Qal mapping effort was completed at a final scale of 1:50,000.

METHODOLOGY

The methodology is attached as a separate document formatted for insertion as metadata in the ArcGIS feature class which will be inserted in the Colorado Groundwater Atlas geodatabase.

SCHEDULE

This Statewide Alluvium ArcGIS feature class product will be inserted in the Colorado Groundwater Atlas around mid-July 2020. It will replace the existing Quaternary alluvium layer in the atlas.

CGS 2020 Statewide Alluvium Methodology

INTRODUCTION

The following is formatted for insertion as metadata with the feature class to be inserted in the Colorado Groundwater Atlas geodatabase. General metadata for the geodatabase will also be applied.

DESCRIPTION

This dataset was created or modified by the Colorado Geological Survey (CGS) into this format for use in the Colorado Groundwater Atlas by the following process.

Alluvial deposits along streams and rivers throughout Colorado with the potential for forming alluvial aquifers in direct hydraulic connection with surface water are compiled as a statewide feature class. Polygons outlining extent of alluvium along waterways were digitized in a consistent manner at scales between 1:24,000 and 1:50,000 using a combination of available LiDAR, topographic DEM rasters, high resolution satellite imagery, and 1:24,000 scale topographic maps. Where needed, published geologic maps and permitted water well geologic logs were used for verification.

This feature class was created in 2020 in ArcGIS for Desktop Version 6.2 (Build 9200); ESRI® ArcGIS 10.6.1.9270.

Access / Use Constraints: none

CREDITS/RESOURCE DETAILS

Barkmann, P.E., Fitzgerald, F.S., Sebol, L.A., Curtiss, W., Pike, J.M., Moore, A., and Taylor, B., 2015, Geology and Groundwater Resources of Douglas County, Colorado: Colorado Geological Survey Open File Report OF-15-10.

Barkmann, P.E., Johnson, E.P., Sebol, L.A., and Fitzgerald, F.S., 2017a, Geology and Groundwater Resources of Chaffee County, Colorado: Colorado Geological Survey Open File Report OF-16-04, 114 p.

Barkmann, P.E., Sebol, L.A., Johnson, E.P., Fitzgerald, F.S., and Curtiss, W., 2017b, Geology and Groundwater Resources of Park County, Colorado: Colorado Geological Survey Open File Report OF-15-11, 50 p.

Barkmann, P.E., Sebol, L.A., McGee, K.H., and Broes, L.D., in progress, Geology and Groundwater Resources of Elbert County, Colorado: Colorado Geological Survey Open File Report OF-18-02.

CWCB/DWR, 2011, Division 1 - South Platte, South Platte Alluvial Data, geodatabase last updated 8/1/2011, accessed February 1, 2020, at Colorado's Decision Support Systems at https://www.colorado.gov/pacific/cdss/division-1-south-platte.

CWCB/DWR, 2014, Statewide Alluvial Aquifers, zipped shapefile last revised June 18, 2014, accessed February 1, 2020, at Colorado's Decision Support Systems at https://www.colorado.gov/pacific/cdss/gis-data-category.

Hurr, R.T., Schneider, P.A., and Minges, D.R., 1975, Hydrology of the South Platte River Valley, northeastern Colorado: Colorado Water Conservation Board Colorado Water Resources Circular 28, 24 p.

Minor, S.A., Caine, J.S., Ruleman, C.A., Fridrich, C.J., Chan, C.F., Brandt, T.R., Holm-Denoma, C.S., Morgan, L.E., Cosca, M.A., and Grauch, V.J., 2019, Geologic map of the Poncha Pass area, Chaffee, Fremont, and Saguache Counties, Colorado: Scientific Investigations Map 3436, accessed at http://pubs.er.usgs.gov/publication/sim3436.

Sebol, L.A., McGee, K.H., Johnson, E.P., and Barkmann, P.E., 2017, Geology and Groundwater Resources of Mesa County, Colorado: Colorado Geological Survey Open File Report OF-17-01, 52 p.

Sebol, L.A., Palkovic, M.J., Broes, L.D., and Barkmann, P.E., in progress, Geology and Groundwater Resources of La Plata County, Colorado: Colorado Geological Survey Open File Report OF-19-01.

Thompson, R.A., Shroba, R.R., Michael N. Machette, Fridrich, C.J., Brandt, T.R., and Cosca, M.A., 2015, Geologic map of the Alamosa 30′ × 60′ quadrangle, south-central Colorado: Scientific Investigations Map 3342, 30 p., accessed at http://pubs.er.usgs.gov/publication/sim3342.

Topper, R.E., 2008, Upper Black Squirrel Creek Basin Acquifer Recharge and Storage Evaluation: Colorado Geological Survey Open File Report OF-08-04.

USGS National Geologic Map Database National Geologic Map Database, accessed February 1, 2020, at https://ngmdb.usgs.gov/ngm-bin/ngm_compsearch.pl.

Watterson, N.A., and Topper, R.E., 2011, Lost Creek Basin Aquifer Recharge and Storage Study: Colorado Geological Survey Open File Report OF-11-05.

Also referenced was the CGS copy of the DWR permitted well statewide database downloaded February 2012.

LINEAGE/METHODOLOGY

Lineage Statement

The existing statewide alluvial aquifer extent shapefile available as a download from Colorado's web portal (CWCB/DWR, 2014) was used as a general guide. Extent was modified using multiple sources. Approximately 70% of the state is covered by one-meter (1-m) resolution lidar data. Where lidar data is available, that data was analyzed with a hillshade image conversion at 1:24,000 scale to digitize along streams and drainages that have significant alluvium. Where 1-m resolution lidar was not available, a 10-m resolution digital elevation model (DEM) was used with a hillshade image conversion, combined with aerial imagery, published geologic maps, and 1:24,000 topographic maps.

Compilation of alluvial extent is part of the CGS county groundwater program for six counties: Park (Barkmann and others, 2017b), Mesa (Sebol and others, 2017), Douglas (Barkmann and others, 2015), Chaffee (Barkmann and others, 2017a), Elbert (Barkmann and others, in progress), and La Plata (Sebol and others, in progress) counties. Alluvial extent coverage for these counties was incorporated with modifications to account for the differences in mapping scales and objectives. Additional mapping was supplemented where necessary.

Alluvial deposits can be complex because of a long history of periods of deposition alternating with periods of incision. As a result, younger alluvial deposits tend to be lower in the landscape where they are hydraulically connected to modern stream. These deposits typically are those of Holocene, Late and Middle Pleistocene in age. Older alluvial deposits tend to be higher in the landscape where they often sit on bedrock-cored terraces and are less likely to be hydraulically connected to modern streams. The intent of this effort was to include only those deposits directly connected to modern streams. Differentiation of the two types of deposit is not always obvious using lidar, DEM, and aerial photography. Published geologic maps provided information to guide delineation that could then be extrapolated over large areas. Alluvial fans from tributaries extend out into trunk river valleys and their deposits can merge with the alluvium of the main river. Because of implied hydraulic connection alluvial fan deposits in the main valleys were included with the alluvium.

The lower South Platte River valley and San Luis Basin are regions with complex alluvial aquifer systems that are intensely utilized. In the lower South Platte River valley, the alluvial aquifer can be very deep and can extend into areas covered with eolian deposits. There are also geologically old abandoned channels that are covered with younger deposits. For this reason, delineation followed existing delineations by Hurr and others (1975) and the South Platte Decision Support System (CWCB/DWR, 2011). In the San Luis Valley a vast unconfined aquifer is comprised of alluvium associated with modern streams coalescing with alluvial fan deposits and local lake deposits. The extent is generalized for existing geologic mapping (Minor and others, 2019; Thompson and others, 2015; USGS National Geologic Map Database).

Some designated groundwater basins have mapped alluvial aquifer systems below the eolian mantle. This data was also included in the data set, as separate files. The districts that have mapping available include the Upper Black Squirrel Creek Basin (Topper, 2008) and Lost Creek Basin (Watterson and Topper, 2011) designated groundwater basins.

Process Step

Description

Topographic expression from DEM rasters, both 1-m lidar and 10-m topographic sources, formed primary delineation of alluvial extent based on identification of relatively smooth flat terrain along rivers and streams. Hillshade images created by ESRI® image analysis were used to accentuate topographic expression (typically azimuth 45, height 30 or azimuth 315, height 45). Delineation marks the base of benches interpreted to be the edge of alluvium. In areas with no clear benches, delineation was approximated near the base of sloped areas. Areas with stepped benches often required consultation of existing maps in the region to select the appropriate bench. Delineation extended along rivers until width dropped below approximately 100 meters. Narrow areas along major rivers connecting extensive areas with wider extent above and below were often included. Alluvial fans, debris fans, and other recent deposits on the river lowland were included; this includes anthropomorphic modifications. In glaciated areas the extent of alluvium was not extended upstream of well-defined moraine features because of complex relations with other deposits. Exceptions were made in areas where many wells are present such as the Animas River valley above Durango.

Rationale

Alluvial deposits associated with active stream drainages typically form low, flat-lying areas near active waterways.

Process Step

Description

Aerial imagery and 1:24,000 map raster images were used to verify or supplement DEM analysis where it was ambiguous or insufficient for delineation. Areal imagery was either 2015 NAIP satellite imagery in the CGS GIS data library or ESRI® ArcGIS online World Imagery server. Topographic maps were USGS 1:24,000 county mosaic compilations in CGS GIS data library. In aerial imagery delineation followed areas of generally even texture, color, and tone. In many areas the alluvial areas are evident from irrigated areas and greener vegetation. Topographic expression was used to identify low, flat-lying areas and delineation of topographic breaks as edges of alluvium.

Rationale

In many areas the DEM hillshade images are not definitive and can be ambiguous. Aerial imagery and topographic maps helped clarify these areas.

Process Step

Description

Published geologic maps provided ground-based information for identifying alluvial areas that are not immediately adjacent to active waterways. In particular, these maps helped differentiate younger, low-lying alluvial deposits connected with the modern streams from the older, higher alluvial deposits on terraces cored by bedrock. Older alluvial deposits (many Middle and all lower Quaternary aged deposits) and exposed bedrock on the slopes below alluvial deposits were primary characteristics used for this differentiation.

Rationale

Used ground-based geologic data to verify interpretations from raster sources.

Process Step

Description

Geologic logs in well-completion reports on file with the Colorado Division of Water Resources (DWR) were consulted in areas of uncertainty, if available. Alluvium in these logs was identified by description of sand, gravel, or boulders. In areas where the base of alluvium, if noted in the geologic log, was higher than the adjacent waterway the deposit was considered older terrace, not part of the alluvial aquifer. Fine sand in areas with mapped eolian deposits was not included as alluvium unless coarser sand and gravel was described at depth.

Rationale

To resolve uncertainty, driller's records were used to distinguish subsurface alluvium from terrace alluvium or eolian deposits.

FUTURE WORK

(Not for metadata)

Concealed Alluvium

Other, younger deposits, typically eolian sediment, often mantles alluvium across large areas and obscures the extent of the alluvial deposits that may be an aquifer. This is particularly evident in much of Colorado extending east of the Front Range. Better delineation of alluvium below younger deposits could be accomplished with several sources of data: geologic logs from existing wells, geophysical investigations, or potentially remote sensing analyses. The best source are reliable geologic logs from existing wells, but these are not always available. While some eolian sediment could be considered as a part of the aquifer system, this is not the case everywhere.

Strath Terrace Deposits

Older alluvium mantles many high terraces cored with bedrock. In most cases these deposits are not directly connected to modern streams yet they may contain groundwater as perched aquifers. In some areas these high terraces extend up gradient to connect with modern alluvium. Delineation of these elevated alluvial terraces deposited on bedrock that can be local perched aquifers would form a valuable companion dataset with the main alluvial coverage. These are potentially vital connections as these areas may be recharge zones, and thus important to incorporate into the data set.