Work plan for U.S. Geological Survey activities during 2016, in cooperation with the City of Rapid City, South Dakota

Prepared for

City of Rapid City

by

U.S. Geological Survey

South Dakota Water Science Center

1608 Mountain View Road

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Introduction

The U.S. Geological Survey (USGS) and the city of Rapid City have had a long-term cooperative relationship to conduct hydrologic investigations to better understand the complex systems that comprise water resources for Rapid City and the surrounding area. This 2016 work plan was finalized January 8, 2016, following various planning meetings and discussions among USGS and Rapid City staff. This program will provide the City with hydrologic data and interpretive information relevant to (1) providing a sustainable, high-quality, regional water supply; (2) protecting ecological resources; and (3) addressing public safety. Funding will be provided through a cooperative cost-share arrangement between USGS and Rapid City.

Work plan activities for 2016

Planned activities for 2016 are described for five program areas. Monitoring of Rapid Creek streamflow is described in section **(1) streamgaging**. Monitoring of water levels and other activities primarily involving the Madison and Minnelusa aquifers are described in section **(2) hydrogeologic data collection and analysis**. Activities to further analyze the Madison and Minnelusa aquifers with a numerical groundwater flow model are in section **(3) application and regionalization of groundwater-flow model**. Evaluation of stormwater runoff is described in section **(4) stormwater monitoring** and evaluation of potential **hydrologic effects of bark beetles** is described in **section (5)**. The total proposed funding level for Rapid City for the complete program is $148,000, as shown on table 2 in the final section of this work plan. This is higher than last year's total of $138,000 due to a one-time cost of $10,000 for installation of a new streamgage to be located just upstream from the Sewage Treatment Plant, which will replace the streamgage that currently is located downstream from the Sewage Treatment Plant. USGS is able to provide $105,105 in matching funds (table 2), which amounts to 41 percent of the total cooperative program of $251, 105.

(1) Streamgaging

Table 1, which reflects participation from other agencies, shows the proposed streamgaging program for calendar year 2016. City staff requested (1) discontinuation of a stage gage that has been operated at Rapid Creek at Jackson Boulevard and (2) relocation of the streamgage located at the Sewage Treatment Plant. With these exceptions, the proposed program is very similar to last year, with an inflationary increase of about 3 percent in the annual cost of a streamgage. Funding from Rapid City for the streamgaging program will consist of $21,884 that will be matched with $17,760 from USGS, of which $3,351 is from the National Stream Information Program (see table 2 on last page of this document). Table 1 does not include the one-time cost

of $10,000 for relocation of the streamgage located at the Sewage Treatment Plant; however, this cost is included as a separate line item in table 2.

Table 1. Streamgaging program for City of Rapid City for calendar year 2016.

Gaging Station and Cooperators	Unmatched Federal	Local & State Cooperators	USGS Match	Total
Rapid Creek at Rapid City				
US Army Corps of Engineers	$7,481			$7,481
USGS NSIP Funding			$3,351	$3,351
Rapid City		$4,130		$4,130
subtotals	$7,481	$4,130	$3,351	$14,962
Rapid Creek below Sewage Plant				
Rapid City		$8,259	$6,703	$14,962
subtotals		$8,259	$6,703	$14,962
Rapid Creek near Farmingdale				
DENR		$4,130	$3,351	$7,481
Rapid City		$4,130	$3,351	$7,481
subtotals		$8,260	$6,702	$14,962
Rapid Creek at Jackson Boulevard (stage only) **– discontinued**[1]				
Rapid City		$0	$0	$0
subtotals		$0	$0	$0
Rapid Creek below Pactola Dam and below Deerfield Dam (2 gages)				
USBR	$6,480			$6,480
Rapid City		$5,365	$4,355	$9,720
SDGF&P		$2,682	$2,177	$4,859
RVWCD		$2,682	$2,177	$4,859
subtotals	$6,480	$10,729	$8,709	$25,918

Summary of funding for all gages	Rapid City	Others	USGS	Total
Rapid Creek blw Sewage Plant	$8,259		$6,703	$14,962
Rapid Creek near Farmingdale	$4,130	$4,130	$6,702	$14,962
Rapid Creek at Jackson Blvd	$0		$0	$0
Rapid Creek blw Pactola and Deerfield	$5,365	$11,844	$8,709	$25,918
Rapid Creek at Rapid City	$4,130	$7,481	$3,351	$14,962
Total Funding	**$21,884**	**$23,455**	**$25,465**	**$70,804**

[1]At request of city staff, this seasonal stage-only gage was discontinued following 2015 operations. This entry will be removed from this table in work plans for future years.

(2) Hydrogeologic Data Collection and Analysis (including Technical Assistance)

Water-level monitoring using continuous recorders will be continued for nine observation wells that are completed in the Madison, Minnelusa, and Minnekahta aquifers. Periodic water-level measurements also will continue for one Madison aquifer well in Rapid City and one

Deadwood aquifer well south of Rapid City. Last year's activities included evaluating potential changes to the observation well network; however, no major needs for changes were identified. The possibility of adding Rapid City production well RC4 (Minnelusa aquifer) to the network was considered; however, this well likely would not be particularly valuable as an observation well. A final decision will be made following more discussion between USGS and City staff.

This component also includes the application of various geophysical methods that may include microgravity, direct-current resistivity, and ground-penetrating radar (GPR). These methods have been applied in recent years to site-specific investigations in recharge areas of the Madison and Minnelusa aquifers that affect Rapid City's groundwater supply. The geophysical applications are useful for purposes such as estimating effective porosity and characterizing the spatial distribution of voids in selected aquifer locations.

This component also includes various forms of technical assistance deemed relevant by city staff. Recent examples have included application of the groundwater flow model for the Rapid City area that is described in the following section; obtaining streamflow measurements to assist in managing high inflows hampering the recent Canyon Lake Dam replacement project; and collection and analysis of water samples for stable isotopes at selected groundwater seepage sites, which has been useful in helping identify areas where seepage has resulted from leaks in the municipal distribution system. Providing assistance to the consulting engineers who will be working towards development of a master plan for future management of the city's municipal water system is another area that may require technical assistance.

(3) Application and Regionalization of Groundwater Flow Model

Participation in a multi-agency effort for development of a regional groundwater flow model of the Madison and Minnelusa aquifers for the Black Hills area is planned to continue. This model will serve as a regional framework for embedding more detailed models for site-specific areas such as Rapid City and other communities. The regional model is being designed to accommodate embedding of the existing Madison/Minnelusa groundwater flow for the Rapid City area (Putnam and Long, 2009; http://pubs.usgs.gov/sir/2009/5205/). The regional model will substantially improve modeling capabilities for the Rapid City area because effects of the regional flow system on local groundwater will be better simulated. Effects of increased water use near the boundaries of the existing model also will be more accurately simulated because artificial boundary effects will be eliminated. These improvements will facilitate analyses of water supply issues in a regional context, which will be useful for long-term planning.

Initial efforts to develop a regional model have been underway since 2011. Other contributing agencies have included the National Park Service, the Black Hills National Forest, and the West Dakota Water Development District (WDWDD). During 2014, WDWDD was the project sponsor in applying for financial assistance under the umbrella of the State Water Plan,

which is administered by the South Dakota Department Environment of Natural Resources (SDDENR). The application was considered by the Board of Water and Natural Resources, which recommended approval of a legislative appropriation for a "Statewide Hydrology and Water Management Study" that would be available for this and other similar projects statewide. The legislation passed, and funding first became available July 1, 2015, at the start of the State's fiscal year. However, this was during a period when WDWDD was without an Administrative Manager, which precluded submitting the requisite application. A new contractor for administrative services was recently selected and a presentation to the WDWDD board was made by USGS staff on Oct. 13, 2015. A main message was that USGS would begin working to seek funding support from other area counties and would work with the new Administrative Manager to prepare an application to the Board of Water and Natural Resources for the next submittal deadline (Sept. 30, 2015). The WDWDD board was supportive of this plan.

The existing groundwater flow model for the Madison and Minnelusa aquifers in the Rapid City area (Putnam and Long, 2009; http://pubs.usgs.gov/sir/2009/5205/) remains fully functional and has been used during recent years to address various questions that have arisen. Intentions are that this model should be used routinely to assist in planning and managing withdrawals from the Madison and Minnelusa aquifers, which form a critical component of the city's water supply. Through artesian springflow, such as the Jackson/Cleghorn spring complex, City Springs, and springs at the Outdoor Campus, these aquifers also play a critical role in maintaining surface flows with critical roles in ecosystem health.

(4) Stormwater Monitoring

Rapid City has implemented programs to improve stormwater quality in response to the "Phase II Final Rule" guidelines issued by the U.S. Environmental Protection Agency. In 2008 the City requested assistance from USGS in helping to evaluate the effectiveness of the City's improvement programs. Since then, this stormwater monitoring component has focused primarily on establishment of baseline conditions in several key urban drainages and evaluating the effectiveness of various best management practices (BMPs) suggested in the City's published guidance (2009 Stormwater Quality Manual) on construction and post-construction control of stormwater discharges. A report summarizing all data and conclusions to date was published in May 2015 (http://pubs.usgs.gov/sir/2015/5069/), which has essentially wrapped up an initial phase of this stormwater monitoring component.

During 2015, planning also was initiated for a subsequent phase that will be initiated during 2016 and will focus on investigating primary sources of bacteria in stormwater, which has been a persistent and vexing question for stormwater management. Preliminary implementation plans have been discussed with City staff and further communications will occur as implementation moves forward. Additional project cooperators for the next phase of stormwater monitoring may

include groups such as the SD Department of Environment and Natural Resources, SDSM&T, Pennington County, and West Dakota Water Development District.

Planned activities for 2016 include initiation of two general objectives: 1) quantify bacteria loads for various infrastructure elements along the drainage flow paths, and 2) identify primary source species for bacteria in stormwater discharges. These objectives will be accomplished over a multi-year period, with 2016 planned as a reconnaissance year to assess the proposed methods and further organize cooperative relationships. The first objective will be accomplished by collection of stormwater samples at several locations along a flow path (beginning at a rooftop or parking lot and ending at the outlet to Rapid Creek) for analyses of bacteria, sediment, and nutrient concentrations. Sites will be characterized according to the infrastructure elements upstream, such as commercial parking lots, street curbs, subsurface drainage pipe, or grassed open channels. This information will allow for a statistical comparison of water-quality results with infrastructure elements to which the stormwater was exposed. The second objective will be accomplished by examining multiple bacterial source tracking methodologies. Three potential methods have been identified for this task: 1) quantitative polymerase chain reaction (qPCR) using the USGS microbiology lab in Columbus, OH, 2) qPCR and pathogenicy using methods developed by Dr. Lisa Kunza and others in the Chemistry and Applied Biological Sciences department at SDSM&T, and 3) pyrosequencing methods investigated by Dr. Jennifer Benning and others in the Civil Engineering Department at SDSM&T. Using multiple source tracking methods will allow for quality control of results and greater certainty of source-species characterization.

(5) Hydrologic Effects from Bark Beetles

This study component was initiated during 2013 at the request of City staff, with a purpose of evaluating potential hydrologic effects of ponderosa pine mortality and loss of forest cover due to the mountain pine beetle epidemic. A short document summarizing conceptual approaches for this work was initially provided to city staff. In general, effects of various deforestation levels will be assessed in terms of expected changes to runoff volume and peak flows.

A primary modeling exercise has involved simulating changes in annual water yield resulting from various levels of incremental die off and regrowth of the ponderosa forest. Hydrologic effects are being examined using the Rainfall-Response Aquifer and Watershed Flow (RRAWFLOW) model (Long, 2015; http://dx.doi.org/10.5194/gmd-8-865-2015), which simulates short- and long-term responses of streamflow from surface runoff and groundwater flow. This model has been modified to include a parameter for vegetation loss resulting from the mountain pine beetle infestation in the watershed. This work currently is being conducted in collaboration with South Dakota School of Mines and Technology, and is part of a Master's thesis project for Brian Freed.

Plans are that modeling and analyses will be completed by January 2016, and a thesis document describing the methods and results will be completed by Brian Freed by April 2016 and provided to cooperators and interested parties. A summary of this project will be presented at the 2016 Western South Dakota Hydrology Conference in Rapid City during April 2016. After completion of this modeling project, a discussion regarding future pine beetle hydrology research will be coordinated with City staff. Potential for collaboration by other interested agencies or parties will be solicited during the upcoming year and may be a factor in determination of future directions.

Planned 2016 funding by task

Approximate funding allocations among planned program activities for calendar year 2016 are listed in Table 2. The proposed funding distribution is subject to modification during 2016, depending on possible changes in priorities established through discussions between USGS and Rapid City staff. The proposed funding level for Rapid City for the overall program is $148,000, which is higher than last year's total of $138,000 due to a one-time cost of $10,000 for relocation of the Sewage Treatment Plant streamgage (item 1b). USGS is able to provide a total of $103,105 in matching funds, which amounts to 41 percent of the total cooperative program of $251, 105.

Table 2. Planned allocation of funding for 2016 work activities

Item number	Proposed activity	Rapid City share	USGS share	Total
1a	Routine streamgaging[1]	$21,884	[1]$17,760	$39,664
1b	Relocation of Sewage Treatment Plant streamgage	$10,000	$0	$10,000
2	Hydrogeologic data collection and analysis	$27,116	$19,930	$47,046
3	Applications of groundwater-flow model	$20,000	$14,700	$34,700
4	Storm water monitoring	$54,000	$39,690	$93,690
5	Hydrologic effects of bark beetles	$15,000	11,025	$26,025
Totals to be shown on Joint Funding Agreement		**$148,000**	[1]**$103,105**	**$251,105**

[1] Of the total USGS share of $17,760 for streamgaging, $3,351 will be from the USGS National Streamflow Information Program, as shown in item 2c of the Joint Funding Agreement.