Work plan for U.S. Geological Survey activities during 2017, 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

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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 2017 work plan was finalized December 22, 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 2017

Planned activities for calendar year 2017 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 involving analysis of 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 sources of selenium in the waste water stream** is described in **section (5)**. The total proposed funding level for Rapid City is $138,000, as shown on table 2 in the final section of this work plan. USGS will provide $103,202 in matching funds (table 2), which amounts to 42.8 percent of the total cooperative program of $241,202.

(1) Streamgaging

Table 1, which reflects participation from other agencies, shows the proposed streamgaging program for 2017. Last year city staff requested relocation of the streamgage at the Water Reclamation Facility. The new streamgage upstream was installed just upstream from the Reclamation Facility and has been fully operational since late last summer. The old streamgage has been discontinued following a final discharge measurement that was made on December 2 to facilitate working of the streamflow record for the final year of record. With this exception, the proposed program is essentially identical to last year, with an inflationary increase of about 2 percent in the annual cost of a streamgage. USGS cooperative matching funds remained constant to reflect flat or decreasing appropriated funds. Funding from Rapid City for the streamgaging program will consist of $22,533 that will be matched with $17,756 from USGS, of which $3,350 is from the National Stream Information Program (see table 2 on last page of this document).

Table 1. Streamgaging program for City of Rapid City for calendar year 2017.

Gaging Station and Cooperators	Unmatched Federal	Local & State Cooperators	USGS Match	Total
Rapid Creek at Rapid City				
US Army Corps of Engineers	$7,607			$7,607
USGS NSIP Funding			$3,350	$3,350
Rapid City		$4,256		$4,256
subtotals	$7,607	$4,256	$3,350	$15,213
Rapid Creek above Water Reclamation Facility				
Rapid City		$8,513	$6,700	$15,213
subtotals		$8,513	$6,700	$15,213
Rapid Creek near Farmingdale				
DENR		$4,257	$3,350	$7,607
Rapid City		$4,256	$3,350	$7,608
subtotals		$8,513	$6,700	$15,213
Rapid Creek below Pactola Dam and below Deerfield Dam (2 gages)				
Bureau of Reclamation	$6,663			$6,663
Rapid City		$5,508	$4,356	$9,864
SDGF&P		$2,754	$2,177	$4,931
RVWCD		$2,754	$2,177	$4,931
subtotals	$6,663	$11,016	$8,710	$26,389

Summary of funding for all gages	Rapid City	Others	USGS	Total
Rapid Creek at Rapid City	$4,256	$7,607	$3,350	$15,213
Rapid Creek blw Sewage Plant	$8,513		$6,700	$15,213
Rapid Creek near Farmingdale	$4,256	$4,257	$6,700	$15,213
Rapid Creek blw Pactola and Deerfield	$5,508	$12,171	$8,710	$26,389
Total Funding	**$22,533**	**$24,035**	**$25,460**	**$72,028**

(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 (4 wells), Minnelusa (4 wells), and Minnekahta (1 well) 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. Table 2 provides a list of wells that are monitored and locations are shown in figure 1. Sites 1–3, which are located near Tilford, are partially funded by the USGS through its Collection of Basic Records (CBR) program.

Table 2. Water-level monitoring sites. [DENR, Department of Environment and Natural Resources]

Site #	Name	USGS Site ID	Monitoring method and well owners
1	Tilford Minnelusa	441759103261201	Continuous, DENR observation well
2	Tilford Madison	441759103261202	Continuous, DENR observation well
3	Tilford Minnekahta	441759103261203	Continuous, DENR observation well
4	City Quarry Minnelusa	440544103180001	Continuous, DENR observation well
5	City Quarry Madison	440544103180002	Continuous, DENR observation well
6	Sioux Park Madison	440430103160202	Continuous, DENR observation well
7	RC-7 Star Village Madison	440427103131701	Periodic, Rapid City, unused well
8	Chapel Lane 1 Minnelusa	440310103173801	Continuous, Chapel Lane, unused well
9	Wildwood North Minnelusa	440149103164901	Continuous, Rapid City well
10	Kieffer Deadwood	435644103183801	Periodic, private well
11	Jackson Springs Madison	440326103180702	Continuous, Rapid City observation well

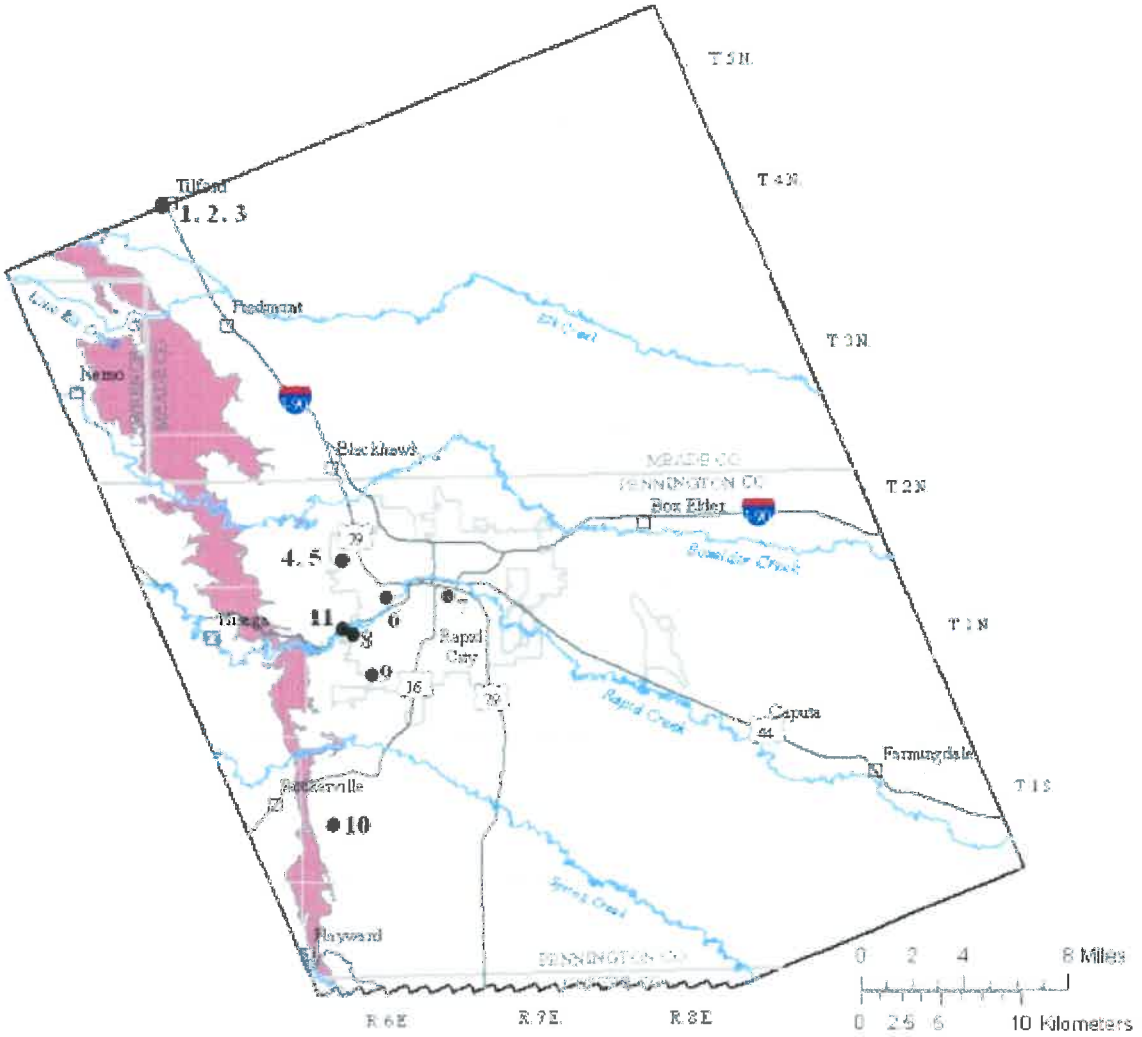

Figure 1. Location of monitoring wells.

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. An ongoing task as part of this component has been monitoring of a network of microgravity sites. Sites have been monitored since 2009 and measurements typically are made once or more each year, depending on hydrologic conditions. An overview of methods and initial results is provided by Scientific Investigations Report 2012–5158 (http://pubs.usgs.gov/sir/2012/5158/).

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 are 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

Ongoing 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/). Putnam and Long's existing model remains fully functional and has been used during recent years to address various questions that have arisen. Intentions are that this model will be used routinely to assist in planning and managing withdrawals from the Madison and Minnelusa aquifers in the Rapid City area, which form a critical component of the city's water supply.

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. An important anticipated aspect will be improved capabilities for modeling of regional artesian springflow, such as the Jackson/Cleghorn spring complex, City Springs, and springs at the Outdoor Campus. Such springs are important for maintaining surface flows with critical roles relative to ecosystem health. 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. The regional model will have utility for

other entities besides the city of Rapid City. Other agencies that have contributed to development of the regional model have included the National Park Service, the Black Hills National Forest, and the West Dakota Water Development District (WDWDD).

Efforts to develop this regional model have been underway since 2011. A preliminary product for the regional model was achieved on Nov. 16, 2016, when Bill Eldridge successfully defended his M.S. thesis project (Eldridge, 2016) in the Department of Geological Engineering at the South Dakota School of Mines and Technology. Bill's thesis project involved development and documentation of preliminary steady-state and transient models as part of the regional modeling effort. Full completion of the modeling effort is anticipated within the next several years and will be achieved by publication of a USGS report documenting model development and selected modeling scenarios.

(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 to help evaluate the effectiveness of the City's improvement programs. This stormwater monitoring component initially 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 essentially wrapped up that initial phase of this stormwater monitoring component.

A subsequent phase was initiated during 2016 that is focusing on investigating primary sources of bacteria in stormwater, which has been a persistent and vexing question for stormwater management. Preliminary plans for implementation have been discussed with City staff and further communications will occur as implementation moves forward. Additional project collaborators 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 2017 are a continuation of the two general objectives initiated in 2016: 1) quantify bacteria loads for various infrastructure elements along the drainage flow paths, and 2) identify primary source species for bacteria in stormwater discharges. A proposal/work plan with more detail was provided to city staff in April 2016. The first objective will be accomplished by collection of stormwater samples at several locations along several pre-defined flow paths (generally beginning at a rooftop or parking lot and ending at an outlet to Rapid Creek) for analyses of bacteria and sediment concentrations. The pre-defined flow paths will be characterized according to the infrastructure elements upstream, such as commercial parking lots, street curbs, subsurface drainage pipes, 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. Two potential methods have been identified for this task: 1) quantitative polymerase chain reaction (qPCR) using the USGS Microbiology lab in Columbus, OH, and 2) pathogenicity using methods developed by Dr. Linda DeVeaux and Dr. Lisa Kunza in the Chemistry and Applied Biological Sciences department at SDSM&T. Using multiple source tracking methods will allow for quality control of results and greater certainty of source-species characterization. USGS will also provide limited technical assistance to a qPCR source tracking project on Rapid Creek funded by West Dakota Water Development District and coordinated by H2E, Inc. Involvement in this project will be mutually beneficial by allowing for intra-laboratory quality-assurance comparison of qPCR source tracking results and bacteria concentration data sharing. Additional activities may involve responding to specific needs identified by city staff, such as addressing questions regarding specific stormwater facilities or providing information for use in public outreach programs.

(5) Evaluation of Potential Sources of Selenium in the Waste Water Stream

This is a new study component that will be initiated during 2017 at the request of city staff, with a purpose of evaluating potential sources of selenium in the inflow to Rapid City's Water Reclamation Facility (WRF). A Maximum Allowable Headworks Loading (MAHL) of 0.4661 pounds per day for selenium has been established for the WRF. Exceedances of the MAHL have occurred sporadically since 1998, with exceedances occurring over the last 14 consecutive quarters. Rapid City does not have any known industries that contribute substantial selenium to the waste water stream. However, naturally occurring selenium is relatively abundant in Cretaceous rocks that are exposed in eastern Rapid City, and infiltration of groundwater to the sanitary sewer system has been presumed as the primary source of selenium in the wastewater stream. To date, the United States Environmental Protection Agency (US EPA) and South Dakota Department of Environment and Natural Resources (SD DENR) have been satisfied with this explanation as the primary cause of the MAHL exceedances. However, US EPA has indicated intentions of reducing the surface-water quality standard for selenium, which also would affect the MAHL. Thus, a scientific study to better characterize sources of selenium to Rapid City's wastewater stream would be highly beneficial.

It is envisioned that 2017 activities for this study component will focus on gathering of preliminary information to be used in developing an efficient process for addressing this issue. USGS staff will coordinate with WRF staff, who have indicated intentions of implementing a detailed study of low-level selenium at strategic locations in the sanitary collection system. Initial USGS activities likely will consist of reviewing MAHL selenium samples/records and other relevant information already assembled by WRF staff and reviewing other relevant information and literature, as appropriate. Another initial activity would be to evaluate the feasibility of performing isotopic analyses for a limited number of samples collected from the waste water stream, which may help determine whether the primary selenium source or sources

are naturally occurring or anthropogenic. Preliminary sampling of both groundwater and surface sources at selected strategic locations is another likely activity for 2017. Sampling of groundwater likely will require an inventory of wells to identify sampling locations in an appropriate variety of geologic formations. Results of groundwater sampling may help drive selection of preliminary surface-water sampling sites, which besides Rapid Creek may include locations along Boxelder Creek (the northeastern quadrant of Rapid City is within this drainage basin) and Spring Creek, which typically has a small, but steady base flow and may be well suited to characterization of selenium concentrations associated with various geologic outcrops. Sampling from springs or stock dams might also be highly informative, as the geologic influences on water in these settings may be much more straightforward than in many streams.

Results from 2017 activities will be used to guide development of plans for additional activities in future years. Priorities and appropriate levels of activity for future activities will be further guided by communications with WRF staff and results of the parallel study of low-level selenium in the sanitary collection system conducted by WRF staff.

Planned 2017 funding by task

Approximate funding allocations among planned program activities for calendar year 2017 are listed in Table 2. The proposed funding distribution is subject to modification during 2017, 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 $138,000. USGS is able to provide a total of $103,202 in matching funds, which amounts to 42.8 percent of the total cooperative program of $241,202.

Table 2. Planned allocation of funding for 2017 work activities

Item number	Proposed activity	Rapid City share	USGS share	Total
1	Streamgaging[1]	$22,533	[1]$17,756	$40,289
2	Hydrogeologic data collection and analysis	$26,466	$19,586	$46,053
3	Applications of groundwater-flow model	$20,000	$14,800	$34,800
4	Storm water monitoring	$54,000	$39,960	$93,960
5	Potential sources of selenium	$15,000	11,100	$26,100
Totals to be shown on Joint Funding Agreement		**$138,000**	**[1]$103,202**	**$241,202**

[1] Of the total USGS share of $17,756 for streamgaging, $3,350 will be from the USGS National Streamflow Information Program, as shown in item 2c of the Joint Funding Agreement.