Work plan for USGS activities during 2014

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 2014 work plan 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 45/55 (USGS/city) cost-share arrangement between USGS and Rapid City. This work plan was finalized March 5, 2014, following planning meetings involving USGS and Rapid City staff.

Work plan activities for 2014

Planned activities for 2014 are described in five categories. 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**. Continued evaluation of stormwater runoff is described in section **(4) stormwater monitoring**. Continuation of a new activity from last year is described in section **(5) hydrologic effects of bark beetles.** The total proposed funding package for the complete program and an approximate distribution of funding between the four individual programmatic areas are discussed in the final section of this work plan.

(1) Streamgaging

The proposed streamgaging program for water year 2014 (Oct. 1, 2013 to Sept. 30, 2014) is presented in table 1, which also reflects participation from various other agencies. The proposed program is essentially identical to last year's program, with an inflationary increase of 3 percent in the annual cost of a streamgage. Total funding from Rapid City for the streamgaging program will consist of $23,100 that will be matched by USGS with $15,728 of Federal Matching Funds (see table 2 on last page of this document) and $3,172 from the National Stream Information Program (NSIP) change to achieve a 45/55 match ratio.

Table 1. Proposed streamgaging program for water year 2014 – City of Rapid City

Streamgage and Cooperators	Unmatched Federal	Local & State Cooperators	USGS Match	Total
Rapid Creek at Rapid City				
US Army Corps of Engineers	$7,050			$7,050
USGS NSIP Funding			$3,172	$3,172
Rapid City		$3,878		$3,878
subtotals	$7,050	$3,878	$3,172	$14,100
Rapid Creek below Sewage Plant				
Rapid City		$7,755	$6,345	$14,100
subtotals		$7,755	$6,345	$14,100
Rapid Creek near Farmingdale				
DENR		$3,877	$3,173	$7,050
Rapid City		$3,877	$3,173	$7,050
subtotals		$7,754	$6,346	$14,100
Rapid Creek at Jackson Boulevard (Water Treatment Plant, phone modem and stage record)				
Rapid City		$2,572	$2,104	$4,676
subtotals		$2,572	$2,104	$4,676
Rapid Creek below Pactola Dam and below Deerfield Dam (2 gages)				
Bureau of Reclamation	$6,150			$6,150
Rapid City		$5,018	$4,106	$9,124
SDGF&P		$2,510	$2,053	$4,563
RVWCD		$2,510	$2,053	$4,563
subtotals	$6,150	$10,038	$8,212	$24,400

Summary of funding for all streamgages	Rapid City	Others	USGS	Total
Rapid Creek below Sewage Plant	$7,755		$6,345	$14,100
Rapid Creek near Farmingdale	$3,878	$3,877	$6,345	$14,100
Rapid Creek at Jackson Boulevard (Water Treatment Plant)	$2,572		$2,104	$4,676
Rapid Creek below Pactola and Deerfield	$5,018	$11,170	$8,212	$24,400
Rapid Creek at Rapid City	$3,878	$7,050	$3,172	$14,100
Total Funding	$23,100	$22,097	$26,179	$71,376

(2) Hydrogeologic Data Collection and Analysis

Water-level monitoring using continuous recorders will be continued during 2014 for nine observation wells that are completed in the Madison, Minnelusa, and Minnekahta aquifers. Periodic water-level measurements also will continue for one Madison well in Rapid City and one Deadwood well south of Rapid City. Technical assistance will continue, as requested, for activities such as collection and analysis of water samples for stable isotopes at selected seepage sites for comparison with stable isotope values for municipal production water. Stable isotope signatures for native groundwater and municipal production water can be discernibly different and can be useful in helping evaluate whether areas with groundwater seepage might be influenced by leaks in the municipal distribution system. Geophysical methods, including microgravity, direct-current resistivity, ground-penetrating radar (GPR), and nuclear-magnetic resonance (NMR), will applied to recharge areas of the Madison and Minnelusa aquifers that affect Rapid City's groundwater supply. These methods are useful for estimating effective porosity and characterizing the spatial distribution of voids in selected aquifer locations.

(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 entire Black Hills area will 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. This modeling effort will substantially improve modeling capabilities for the Rapid City area because effects of the regional flow system on local groundwater will be better simulated. The effects of increased water use near the boundaries of the existing model will be more accurately simulated with this proposed regional model 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. Continuing participation in development of the regional groundwater flow model will be contingent on continued participation from other area agencies.

Initial efforts towards development of a regional model have been underway since 2011. To date, other contributing agencies have included the National Park Service and the Black Hills National Forest. During 2013, the West Dakota Water Development District (WDWDD) voted to provide financial support as another participating agency. During an upcoming meeting WDWDD will consider whether to further serve as a lead agency in seeking additional funding under the umbrella of the State Water Plan, which is administered by the South Dakota Department Environment of Natural Resources (SDDENR). A proposal for this regional modeling effort has been reviewed by staff from SDDENR, who suggested that the State Water Plan would be an appropriate funding mechanism. This proposal also has been shared with the

city of Spearfish and Lawrence County, who previously have supported hydrologic studies. Formal support from Spearfish and Lawrence County will be sought after WDWDD has decided whether to serve as a lead coordinating agency.

(4) Stormwater Monitoring

Rapid City has implemented programs to improve stormwater quality in response to the "Phase II Final Rule" stormwater guidelines issued by the U.S. Environmental Protection Agency. As part of this program, the city has published guidance (2009 Stormwater Quality Manual) on construction and post-construction control of stormwater discharges through best management practices (BMPs). Within the Stormwater Quality Manual, various BMP devices are suggested and described in detail; however, little information exists on field-verified performance measures of these BMPs in Rapid City. Within the past few years, several BMP structural strategies have been installed during site developments that include designs targeted at improving water quality (as opposed to the traditional large flood detention ponds). Such devices include extended sand-filter detention basins and constructed wetlands.

At the request of city staff, a concentrated effort to assess the performance of recently installed BMP devices will be continued. During 2014, monitoring will continue for the three BMP features (constructed wetland channels) located in the downtown greenway between East Boulevard and 3rd Street. At each site, inflow and outflow data will be collected for approximately three storm runoff events to document the volume of stormwater treated and mass of pollutants removed. This information can be used to supplement the Stormwater Quality Manual with expected pollutant-specific removal rates. Pollutants sampled will include total suspended sediment, bacteria, chloride, nutrients, and metals. Approximately four samples will be collected at each inlet and outlet location throughout each storm runoff hydrograph. Replacement of certain stage monitoring equipment will occur at these wetland channel sites, but minimal additional disturbance to stormwater infrastructure is expected. Additional BMP monitoring may be performed at other locations within Rapid City, such as those along the Jackson Boulevard corridor, with more detailed planning to be determined by consultation with city personnel.

Data will be stored on the National Water Information System (NWIS), and intermediate reporting of results will be accomplished through progress reports and conference presentations. Results of the wetland channel sampling will be summarized in a brief USGS publication. The adequacy of data sets for publication will be evaluated after all data are obtained from the 2014 runoff season, and discussions will be held with City staff regarding publication planning. The planned publication also will include data sets collected during several previous years of stormwater monitoring.

(5) Hydrologic Effects from Bark Beetles

At the request of city staff, this new study category was initiated last year to address potential hydrologic effects of ponderosa pine mortality and forest cover loss due to the mountain pine beetle epidemic. A short document summarizing conceptual approaches for this work was provided last year to city staff. In general, effects of various deforestation levels will be assessed in terms of expected changes to runoff volume and peak flows. Various other agencies also have expressed interest in this activity and discussions regarding possible collaboration and funding partnerships currently are underway. Final scoping will be determined when future levels of participation and specific study needs have been determined through discussions with interested agencies. Meanwhile, several possible study aspects may be addressed, as described below.

One study aspect that was initiated last year will involve reconsideration of relevant data sets associated with the 1988 Galena Fire, for which extensive pre- and post-fire data sets provide opportunities for useful insights. Although fire represents a sudden and dramatic environmental change compared to the gradual decline of forest cover due to pine beetle deforestation, this scenario essentially represents one extreme end of a spectrum regarding potential hydrological effects from deforestation. A previous analysis of Galena Fire hydrologic effects considered data only through 1998 (see http://pubs.usgs.gov/wri/wri034323/); however, about 15 years of additional data are now available. It is further anticipated that the Galena Fire data sets will be especially useful for calibrating hydrologic response models that will be applied to watersheds of interest to Rapid City, which is envisioned as the main focus for this study category.

A primary modeling exercise will involve simulating changes in annual water yield resulting from various levels of incremental die off and regrowth of the ponderosa pine forest. The model will be calibrated using historical streamflow data from several streamgages that represent different hydrogeologic settings—such as the Precambrian core of the Black Hills (dominated by surface-water runoff) versus the Limestone Plateau area, where the hydrologic budget is dominated by groundwater recharge. The model will derive empirical relationships involving forest cover utilizing aerial photography, satellite imagery, precipitation records, and our streamgage network for evidence of the physical response to the existing condition and the recent widespread mortality. The model will permit examination of future water yield by running forward various scenarios for future possible changes in forest cover and associated changes to the water budget across the watershed. The model will be developed to span different scales. For example, the model will initially be calibrated to streamgages based on the overall fraction of tree mortality or other land-cover factors at the basin scale. Similar methodologies have been used to simulate springflow response to climate change, and may be applicable to limestone regions of the watershed. Once calibrated, the soil-moisture component of the model could then be applied to sub-basin scales to provide a more realistic response of the basin to events, such as

extreme rainfall and runoff events. In examining various aspects of the hydrologic response, models such as HEC-HMS (supported and maintained by U.S. Army Corps of Engineers) and the Precipitation-Runoff Modeling System (supported and maintained by USGS), or the other model developed from the larger basin-scale study, will be used to assess the watershed response to extreme hydrologic events, such as peak discharge and minimum flows.

Intermediate reporting of results will be accomplished through progress reports and conference presentations. Final results will be included in a USGS Scientific Investigations Report that likely would focus primarily on results of modeling exercises. Scoping for the final publication could be affected by modeling needs and associated considerations for other agencies that may join in future collaborations.

Planned 2014 funding by task

Approximate funding allocations among planned program activities for 2014 are listed in Table 2. Planned work efforts and associated funding are to be on a calendar year basis for 2014, with the exception of Item 1 (streamflow gaging), which will be for water year 2014 (Oct. 1, 2013 to Sept. 30, 2014). A 45/55 cost share between Rapid City and USGS is accomplished for all program components. The proposed distribution of program funding is subject to modification during 2014, depending on possible changes in priorities established through discussions with Rapid City staff.

Table 2. Planned allocation of funding for 2014 work activities

Item number	Proposed activity	Rapid City share	USGS share	Total
1	Streamgaging[1]	$23,100	[1]$15,728	$38,828
2	Hydrogeologic data collection and analysis	$25,000	$20,500	$45,500
3	Applications of groundwater-flow model	$13,000	$10,660	$23,660
4	Storm water monitoring	$46,900	$38,458	$85,358
5	Hydrologic effects of bark beetles	$30,000	24,600	$54,600
Totals to be shown on Joint Funding Agreement		**$138,000**	**[1]$109,946**	**$247,946**

[1] Additional funding of $3,172 for the streamgaging program will be provided by USGS through the National Streamflow Information Program, to accomplish an effective 45/55 match.