A Solution to Iron County's Cedar Valley Over Drafting of Ground Water

Introduction

Most Iron County residents share a diminishing resource: ground water pumped from wells in the valleys west of the major faults that mark the beginning of the Colorado Plateau. The vast majority of the water used in central Iron County comes from layered sand and gravel aquifers under the valleys. Radioactive dating has shown that most of the water supply is quite old, having been deposited during cooler and wetter times that triggered the expansion of Lake Bonneville, about 18,000 years ago. Today our withdrawals of old water exceed annual replacement ("recharge") by nearly 10,000 acre-feet (the amount of water that would cover 10,000 acres of land, one foot deep) every year. This "over drafting" has caused disruptive surface settlement in parts of Cedar Valley

Development of New Water Sources

As one alternative to Cedar Valley over-pumping, Iron County residents may be asked in about seven years to pay hundreds of millions of their tax dollars for construction of wells and pipelines to import 25,000 acre-feet of water from the West Desert of Beaver County. Another, much cheaper method to develop additional water for Iron County is to begin now to explore for and develop additional local water supplies known to exist in the mountains that surround us.

Our prolific valley aquifer systems are bounded on the east, west, and south by high mountains containing thick, porous sandstones and fractured volcanic and granitic bedrock. Most of the precipitation in the county falls directly on these mountains, as shown by measured amounts of rain and water content of snow. For example, average annual accumulation at Midway, near the summit of Highway 14, is about 40 inches, compared to about nine to12 inches on the valley floors. Precipitation on Stoddard Mountain, Iron Mountain, and the Harmony Mountains exceeds 20 inches, twice the amount that falls in the valleys.

Why We Must Look to the Mountains for More Water

Virtually all of the published scientific reports about water in Iron County agree that little of the water falling in the surrounding mountains flows underground into the valley aquifers. Much of it flows to the southeast deep in the subsurface, following shattered rocks exposed in NW to SE fracture systems. The recharge to the valley aquifers is primarily from direct soaking in ("infiltration") of melting snow and rainfall, and infiltration of runoff water from the beds of streams such as Coal Creek, Parowan Creek, and Kanarra Creek that enter the valleys from the east. Surface water that reaches Quichapa Lake and Little Salt Lake is eventually lost to evaporation, as the lake floors consist of "impermeable" (tight) clays that transmit little water into the underlying aquifers.

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The good news is that all of this "lost" water is replaced each year by alpine precipitation. Surface water flowing westward in streams from the Markagunt and Kolob portions of the Colorado Plateau is available to be captured in new reservoirs, and the water transferred into the western valleys through pipelines that could drive hydroelectric turbines to generate renewable energy.

Infiltrating precipitation (high quality ground water) can be produced from carefully located wells drilled into the porous and/or fractured bedrock in the mountainous portions of Iron County. For example, Brian Head town recently completed a well near their Town Hall that produces more than 2,000 gallons per minute from fractured and porous pebbly sandstones about 1,500 feet below ground. Many of the best wells in neighboring Washington County are already developed in fractured granitic bedrock along the western edge of New Harmony Valley, and in the porous and permeable Navajo and Kayenta Formation bedrock sandstones that occur in much of Washington County.

Why New Approaches are Necessary

Exploration for new water is risky. Political risk--for example risk associated with transferring water rights out of Cedar Valley-- appears to be bigger than the geologic risk of finding new water in the bedrock aquifers of Iron County. Because of that risk, until now there has not been a mechanism to fund new water exploration. State, County, or private funds on the order of $1,000,000 must be raised.

Summary

Exploration of bedrock aquifers in the mountains of Iron County could result in the identification of more renewable water than is currently pumped ("over drafted") from the sand and gravel aquifers under Cedar Valley. Average annual precipitation records show that water production from the bedrock aquifers in the mountainous areas of the county can be sustained without damaging existing flows from the springs and creeks now tapped for use.

Local scientists, engineers, and public officials can work together to develop more of the water available from the bedrock aquifers and mountain streams in Iron County. Enough new, high quality, water will be found to support present needs and anticipated future growth.

Let's go get it now!

Utah Professional Geologist No. 5280804-2250
January 14, 2016

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SUBMISSION OF WATER DEVELOPMENT PROJECTS:
A SOLUTION TO OVER DRAFTING OF CEDAR VALLEY, IRON COUNTY, UTAH

Through the development of scientific studies defining the aquifer within the Cedar Basin, it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without more water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget.

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This submittal describes an opportunity to develop ground water from the porous and fractured bedrock aquifers within the western and eastern boundaries of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR).

Each well capable of 2,000 gallons per minute would produce 4.456 cubic feet per second, or 8.836 acre-feet per day. Therefore, one well pumped for 365 days each year would provide more than 3,200 acre-feet. Likely infiltration rates from average annual precipitation in those portions of the surrounding mountains within the basin are in excess of 20,000 acre-feet per year.

Exploratory wells would be the start of an eventual larger set of wells utilized to reduce over drafting of the Cedar Valley Basin alluvial aquifer system. Water could be utilized for industrial, agricultural, and culinary purposes.

STANDARD FORM 2015-1 (06/2015)

SUBMISSION OF WATER DEVELOPMENT PROJECTS: RE-ENTRY OF THE ARCo THREE PEAKS EXPLORATORY OIL WELL

Through the development of scientific studies defining the aquifer within the Cedar Basin it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget. This form is being circulated to document additional water supply sources that could be utilized to further alleviate the water deficit in the aquifer, as well as provide water for the future residents of the valley. This form will be evaluated for completeness of content. Please ensure that the proposed project is fully defined and information to substantiate the claim is submitted for a complete evaluation.

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Name, Title, and Address of authorized Agent
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A. Provide names, addresses, phone numbers and email addresses of those who filled out this form.
See above.

B. Project Description With Vital Details.
1. Scope of Work and Project Description
2. Type of System or Facility
3. Quantity of Water Anticipated
4. Scientific Analysis of Water Resource
5. Uses (irrigation, culinary, industrial, etc.)
6. Years Resource is Available
7. Constructability
8. Additional information to describe resource and availability (additional sheets provided)

B.1. This project is an opportunity to develop ground water from the fractured quartz monzonite bedrock aquifer within the western portion of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR). The availability of water would be proven initially with the recompletion of one abandoned exploratory oil well along Iron Springs Road. That ARCo well was drilled on private lands. The well would be re-entered and tested with perforations through existing casing at depths ranging from 2,490 to 2,610 feet below ground level, with projected sustainable productivity of more than 2,000 gallons per minute. Produced water could be pumped into a reservoir constructed in Iron Springs Creek, and allowed to percolate into the Cedar Valley alluvial basin. Water could eventually be conducted approximately 6 miles to the southeast via pipeline to industrial and residential consumers along Utah Highway 56.

B.2. This well would be one of an eventual larger set of wells utilized to reduce over drafting of the Cedar Valley Basin alluvial aquifer system. Water could be utilized for both industrial and culinary purposes. The well location is near to existing power lines and roads so that only minimal new development would be necessary to test the concept.

B.3. A well capable of 2,000 gallons per minute would produce 4.456 cubic feet per second, or 8.836 acre-feet per day. Therefore, one well pumped for 365 days each year would provide more than 3,200 acre-feet.

Recharge estimates for the bedrock aquifers under Harmony Mountains and Three Peaks prepared by Player in 2010 range from 12,800 to 16,000 acre-feet per year, showing that continuous production of 12,000 acre-feet per year would not draw down the bedrock aquifer.

THE AREA UNDERLAIN BY THE FRACTURED QUARTZ MONZONITE AQUIFER WEST OF CEDAR VALLEY IS APPROXIMATELY 200 SQUARE MILES. THE FOLLOWING ESTIMATE OF RECHARGE IS BASED ON 15 INCHES OF PRECIPITATION PER YEAR AND 10% INFILTRATION:

Precipitation = 1.25 feet per year
Infiltration at 10% = .125 feet per year
Area = 200*640 = 128,000 acres
Annual infiltration = .125*128, 000 = 16,000 acre-feet per year

Alternatively, recharge would not be less than 12,800 acre-feet with one foot (12 inches) of precipitation and 0.1 foot of infiltration per year.

B.4. The likelihood of a sustainable bedrock aquifer resource in the Harmony Hills west of Cedar Valley was shown by Player in geohydrologic reports prepared for the Cedar City Water Utility. Scientific studies included estimation of bedrock thickness, and review of published and unpublished chemical analyses of spring waters issuing from the bedrock aquifers. Summaries of those studies are attached to a cover letter for the Player-Nelson submissions.

One water sample was obtained from the Quichapa Creek No. 1 well, drilled in 2012. Water from the quartz monzonite aquifer (encountered below 500 feet) was mixed with water from a thin sandstone layer in the Quichapa Volcanics at about 225 feet below ground level. Total dissolved solids (TDS) in the mixed sample were 205 mG/L (milligrams per liter of water).

Water from the Quichapa Creek Left-hand Canyon spring was sampled on the same day. That water had a lower TDS of 165 mG/L. It is interesting to note that water from the test well was found to be significantly younger (approximately 510 years before present) than water issuing from the surface spring in Quichapa Left-hand Canyon (approximately 1,660 years before present). The age difference suggests that recharge water occurring in the fractured quartz monzonite aquifer is younger than water that is the source of the springs in the shallower but less permeable Quichapa Volcanic rocks.

B.5. Water pumped into a reservoir along Iron Springs Creek would be usable by for irrigation in the western portion of Cedar Valley, allowing farmers and ranchers to switch from expensive pumped wells to virtually free canal water.

B.6. The bedrock aquifer resource is sustainable due to annual infiltration from precipitation. In the unlikely event of long term drought, the production of 3,200 acre-feet per year could be sustained for almost 3,600 years without recharge into the fractured quartz monzonite bedrock aquifer system within the Cedar Valley Basin. That aquifer is estimated to contain more than 11,500,000 acre-feet of water in place.

B.7. This well could be drilled by local drilling contractors. Power lines are in place along Highway 14 for easy access to the drill site.

B.8. Summaries of bedrock aquifer studies completed in 2010 are attached to the cover letter for the Player-Nelson submissions. More detailed reports can be provided when requested.

C. A map showing the proposed location for the first well at Woods Ranch is attached.

C.1. The well site is on private property.

C.2. There are no potential conflicts. Re-entry of the well will require a permit from the Utah Division of Oil, Gas, and Mining.

C.3. The area is flat and will not require grading.

D.1. Federal issues are minimal on private property. Iron Springs Creek dried up as the Cedar Basin aquifer was over drawn, and no fishery is present. The proposed area is outside of managed Sage Grouse habitat.

D.2. State issues are few. Cedar Basin water rights will be transferred by the Utah Division of Water Rights into the old ARCo well prior to beginning full scale production. The sources of those water rights would be farmers, ranchers, Cedar City Municipal Water Utility, and Southern Utah University. It is at least possible that the well would discover "new water" that could be appropriated to the District.

D.3. Local issues are unlikely to be problematic

E. **Cost Estimate:** Each exploratory well will cost on the order of $200,000 to complete and equip with pumps and short pipelines to streams. Full development of 15 wells (described in a separate Submission) would cost approximately $3,000,000 to develop 12,000 acre-feet per year. The CAPEX for full development of the aquifer would be on the order of $250 per acre-foot.

F. **Additional Alternatives:** Separate Submissions of Water Development Projects from Player and Nelson include the following: (1) Construction of a Cretaceous aquifer test well at the Sheepherders Cabin Road, about one mile west of Woods Ranch; and (2) Deepening of the Cedar City Quichapa Creek Number 1 well into the fractured quartz monzonite aquifer.

G. **Environmental Effects:** Full scale production of water from the fractured quartz monzonite aquifer west of Cedar Valley could lead to the elimination of over drafting from the Cedar Valley aquifer system.

H. **Cultural Resources:** Iron Springs Gap has provided access to several industrial and mining operations, and has been "disturbed" for 100 years. No cultural or archeological resources are present at the site. For your information, Player served as an environmental inspector during construction of the Kern River Pipeline, and supervised SUU archeologist Barbara Frank as she prepared clearances across a 100-mile segment of the line from Milford to eastern Nevada.

J. **Additional Information:** Player reviewed the Harmony Hills bedrock aquifer system for Cedar City in 2010. All of his work will be available for review with the permission of City Engineer's office. For example, additional data includes meteorological studies, summaries of geology, water analyses, aquifer rock properties, old well records, etc. Summaries of the aquifer study are attached to the cover letter provided with the Player-Nelson Submissions.

Respectfully Submitted,

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Idaho Professional Geologist No. 1050
Certified Petroleum Geologist No. 3097

H. Roice Nelson, Jr.
Texas Professional Geoscientist No. 5120
Louisiana Professional Geoscientist No. 879

Attachments:

1. Location Map

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STANDARD FORM 2015-1 (06/2015)

SUBMISSION OF WATER DEVELOPMENT PROJECTS: DEEPENING AND TESTING THE QUICHAPA CREEK NO. 1 EXPLORATORY WELL

Through the development of scientific studies defining the aquifer within the Cedar Basin it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget. This form is being circulated to document additional water supply sources that could be utilized to further alleviate the water deficit in the aquifer, as well as provide water for the future residents of the valley. This form will be evaluated for completeness of content. Please ensure that the proposed project is fully defined and information to substantiate the claim is submitted for a complete evaluation.

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A. Provide names, addresses, phone numbers and email addresses of those who filled out this form.
See above.

B. Project Description With Vital Details.
1. Scope of Work and Project Description
2. Type of System or Facility
3. Quantity of Water Anticipated
4. Scientific Analysis of Water Resource
5. Uses (irrigation, culinary, industrial, etc.)
6. Years Resource is Available
7. Constructability
8. Additional information to describe resource and availability (additional sheets provided)

B.1. This project is an opportunity to develop ground water from the fractured quartz monzonite bedrock aquifer within the western portion of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR). The availability of large quantities of water would be proven initially with the deepening of one 702 feet deep, suspended water well near the convergence of the left and right-hand canyon branches of Quichapa Creek. That Cedar City well was drilled on SITLA lands. The well should be re-entered and deepened to approximately 1,200 feet below ground level, with projected sustainable productivity of up to 2,000 gallons per minute. Produced water could initially be pumped into an existing Cedar City culinary water pipeline now carrying waters from two Quichapa Creek springs. Produced water could also be injected into one or more existing Quichipa Lake wells, and allowed to percolate into the Cedar Valley alluvial basin.

B.2. This well would be one of an eventual larger set of wells utilized to reduce over drafting of the Cedar Valley Basin alluvial aquifer system. Water could be utilized for industrial, agricultural, and culinary purposes. The well location is near to existing power lines, pipelines, and roads so that only minimal new development would be necessary to test the concept.

B.3. A well capable of 2,000 gallons per minute would produce 4.456 cubic feet per second, or 8.836 acre-feet per day. Therefore, one well pumped for 365 days each year would provide more than 3,200 acre-feet.

The ARCo well drilled in Iron Springs Gap disclosed about 4,000 feet of intrusive quartz monzonite, while at least 3,000 feet are revealed at the outcrops (surface exposures) in the Pine Valley Mountains.

Recharge estimates for the fractured bedrock aquifers prepared by Player in 2010 range from 12,800 to 16,000 acre-feet per year, showing that continuous production of 12,000 acre-feet per year would not draw down the bedrock aquifer:

THE AREA UNDERLAIN BY THE FRACTURED QUARTZ MONZONITE AQUIFER WEST OF CEDAR VALLEY IS APPROXIMATELY 200 SQUARE MILES. THE FOLLOWING ESTIMATE OF RECHARGE IS BASED ON 15 INCHES OF PRECIPITATION PER YEAR AND 10% INFILTRATION:

Precipitation = 1.25 feet per year
Infiltration at 10% = .125 feet per year
Area = 200*640 = 128,000 acres
Annual infiltration = .125*128, 000 = 16,000 acre-feet per year

Alternatively, recharge would not be less than 12,800 acre-feet with one foot (12 inches) of precipitation and 0.1 foot of infiltration per year.

B.4. The likelihood of a sustainable bedrock aquifer resource in the Harmony Hills west of Cedar Valley was shown by Player in geohydrologic reports prepared for the Cedar City Water Utility. Scientific studies included estimation of bedrock thickness, and review of published and unpublished chemical analyses of spring waters issuing from the bedrock aquifers. Summaries of those studies are attached to the cover letter accompanying this Submission.

One water sample was obtained from the Quichapa Creek No. 1 well, drilled in 2012. Water from the quartz monzonite aquifer (encountered below 500 feet) was mixed with water from a thin sandstone layer in the Quichapa Volcanics at about 225 feet below ground level. Total dissolved solids (TDS) in the mixed sample were 205 mG/L (milligrams per liter of water).

Water from the Quichapa Creek Left-hand Canyon spring was sampled on the same day. That water had a lower TDS of 165 mG/L. It is interesting to note that water from the test well was found to be significantly younger (approximately 510 years before present) than water issuing from the surface spring in Quichapa Left-hand Canyon (approximately 1,660 years before present). The age difference suggests that recharge water occurring in the fractured quartz monzonite aquifer is younger than water that is the source of the springs in the shallower but less permeable Quichapa Volcanic rocks.

B.5. Water pumped into a pipeline along Quichapa Creek would be usable by for culinary water of irrigation in the western portion of Cedar Valley. Alternatively, the "new" water could be used to recharge the Cedar Valley aquifer system through drawn down Quichapa Lake wells.

B.6. The bedrock aquifer resource is sustainable due to annual infiltration from precipitation (see above). In the unlikely event of long term drought, the production of 3,200 acre-feet per year could be sustained for more than 3,600 years without any recharge into the fractured quartz monzonite bedrock aquifer system (at least 3,000 feet thick, with 3 percent fracture porosity) beneath the westernmost portion of the Cedar Valley Basin. That aquifer is estimated to contain more than 11,500,000 acre-feet of water in place.

B.7. This well could be deepened and completed by local drilling contractors. Power lines and a road are in place for easy access to the drill site.

B.8. Summaries of bedrock aquifer studies completed in 2010 are attached to the cover letter. More detailed reports can be provided when requested.

C. A map showing the location of the Quichapa Creek No. 1 well is attached.

C.1. The Quichapa Creek well was drilled on SITLA lands.

C.2. Agreements with nearby surface owners at Quichapa Creek is likely. Power lines and water lines already cross the Bumble Bee Road right of way.

C.3. Roads and pipelines are already constructed. The well head (casing) is in place.

D.1. Federal issues are minimal at Quichapa Creek. The entire proposed area is outside of managed Sage Grouse Habitat.

D.2. State issues are few. Cedar Basin water rights will be transferred by the Utah Division of Water Rights into the ARCo well prior to beginning full scale production. The sources of those water rights would be farmers, ranchers, Cedar City Municipal Water Utility, and Southern Utah University. It is at least possible that the well would discover "new water" that could be appropriated to the District. Permits to reenter the well must be obtained from the Utah Division of Water Rights.

D.3. Local issues are few.

E. **Cost Estimate:** Costs to reenter the well will be on the order of $150,000 to complete and equip with pumps and a short pipeline (less than 100 feet).

F. **Additional Alternatives:** Separate Submissions of Water Development Projects from Player and Nelson include the following: (1) Construction of a Cretaceous aquifer test well at the Sheepherders Cabin Road, about one mile west of Woods Ranch; and (2) Reentry of the ARCo Three Peaks No. 1 Exploratory Oil Well.

G. **Environmental Effects:** Injection of water into Quichapa Lake wells would aid in the recharge of Cedar Valley Basin aquifer(s)

H. **Cultural Resources:** No cultural or archeological resources are present at the site. The site was inspected and cleared prior to commencement of drilling in 2012. For your information, Player served as an environmental inspector during construction of the Kern River Pipeline, and supervised SUU archeologist Barbara Frank as she prepared clearances across a 100-mile segment of the line from Milford to eastern Nevada.

I. **Additional Information:** Player reviewed the fractured quartz monzonite bedrock aquifer system for Cedar City in 2010. All of his work will be available for review with the permission of City Engineer's office. For example, additional data includes meteorological studies, summaries of geology, water analyses, aquifer rock properties (matrix porosity and fracture systems), old well records, etc. Summaries of the aquifer study are attached to the cover letter that accompanies this Submission.

Respectfully Submitted,

Gary Farnsworth Player
Utah Professional Geologist No. 5280804-2250
Idaho Professional Geologist No. 1050
Certified Petroleum Geologist No. 3097

H. Roice Nelson, Jr.
Texas Professional Geoscientist No. 5120
Louisiana Professional Geoscientist No. 879

Attachments:

1. Location Map

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STANDARD FORM 2015-1 (06/2015)

SUBMISSION OF WATER DEVELOPMENT PROJECTS: CRETACEOUS BEDROCK WELL AT SHEEPHERDERS CABIN ROAD

Through the development of scientific studies defining the aquifer within the Cedar Basin it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget. This form is being circulated to document additional water supply sources that could be utilized to further alleviate the water deficit in the aquifer, as well as provide water for the future residents of the valley. This form will be evaluated for completeness of content. Please ensure that the proposed project is fully defined and information to substantiate the claim is submitted for a complete evaluation.

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A. Provide names, addresses, phone numbers and email addresses of those who filled out this form.
See above.

B. Project Description With Vital Details.
1. Scope of Work and Project Description
2. Type of System or Facility
3. Quantity of Water Anticipated
4. Scientific Analysis of Water Resource
5. Uses (irrigation, culinary, industrial, etc.)
6. Years Resource is Available
7. Constructability
8. Additional information to describe resource and availability (additional sheets provided)

B.1. This project is an opportunity to develop ground water from porous bedrock aquifers within the eastern portion of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR). The availability of water would be proven initially with the completion of one well south of Utah Highway 14. The first well would be drilled along Sheepherders Cabin Road on lands owned by Southern Utah University. The well would be drilled to a depth of 500 to 1,000 feet, with projected sustainable productivity of 1,000 to 1,500 gallons per minute. Produced water would be pumped into a tributary of Crow Creek, and allowed to flow down Crow Creek to its intersection with Ashdown Creek (where it becomes Coal Creek). Water could then be directed to a proposed off stream storage facility along Rock Creek, or be allowed to flow into Cedar Valley via existing stream channels and newly constructed canals.

B.2. This well would be one of an eventual larger set of wells utilized to stabilize flow in the Coal Creek drainage system throughout the spring and summer months. Water could be utilized for both agricultural and culinary purposes. The well location is near to existing power lines and Crow Creek so that only minimal new development would be necessary to test the concept.

B.3. Each well capable of 1,000 gallons per minute would produce 2.228 cubic feet per second, or 4.418 acre-feet per day. Therefore, one well pumped for 182 days each year would provide slightly more than 800 acre-feet. Eventual development of only five wells could provide about 4,000 acre-feet in the same period of time. A development of 15 wells, each producing 1,000 gallons per minute, would provide approximately 12,000 acre-feet in six months, allowing wells in the valley floor to be shut-in, so that all over-drafting of the valley aquifers could be eliminated. Recharge estimates for the bedrock aquifers prepared by Player in 2010 range from 10,000 to 15,000 acre-feet per year, showing that continuous production of 12,000 acre-feet per year would not draw down the bedrock aquifer.

B.4. The likelihood of a sustainable bedrock aquifer resource in the western portion of the Markagunt Plateau was shown by Player in geohydrologic reports prepared for the Cedar City Water Utility. Scientific studies included estimation of bedrock thickness, laboratory measurements of aquifer porosity, and review of published and unpublished chemical analyses of spring waters issuing from the bedrock aquifers. Summaries of those studies are attached to a cover letter delivered with this Submission.

Water samples from Cedar City springs developed in Right Hand Canyon, south of Coal Creek, averaged 230 -250 mG/L of Total Dissolved Solids (TDS), comparable to water developed in Cedar Valley. One sample collected by Player from the "piped spring" exiting Cretaceous Straight Cliffs Sandstones due east of the major landslide along Highway 14 was analyzed at the SUU water laboratory in December of 2014. That sample had at a TDS of 230 mG/L, the same as the waters issuing from springs in Cretaceous bedrock at Right Hand Canyon.

B.5. Water pumped into Coal Creek would be usable by for irrigation in Cedar Valley, allowing farmers and ranchers to switch from expensive pumped wells to virtually free canal water. Water stored at Rock Creek (to be described in a future Submission) or other CICWCD facilities along Coal Creek would be suitable for domestic and industrial use after suspended solids settled out during residency in reservoirs.

B.6. The bedrock aquifer resource is sustainable due to annual infiltration from precipitation. In the unlikely event of long term drought, the production of 4,000 acre-feet per year could be sustained for more than 6,900 years without recharge to that portion of the bedrock aquifer system within the Cedar Valley Basin estimated to contain more than 27,648,000 acre-feet of water in place.

B.7. This well could be drilled by local drilling contractors. Power lines are in place near the Sheepherders Cabin Road for easy access to the drill site. Produced water could be piped to a Crow Creek tributary within an economical and short (less than 500 feet) PVC pipeline.

B.8. Summaries of bedrock aquifer studies completed in 2010 are attached to the cover letter referenced above. More detailed reports can be provided when requested.

C. A map showing the proposed location for the first well at Sheepherders Cabin road is attached.

C.1. The first test well would be drilled on lands owned by Southern Utah University.

C.2. Rapid agreement with surface owners at SUU is likely. Power lines and water lines will cross an SUU right of way, requiring negotiated access.

C.3. The proposed test well location is on private, developed lands. A well at Sheepherders Cabin Road would require a power line to be constructed across an SUU road. Produced water could be directed to Crow Creek through a tributary channel, less than 500 feet away from the proposed drill site.

D.1. Federal issues are minimal on private property. Crow Creek and Coal Creek are both certified as having no fishery. The entire proposed area is outside of designated Sage Grouse Habitat.

D.2. State issues are few. Proposed stream flow maintenance could be done at rates that do not exceed 35 cubic feet per second, rates routinely exceeded naturally during spring run off. Cedar Basin water rights will be transferred by the Utah Division of Water Rights into each well prior to beginning full scale production. The sources of those water rights would be farmers, ranchers, Cedar City Municipal Water Utility, and Southern Utah University. It is at least possible that the wells would discover "new water" that could be appropriated to the District.

D.3. Local issues are unlikely to be problematic.

E. **Cost Estimate:** An exploratory well will cost on the order of $200,000 to complete and equip with pumps and short pipelines to streams. A full scale development of 15 wells would cost approximately $3,000,000 to produce 12,000 acre-feet per year. The CAPEX for full development of the aquifer would be on the order of $250 per acre-foot.

F. **Additional Alternatives:** Separate Submissions of Water Development Projects from Player and Nelson include the following: (1) A re-entry of the ARCo Three Peaks well to test the fractured quartz monzonite aquifer at Iron Springs; and (2) Deepening of the Cedar City Quichapa Creek Number 1 well into the fractured quartz monzonite aquifer.

F. **Environmental Effects:** Continuous summertime flow of Coal Creek could possibly allow the establishment of a trout fishery. Eventual construction of off-stream storage at Rock Creek would allow development of both trout and bass fisheries.

H. **Cultural Resources:** No cultural or archeological resources are present at the site. For your information, Player served as an environmental inspector during construction of the Kern River Pipeline, and supervised SUU archeologist Barbara Frank as she prepared clearances across a 100-mile segment of the line from Milford to eastern Nevada.

I. **Additional Information:** Player reviewed the Markagunt Plateau bedrock aquifer system for Cedar City in 2010. All of his work will be available for review with the permission of the City Engineer's office. For example, additional data includes meteorological studies, summaries of geology, water analyses, aquifer rock properties (matrix porosity and fracture systems), old well records, etc. Summaries of the aquifer study are attached to the cover letter accompanying this Submission.

Respectfully Submitted,

Gary Farnsworth Player
Utah Professional Geologist No. 5280804-2250
Idaho Professional Geologist No. 1050
Certified Petroleum Geologist No. 3097

H. Roice Nelson, Jr.
Texas Professional Geoscientist No. 5120
Louisiana Professional Geoscientist No. 879

Attachments:

1. Location Map

C:\Users\Gary\Google Drive\Gary's Folder\AQUA\CICWCD\STANDARD SUBMISSIONS\STANDARD FORM 20151 SHEEPHERDERS CABIN WELL.wpd

STANDARD FORM 2015-1 (06/2015)

SUBMISSION OF WATER DEVELOPMENT PROJECTS: EXPLORATORY WELL AT THE WATER TANK NEAR THREE PEAKS REC AREA

Through the development of scientific studies defining the aquifer within the Cedar Basin it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget. This form is being circulated to document additional water supply sources that could be utilized to further alleviate the water deficit in the aquifer, as well as provide water for the future residents of the valley. This form will be evaluated for completeness of content. Please ensure that the proposed project is fully defined and information to substantiate the claim is submitted for a complete evaluation.

Name and Address of Applicant
Gary F. Player
1671 W 546 S
Cedar City, Utah 84720
gfplayer@kennylakeventures.us

Name, Title, and Address of authorized Agent
Roice Nelson
2155 W 700 S, No. 31
Cedar City, Utah 84720
rnelson@walden3d.com

A. Provide names, addresses, phone numbers and email addresses of those who filled out this form.
See above.

B. Project Description With Vital Details.
1. Scope of Work and Project Description
2. Type of System or Facility
3. Quantity of Water Anticipated
4. Scientific Analysis of Water Resource
5. Uses (irrigation, culinary, industrial, etc.)
6. Years Resource is Available
7. Constructability
8. Additional information to describe resource and availability (additional sheets provided)

B.1. This project is an opportunity to develop ground water from the fractured quartz monzonite bedrock aquifer within the western portion of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR). The availability of large quantities of water would be proven by a well drilled adjacent to the water storage tank at the west end of Mid Valley Road in Enoch. Produced water could initially be pumped into the existing CICWCD tank now used to pressurize a culinary water pipeline.

B.2. This well would be one of an eventual larger set of wells utilized to reduce over drafting of the Cedar Valley Basin alluvial aquifer system. Water could be utilized for industrial, agricultural, and culinary purposes. The well location is near to existing power lines, pipelines, and roads so that only minimal new development would be necessary to test the concept.

B.3. A well capable of 2,000 gallons per minute would produce 4.456 cubic feet per second, or 8.836 acre-feet per day. Therefore, one well pumped for 365 days each year would provide more than 3,200 acre-feet. The ARCo well drilled in Iron Springs Gap disclosed about 4,000 feet of intrusive quartz monzonite, while about 3,000 feet are revealed at the outcrops (surface exposures) in the Pine Valley Mountains and Three Peaks east of Iron Springs Gap.

Recharge estimates for the fractured bedrock aquifers prepared by Player in 2010 range from 12,800 to 16,000 acre-feet per year, showing that continuous production of 12,000 acre-feet per year would not draw down the bedrock aquifer:

THE AREA UNDERLAIN BY THE FRACTURED QUARTZ MONZONITE AQUIFER WEST OF CEDAR VALLEY IS APPROXIMATELY 200 SQUARE MILES. THE FOLLOWING ESTIMATE OF RECHARGE IS BASED ON 15 INCHES OF PRECIPITATION PER YEAR AND 10% INFILTRATION:

> **Precipitation = 1.25 feet per year**
> **Infiltration at 10% = .125 feet per year**
> **Area = 200*640 = 128,000 acres**
> **Annual infiltration = .125*128, 000 = 16,000 acre-feet per year**

Alternatively, recharge would not be less than 12,800 acre-feet with one foot (12 inches) of precipitation and 0.1 foot of infiltration per year.

B.4. The likelihood of a sustainable bedrock aquifer resource in the Harmony Hills west of Cedar Valley was shown by Player in geohydrologic reports prepared for the Cedar City Water Utility. Scientific studies included estimation of bedrock thickness, and review of published and unpublished chemical analyses of spring waters issuing from the bedrock aquifers. Summaries of those studies are attached to this Submission.

One water sample was obtained from the Quichapa Creek No. 1 well, drilled in 2012. Water from the quartz monzonite aquifer (encountered below 500 feet) was mixed with water from a thin sandstone layer in the Quichapa Volcanics at about 225 feet below ground level. Total dissolved solids (TDS) in the mixed sample were 205 mG/L (milligrams per liter of water).

Water from the Quichapa Creek Left-hand Canyon spring was sampled on the same day. That water had a lower TDS of 165 mG/L. It is interesting to note that water from the test well was found to be significantly younger (approximately 510 years before present) than water issuing from the surface spring in Quichapa Left-hand Canyon (approximately 1,660 years before present). The age difference suggests that recharge water occurring in the fractured quartz monzonite aquifer is younger than water that is the source of the springs in the shallower but less permeable Quichapa Volcanic rocks.

B.5. Water pumped into the water tank at the west end of Mid Valley Road would be usable for irrigation and culinary water in the north western portion of Cedar Valley.

B.6. The bedrock aquifer resource is sustainable due to annual infiltration from precipitation (see above). In the unlikely event of long term drought, the production of 3,200 acre-feet per year could be sustained for more than 3,600 years without any recharge into the fractured quartz monzonite bedrock aquifer system (at least 3,000 feet thick, with 3 percent fracture porosity) beneath the westernmost portions of the Cedar Valley Basin. That aquifer is estimated to contain more than 11,500,000 acre-feet of water in place.

B.7. This well could be deepened and completed by local drilling contractors. Power lines and a road are in place for easy access to the drill site.

B.8. Several residential wells have been drilled within one to two miles of the water tank. Well logs available from the UDWR show that weathered soils are underlain by "rocks" variously described as "layers of rocks with water," "gravel," and "granite." Water levels in all of the wells were reported as 150 to 300 feet below ground level. A well at the SW corner of section 7, T. 35 S., R. 11 W. produced 200 gallons per minute with 40 feet of drawdown in 6" casing from perforations ranging from 240 to 420 feet below ground. The closest well log in section 14 of T. 35 S., R. 12 W. first reported "Rocks" at 240 feet BGL. All of the residential wells were terminated after the shallowest occurrence of ground water, generally described as water occurring in gravel or rock "layers." These could best be interpreted as fracture systems in bedrock.

Summaries of bedrock aquifer studies completed in 2010 are attached. More detailed reports can be provided when requested.

C. A map showing the location of the Water Tank well is attached.

C.1. The water tank was constructed on lands controlled by CICWCD.

C.2. Agreements with surface owners is likely. Power lines and water lines are in place.

C.3. Local issues are not likely to arise.

D.1. Federal issues are minimal. The entire proposed area is outside of managed Sage Grouse Habitat.

D.2. State issues are few. Cedar Basin water rights will be transferred by the Utah Division of Water Rights into the Water Tank well prior to beginning full scale production. The sources of those water rights would be farmers, ranchers, Cedar City Municipal Water Utility, and Southern Utah University. It is at least possible that the well would discover "new water" that could be appropriated to the District. Permits to reenter the well must be obtained from the Utah Division of Water Rights.

D.3. Local issues are few.

E. **Cost Estimate:** Costs to drill the well will be on the order of $150,000 to complete and equip with pumps and a short pipeline to the water tank.

F. **Additional Alternatives:** Separate Submissions of Water Development Projects from Player and Nelson include the following: (1) Construction of a Cretaceous aquifer test well at the Sheepherders Cabin Road, about one mile west of Woods Ranch; (2) Construction of a Cretaceous aquifer test well at Woods Ranch Park; (3) Reentry of the ARCo Three Peaks No. 1 Exploratory Oil Well; (4) Construction of an approximately 6,000 acre-feet off-stream storage reservoir at Rock Creek, upstream from Rusty's Ranch House restaurant; (5) Re-entry and completion to1,200 feet of the Cedar City Quichapa Creek No. 1 well; (6) Construction of a directional well through the Straight Cliffs (Cretaceous) rocks above the major landslide along Highway 14. That well could drain water from the bedrock cliff south of the Highway and reduce the danger of recurring landslides southeast of the highway; and (7) Construction of sufficient wells in the bedrock aquifer(s) to eliminate over drafting of the Cedar Valley Basin aquifer(s).

G. **Environmental Effects:** The proposed location is barren, having been cleared prior to construction of the CICWCD water tank.

H. **Cultural Resources:** No cultural or archeological resources are present at the site. For your information, Player served as an environmental inspector during construction of the Kern River Pipeline, and supervised SUU archeologist Barbara Frank as she prepared clearances across a 100-mile segment of the line from Milford to eastern Nevada.

I. **Additional Information:** Player reviewed the fractured quartz monzonite bedrock aquifer system for Cedar City in 2010. All of his work will be available for review with the permission of City Engineer's office. For example, additional data includes meteorological studies, summaries of geology, water analyses, aquifer rock properties (matrix porosity and fracture systems), old well records, etc. Summaries of the aquifer study are attached to this Submission.

Respectfully Submitted,

Gary Farnsworth Player
Utah Professional Geologist No. 5280804-2250
Idaho Professional Geologist No. 1050
Certified Petroleum Geologist No. 3097

Roice Nelson
Texas Professional Geoscientist No. 5120
Louisiana Professional Geoscientist No. 879

Attachments:

1. Location Map
2.

C:\Users\Gary\Google Drive\Gary's Folder\AQUA\CICWCD\STANDARD SUBMISSIONS\STANDARD FORM 20151 WATER TANK WELL AT THREE PEAKS REC AREA.wpd

STANDARD FORM 2015-1 (06/2015)

SUBMISSION OF WATER DEVELOPMENT PROJECTS: WOODS RANCH WELL

Through the development of scientific studies defining the aquifer within the Cedar Basin it has been documented that additional water resources will be necessary to sustain the growth and further development of the area. Without water the future economic development will be impacted by the availability and cost of existing water supplies to accommodate only the growth capable within our current water budget. This form is being circulated to document additional water supply sources that could be utilized to further alleviate the water deficit in the aquifer, as well as provide water for the future residents of the valley. This form will be evaluated for completeness of content. Please ensure that the proposed project is fully defined and information to substantiate the claim is submitted for a complete evaluation.

Name and Address of Applicant
Gary F. Player
1671 W 546 S
Cedar City, Utah 84720
gfplayer@kennylakeventures.us

Name, Title, and Address of authorized Agent
Roice Nelson
2155 W 700 S, No. 31
Cedar City, Utah 84720
rnelson@walden3d.com

A. Provide names, addresses, phone numbers and email addresses of those who filled out this form.
See above.

B. Project Description With Vital Details.
1. Scope of Work and Project Description
2. Type of System or Facility
3. Quantity of Water Anticipated
4. Scientific Analysis of Water Resource
5. Uses (irrigation, culinary, industrial, etc.)
6. Years Resource is Available
7. Constructability
8. Additional information to describe resource and availability (additional sheets provided)

B.1. This project is an opportunity to develop ground water from porous bedrock aquifers within the eastern portion of the Cedar Valley basin as defined by the Utah Division of Water Rights (UDWR). The availability of water would be proven initially with the completion of one well adjacent to Utah Highway 14. The first well would be drilled at Woods Ranch Park on lands owned by Iron County. The well would be drilled to a depth of 500 to 1,000 feet, with projected sustainable productivity of 1,000 to 1,500 gallons per minute. Produced water would be pumped into Crow Creek, and allowed to flow down Crow Creek to its intersection with Ashdown Creek (where it becomes Coal Creek). Water could then be directed to a proposed storage facility along Rock Creek, or be allowed to flow into Cedar Valley via existing stream channels and newly constructed canals.

B.2. This well would be one of an eventual larger set of wells utilized to stabilize flow in the Coal Creek drainage system throughout the spring and summer months. Water could be utilized for both agricultural and culinary purposes. The well location is near to existing power lines and Crow Creek so that only minimal new development would be necessary to test the concept.

B.3. Each well capable of 1,000 gallons per minute would produce 2.228 cubic feet per second, or 4.418 acre-feet per day. Therefore, one well pumped for 182 days each year would provide slightly more than 800 acre-feet. As described in a separate Submission, eventual development of only five wells could provide about 4,000 acre-feet in the same period of time. A development of 15 wells, each producing 1,000 gallons per minute, would provide approximately 12,000 acre-feet in six months, allowing wells in the valley floor to be shut-in, so that all over-drafting of the valley aquifers could be eliminated.

Recharge estimates for the bedrock aquifers prepared by Player in 2010 range from 10,000 to 15,000 acre-feet per year, showing that continuous production of 12,000 acre-feet per year would not draw down the bedrock aquifer.

B.4. The likelihood of a sustainable bedrock aquifer resource in the western portion of the Markagunt Plateau was shown by Player in geohydrologic reports prepared for the Cedar City Water Utility. Scientific studies included estimation of bedrock thickness, laboratory measurements of aquifer porosity, and review of published and unpublished chemical analyses of spring waters issuing from the bedrock aquifers. Summaries of those studies are attached to this Submission.

Water samples from Cedar City springs developed in Right Hand Canyon, south of Coal Creek, averaged 230 -250 mG/L of Total Dissolved Solids (TDS), comparable to water developed in Cedar Valley. One sample collected by Player from the "piped spring" exiting Cretaceous Straight Cliffs Sandstones due east of the major landslide along Highway 14 was analyzed at the SUU water laboratory in December of 2014. That sample had at a TDS of 230 mG/L, the same as the waters issuing from springs in Cretaceous bedrock at Right Hand Canyon.

B.5. Water pumped into Coal Creek would be usable by for irrigation in Cedar Valley, allowing farmers and ranchers to switch from expensive pumped wells to virtually free canal water. Water stored at Rock Creek (described in a separate Submission) or other CICWCD facilities along Coal Creek would be suitable for domestic and industrial use after suspended solids were settled out during residency in reservoirs.

B.6. The bedrock aquifer resource is sustainable due to annual infiltration from precipitation. In the unlikely event of long term drought, the production of 800 acre-feet per year could be sustained for more than 34,000 years without recharge in the bedrock aquifer system within the Cedar Valley Basin estimated to contain more than 27,648,000 acre-feet of water in place.

B.7. This well could be drilled by local drilling contractors. Power lines are in place along Highway 14 for easy access to the drill site. Produced water could be piped to Crow Creek within an economical and short (generally less than 500 feet) PVC pipeline.

B.8. Summaries of bedrock aquifer studies completed in 2010 are attached. More detailed reports can be provided when requested.

C. A map showing the proposed location for the first well at Woods Ranch is attached.

C.1. The first test well would be drilled at Woods Ranch Park on lands owned by Iron County.

C.2. Agreements with surface owners at Woods Ranch is assured. Power lines and water lines will cross the Highway 14 right of way, requiring negotiated access.

C.3. The proposed test well location is on private, developed lands. A well at Woods Ranch would require a power line to be constructed across Highway 14. Produced water could be directed to Crow Creek through an existing culvert under Highway 14, or through a new pipeline to be buried under the right of way if such a culvert does not exist.

D.1. Federal issues are minimal on county-owned property. Crow Creek and Coal Creek are both certified as having no fishery. The entire proposed area is outside of designated Sage Grouse Habitat.

D.2. State issues are few. Proposed stream flow maintenance will be done at rates that do not exceed 35 cubic feet per second, rates routinely exceeded during spring run off. Cedar Basin water rights will be transferred by the Utah Division of Water Rights into each well prior to beginning full scale production. The sources of those water rights would be farmers, ranchers, Cedar City Municipal Water Utility, and Southern Utah University. It is at least possible that the wells would discover "new water" that could be appropriated to the District.

D.3. Iron County Commission has already approved an exploratory well at Woods Ranch. The drilling permit from UDWR has expired, and must be renewed.

E. **Cost Estimate:** Each exploratory well will cost on the order of $200,000 to complete and equip with pumps and short pipelines to streams. Full development of 15 wells (described in a separate Submission) would cost approximately $3,000,000 to develop 12,000 acre-feet per year. The CAPEX for full development of the aquifer would be on the order of $250 per acre-foot.

F. **Additional Alternatives:** Separate Submissions of Water Development Projects from Player and Nelson include the following: (1) Construction of another Cretaceous aquifer test well at the Sheepherders Cabin Road, about one mile west of Woods Ranch; (2) A re-entry of the ARCo Three Peaks well to test the fractured quartz monzonite aquifer at Iron Springs; (3) Deepening of the Cedar City Quichapa Creek Number 1 well into the fractured quartz monzonite aquifer; (4) Construction of an approximately 6,000 acre-feet off-stream storage reservoir at Rock Creek, upstream from Rusty's Ranch House restaurant; (5) Construction of a test well into the fractured quartz monzonite aquifer east of Three Peaks Park, adjacent to the CICWCD water storage tank; (6) Construction of a directional well through the Straight Cliffs (Cretaceous) rocks above the major landslide along Highway 14. That well could drain water from the bedrock and reduce the danger of recurring landslides southeast of the highway; and (7) Construction of sufficient wells

in the bedrock aquifer(s) to eliminate over-drafting of the Cedar Valley Basin aquifer(s).

G. **Environmental Effects:** Continuous summertime flow of Coal Creek could possibly allow the establishment of a trout fishery. Construction of off-stream storage at Rock Creek would allow development of both trout and bass fisheries.

H. **Cultural Resources:** Woods Ranch is a developed Iron County park that has been "disturbed" for 50 years. The proposed well site is at the NE corner of an open field that has been used by Boy Scouts, families and others for camping and athletics. No cultural or archeological resources are present at the site. For your information, Player served as an environmental inspector during construction of the Kern River Pipeline, and supervised SUU archeologist Barbara Frank as she prepared clearances across a 100-mile segment of the line from Milford to eastern Nevada.

I. **Additional Information:** Player reviewed the Markagunt Plateau bedrock aquifer system for Cedar City in 2010. All of his work will be available for review with the permission of City Engineer's office. For example, additional data includes meteorological studies, summaries of geology, water analyses, aquifer rock properties (matrix porosity and fracture systems), old well records, etc. Summaries of the aquifer study are attached to this Submission.

Respectfully Submitted,

Gary Farnsworth Player
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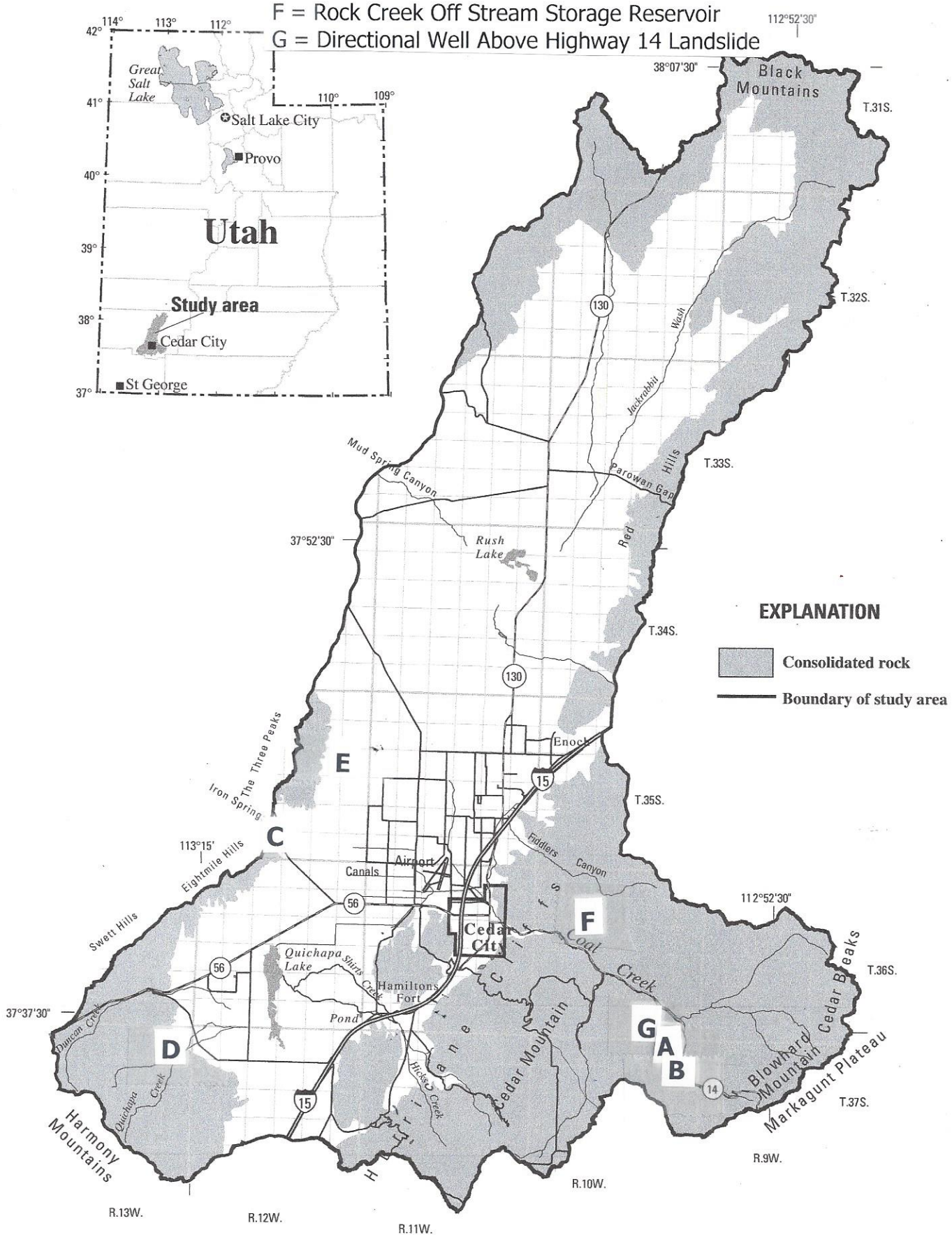
Attachments:

1. Location Map
2.

C:\Users\Gary\Google Drive\Gary's Folder\AQUA\CICWCD\STANDARD SUBMISSIONS\STANDARD FORM 20151 WOODS RANCH WELL.wpd

A = Sheepherders Cabin Road Well
B = Woods Ranch Well
C = ARCo Three Peaks Oil Well Re-Entry
D = Quichapa Creek No. 1 Well Re-Entry
E = Three Peaks Water Tank Well
F = Rock Creek Off Stream Storage Reservoir
G = Directional Well Above Highway 14 Landslide



LOCATIONS OF PROPOSED WATER DEVELOPMENT PROJECTS FOR CICWCD
By: Gary F. Player and H. Roice Nelson, August 2015

WATER STORED IN MOUNTAINS WEST OF CEDAR BREAKS					
AND EAST OF CEDAR VALLEY , IRON COUNTY, UTAH					
AREA	4	TOWNSHIPS			
AREA	144.00	SQ. MILES			
AREA	92,160.00	ACRES			
AREA	4,014,489,600.00	SQ. FEET			
GROSS THICK.	1,000.00	FEET	MINIMUM		
GROSS THICK.	3,000.00	FEET	LIKELY		
GROSS THICK.	5,000.00	FEET	MAXIMUM		
SANDSTONE PROPORTION	0.40	VOL/VOL	MINIMUM		
SANDSTONE PROPORTION	0.50	VOL/VOL	LIKELY		
SANDSTONE PROPORTION	0.60	VOL/VOL	MAXIMUM		
POROSITY	0.15	VOL/VOL	MINIMUM		
POROSITY	0.20	VOL/VOL	LIKELY		
POROSITY	0.25	VOL/VOL	MAXIMUM		
VOLUME OF WATER = AREA * THICKNESS * SANDSTONE PROPORTION * POROSITY					
	MINIMUM	5,529,600.00	ACRE-FEET		
	LIKELY	27,648,000.00	ACRE-FEET		
	MAXIMUM	69,120,000.00	ACRE-FEET		
LIKELY VOLUME OF GROUND WATER IN PLACE UNDER 4 TOWNSHIPS:					
		27,648,000.00	ACRE-FEET		
ANNUAL INFILTRATION:					
PRECIPITATION	15	INCHES PER YEAR	MINIMUM	*1.25*	*FEET*
PRECIPITATION	20	INCHES PER YEAR	LIKELY	*1.67*	*FEET*
PRECIPITATION	30	INCHES PER YEAR	MAXIMUM	*2.50*	*FEET*
AREA	4	TOWNSHIPS			
AREA	144.00	SQ. MILES			
AREA	92,160.00	ACRES			
AREA	4,014,489,600.00	SQ. FEET			
INFILTRATION	0.05	VOL/VOL	MINIMUM		
INFILTRATION	0.1	VOL/VOL	LIKELY		
INFILTRATION	0.15	VOL/VOL	MAXIMUM		
ANNUAL INFILTRATION = AREA * PRECIPITATION * INFILTRATION					
	MINIMUM	5,760.00	ACRE-FEET		
	AVERAGE	15,360.00	ACRE-FEET		
	MAXIMUM	34,560.00	ACRE-FEET		
LIKELY VOLUME OF INFILTRATION UNDER 4 TOWNSHIPS EACH YEAR:					
		15,360.00	ACRE-FEET		
	GARY F. PLAYER				
	8/26/2011				