ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

SUMMARY

Sawyer Springs was discovered by Mormon pioneers around 1850, and was a welcome watering point along the original road to St. George from northern Utah. Evidence of earlier use of the Springs by Native Americans is provided by the presence of white flint chips and cores littering the ground near the area of the Springs.

The springs have historical significance and should be preserved, along with their ecology.

Under natural conditions, ground water from aquifers in the Pine Valley Mountains flows out of the ground at Sawyer Springs without artificial pumping. Sawyer Springs historically discharged water from two aquifers: (1) a shallow alluvial aquifer; and (2) fractured bedrock of the Pine Valley Mountains.

Wells operated by representatives of the Church of Jesus Christ of Latter Day Saints have now interfered with the surface flow of Sawyer Springs and water rights of Mr. Bruce Whited. Historic flow of the Spring, about 2.16 cubic feet per second, is reduced to zero by aggressive pumping of irrigation wells B and D each growing season. Flow in Ash Creek has also diminished greatly since ground water production began at Church well B.

Natural conditions no longer operate. Water levels have been lowered.

Prior to the drilling and completion in 1993 of Church wells A and B, the Points of Diversion for all of the Church water rights in New Harmony Valley were in 5 wells located in sections 19 and 20 of T. 38 S., R. 12 W. SLBM. These wells produced water of poor chemical quality and at lower rates than the production from well B. In order to move their points of diversion from the area of poor quality water into an area where ground water of excellent chemical quality could be produced, the Corporation of the Presiding Bishop LDS Church filed change application a20468 with the Utah Division of Water Rights.

The change application was filed on October 24, 1996, about three years after the completion of Church well B, and after three years of aggressive pumping of the fractured bedrock aquifer in section 35 of T. 38 S., R. 13 W. The change order was approved on August 11, 1997, near the end of the fourth irrigation season in which water was pumped from church well B without legal sanction by the Utah Division of Water Rights.

Individuals and drilling contractors might have been prosecuted by UDWR for similar actions.

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Some "experts" have stated that reductions in flow at Sawyer Springs can be attributed to "years of severe drought" in southern Utah. According to records compiled at the Western Climate Center of the Desert Research Institute (DRI), average annual precipitation at New Harmony for the period of record from 1948 to 2006 (through June of 2006) was 17.41 inches. Average annual precipitation for the twelve complete years inclusive from 1994 to 2005 was also 17.41 inches. These climate records show that precipitation at New Harmony since 1994 has been exactly the average of the 58 years of record available for review.

Similar relationships to average climate and precipitation since1994 are shown at Veyo (west of the Pine Valley Mountains), and from the two nearest SNOTEL sites: Long Flat, and Kolob.

There is no drought at Sawyer Springs.

V. M. Heilwell of the United States Geological Survey related the average annual volume of precipitation on the eastern slope of the Pine Valley Mountains (about 23 inches) to infiltration, using methods developed by the U. S. Geological Survey. These values for infiltration ranged from 1,000 to 4,000 acre-feet per year.

Volumetric estimations of recharge, when compared to field data from a 1996 pump test, show that the annual recharge rate per one-mile-wide portion of the aquifer ranges from 350 to 500 acre-feet. Given an estimated width of twelve miles for the aquifer between Kanarra Creek and Pace Draw, annual recharge into that portion of the fractured bedrock aquifer ranges from a minimum of 4,200 acre-feet to a likely maximum of 6,800 acre-feet per year.

Enough water is present in and around Sawyer Canyon to supply Whited and the Church. However, wells B and D are so close that they interfere with Sawyer Spring.

Waters east and west of Ash Creek are dissimilar, and there is little connection between aquifers on either side of the Ash Creek Fault. Structural geology and physical chemistry indicate that ground water from the Pine Valley Mountains west of Ash Creek is intercepted by faults and fracture systems at Ash Creek and that little ground water flows across Ash Creek to the east. Ground water east of Ash Creek flows south under New Harmony valley, and is deflected to the southeast by faulting and fracturing under Ash Creek.

The Church moved its water rights into a different aquifer without authorization.

Annual reductions in ground water levels at Sawyer Springs are directly correlable to aggressive pumping of Church wells B and D. Constant pumping rates averaging 1,700 gallons per minute have lowered ground water levels enough to eliminate the surface flow of water from the springs.

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Water level sensors placed in monitoring wells near Sawyer Springs by Mr. Bruce Whited have shown unequivocally that draw down in Section 35, T. 38 S., R. 13 W. is directly related to aggressive pumping of Church wells B and D. Ground water production from those wells must be reduced in order to end interference with surface flow from Lower Sawyer Spring.

Church employees have been hostile to Whited. Their intent seems to have been to purposefully dry up Sawyer Springs.

Attest:

Gary F. Player
Utah Professional Geologist No. 5280804-2250

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

INTRODUCTION

STATEMENT OF THE PROBLEM

Diversions of surface water from Sawyer Springs and Ash Creek are the sole remaining irrigation water sources for Mr. Bruce Whited of New Harmony, Utah. He has relied on Sawyer Springs for irrigation water since he purchased Utah Water Right No. 81-17. The certificated water right is for all of the surface flow in Sawyer Creek. Historically, virtually all of the surface flow in Sawyer Creek at its intersection with Ash Creek has been produced from Sawyer Springs.

Sawyer Creek is dependent on Sawyer Springs for its flow.

Under the direction of geologist Gary F. Player, business representatives of the Church of Jesus Christ of Latter Day Saints began in 1992 to explore for a water source that could someday provide culinary water of sufficient quantity and quality to allow for construction of a residential subdivision on Church lands near Ash Creek   Player located sites for two wells in Death Valley Wash near the foot of the Pine Valley Mountains near Sawyer Creek. The presence of Sawyer Springs indicated to him that prolific wells could be completed in alluvial fan and/or bedrock aquifers west of Ash Creek.

Gary Player was aware of Sawyer Springs in 1992 and planned the Church's water exploration program to test ground water near the springs.

The Natural Resource Section of the Real Estate Division of the Church hired Mr. Vern Grimshaw of Enoch, Utah to drill at least four wells in the New Harmony area in the summer of 1993. Two of the wells were drilled near Interstate 15 in the eastern portion of New Harmony Valley. Two other wells (labeled wells 1 and 2 by Player) were originally planned for Death Valley Wash, but difficulties in access caused the first well (now called Church well A) to be drilled just west of Ash Creek in section 35, T. 38 S., Range 13 W. SLBM.

Well A was drilled and completed with six (6) inch diameter casing. The purpose of the well was only to gather information about water resources, as the Church had not yet prepared a change application to move the Points of Diversion for their water rights across New Harmony Valley to the foothills of the Pine Valley Mountains. Test well A was successful, producing moderate quantities of high quality water from fractured bedrock.

After reviewing the results of well A, Church representatives elected to drill a larger diameter production well close to well A, in order to determine the feasibility of large scale water development. The result of that decision was the completion of well B, only 825 feet to the southeast of well A. Player supervised the drilling and completion of well B, but resigned from Church employment soon after.

Wells A and B were drilled only to explore for water. Permission to use any water found was not granted by UDWR until several years after the wells were completed.

Player had always considered his Church employment to be beneficial to both the Church and its neighbors. Ironically, he has now been hired to defend Mr. Whited against the Church from interference caused by aggressive over-pumping of Church well B. Player never supposed that his successful development of water from the fractured bedrock aquifer of the Pine Valley Mountains would eventually lead to the dewatering of Sawyer Springs, and, consequently, Mr. Bruce Whited.

To further compound damages to Bruce Whited, flow in Ash Creek has diminished greatly since ground water production began at Church well B. Historical flow was continuous throughout most summers before 1994, with most of the flow consisting of seepage into the creek from ground water. Now the only water in Ash Creek available for diversion by Whited is runoff water following occasional thunder storms.

All of Bruce Whited's water rights in Sawyer Creek and Ash Creek have been damaged by interference from over pumping of Church wells B and D.

Hydrological and geological observations and interpretations presented in this report will show without room for doubt that ground water in the fractured bedrock aquifer of the Pine Valley Mountains is directly connected to surface water in Sawyer Springs and Ash Creek. The report will also show that climatic conditions since 1994 are the same as they have been at and near New Harmony for as long as records have been kept.

Reductions in the flow of Sawyer Springs and Ash Creek can only be attributed to aggressive over pumping of Church-owned wells surrounding Sawyer Springs. Pumping of those wells has depleted shallow ground water in section 35 of T. 38 S., R. 13 W. and has interfered with surface water rights of Mr. Bruce Whited.

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A DESCRIPTION OF SAWYER SPRINGS

Sawyer Springs is a natural feature near the base of the eastern slope of the Pine Valley Mountains, south of New Harmony, Utah. The following discussion compares that natural feature to four distinguishing features of a spring:

1. *A spring is a point or an area where groundwater flows out of the ground without artificial pumping*.

The U. S. Geological Survey (USGS) has published a topographic map (New Harmony Quadrangle) at a scale of 1:24,000, or one inch equals 2,000 feet. The "provisional edition," dated 1986, shows "Sawyer Spring" along the south line of section 35, T. 38 S., R. 13 W. The label provided by the USGS is a little more than 5/8 of an inch long at the scale of the map, suggesting that the Springs could occur within an area about 1,250 feet wide from west to east. The specific location of the Springs is not shown as a point, but as an area.

Sawyer Springs was discovered by Mormon pioneers around 1850, and was a welcome watering stop along the original road to St. George from northern Utah. Evidence of earlier use of the Springs by Native Americans is provided by the presence of white flint chips and cores littering the ground near the area of the Springs.

Under natural conditions, ground water from the fractured bedrock aquifer of the Pine Valley Mountains flows out of the ground at Sawyer Springs without artificial pumping.

2. *Depending on how constant the supply of the water is - rainfall or snow melt that infiltrates the earth - springs can be ephemeral (intermittent) or perennial (continuous).*

Perennial springs flow all year, and from year to year for one reason: sufficient precipitation occurs to maintain water saturation in the aquifer that intersects the ground level. Flow may fluctuate dramatically from year to year, or even from month to month, but the intersection of the aquifer with ground level is maintained. Sawyer Springs was a perennial spring until at least 1993, when the same aquifer that issues from the Springs was first penetrated by high-capacity wells. Since 1993, Sawyer Springs flow has frequently become intermittent or reduced in volume.

3. *Water issuing from an "artesian" spring may rise to an elevation higher than the top of the aquifer from which it issues.*

Infiltration into the aquifer that is the source of Sawyer Springs occurs at elevations up to 5,000 feet higher than the elevation of the bulk of the aquifer. Water is partially confined in permeable fractures between masses of relatively impermeable granitic rock and locally beneath layers of fine-grained soils within Sawyer Canyon that do not rapidly transmit water. The elevation difference between the recharge area and lower segments of the aquifer causes confined water to be pressurized by the weight of the up gradient water. Sawyer Springs is down gradient from its recharge area and acts as a pressure relief valve for the aquifer: water may be observed to "boil" above the level surface of ponds or streams present within the area of the Springs.

4. *When water issues from the ground it may accumulate in pools or flow down gradient in surface streams.*

Under natural hydrological conditions, water issuing from the ground in the area called Sawyer Springs accumulates in artificial ponds developed by the water rights owner, and in surface streams that flow into Sawyer Canyon to form Sawyer Creek. In most years run-off from snow melt and rain storms in Sawyer Canyon is intermittent: most of the water entering Ash Creek from Sawyer Canyon each summer is ground water issuing from Sawyer Springs.

It is important to acknowledge that natural conditions at Sawyer Springs have been altered by the Church wells, and that Bruce Whited has been damaged.

WHY DOES LOWER SAWYER SPRING OCCUR WHERE IT DOES?

Springs are rare on the eastern slope of the Pine Valley Mountains. One reason for the absence of springs is that the geology of the slope is relatively uniform. All of the exposed rocks that surround Sawyer Canyon are igneous rocks of similar composition and texture with little or no soil cover. Fracturing is pervasive, but the masses of rock between the fracture systems are virtually impervious.

The surface area of the Pine Valley Mountains within the New Harmony quadrangle is about 25,000 acres, projected onto a horizontal plane. This area is underlain by fractured bedrock (see above) that is recharged by portions of the annual precipitation and snow melt. However, only four areas with major springs are shown on the USGS map: Comanche Spring, at an elevation of about 5,800 feet, northwest of New Harmony; Death Valley Spring, at an elevation of about 6,300 feet near the headwaters of Death Valley Wash; Sawyer Springs, at an elevation of about 5,000 feet in Sawyer Canyon; and Siler Spring, near the southeast corner of the quadrangle at an elevation of about 7,500 feet.

Comanche Spring is 600 feet below the flanking terraces of Comanche Creek. Death Valley Spring is 600 to 900 feet below flanking terraces of Death Valley Wash. Sawyer Springs is 600 feet lower than the flanking canyon walls of Sawyer Canyon. Siler Spring, at the highest elevation of any of the labeled springs, is 1,200 feet lower than the ridge line that extends northwest from the area of the spring.

This discussion of spring elevations is summarized in the following Table:

Name of Spring	Approximate Spring Elevation (feet)	Approximate "Depression" of Spring Elevation, Compared to Surrounding Terrain (feet)
Comanche	5,800	600
Death Valley	6,300	600 - 900
Lower Sawyer	5,000	600
Siler	7,500	1,200

All four of the springs are located in canyons or along steep cliffs that trend approximately northeast to southwest. This trend corresponds to the orientation of one of the major fracture systems present in the granitic rocks of the Pine Valley Mountains (Figure One, Enclosed).

The springs formed where erosion along the fractured rocks lowered the ground surface enough to intersect the aquifer(s) that occur in the fractures. At Lower Sawyer Spring, at least some of the water escapes from a partially confined aquifer and "boils" to the surface in the developed pond.

HYDROGEOLOGY OF SAWYER SPRINGS

Aquifers

Under natural conditions Sawyer Springs discharge water from two aquifers: (1) a shallow alluvial aquifer; and (2) the fractured bedrock of the Pine Valley Mountains quartz monzonite.

Description of the Shallow Alluvial Aquifer

Water in the shallow alluvial aquifer at Sawyer Springs is enclosed in clay, silt, sand, and gravel sediments eroded off of the Pine Valley Mountains. The shallow aquifer is very small. Drainage divides limit the drainage area of Sawyer Canyon above Ash Creek to about four square miles, while the area covered by a veneer of alluvial sediments is less than two square miles. The average thickness of the alluvium is unknown, but is probably less than 50 feet. Exposures in a reservoir excavated for Elliott Christensen between well D and lower Sawyer Spring suggest that the sediments there are about 20 feet thick. Stream banks and a test pit excavated at Lower Sawyer Spring disclosed about 30 feet of unconsolidated, alluvial sediments. The following Table displays a wide range of possible values for aquifer properties of the shallow alluvial aquifer:

Aquifer Area (square miles)	Aquifer Area (acres)	Average Thickness (feet)	Gross Volume (acre-feet)	Specific Yield	Stored Available Water Volume (acre-feet)	Annual Recharge * To Shallow Alluvial Aquifer (acre-feet)
1.5	960	30	28,800	.25	7,200	160
2.0	1280	30	38,400	.25	9,600	213.38
2.5	1600	40	64,000	.30	19,200	266.72
3	1920	50	96,000	.30	28,800	320.06

***Note: Annual recharge is determined by multiplying 20 inches (1.667 feet) of annual precipitation by the surface area of the aquifer in acres, and dividing the result by 10, assuming that 10 percent of the precipitation infiltrates into the alluvial aquifer.**

Description of the Pine Valley Mountain Fractured Bedrock Aquifer System

Most of the Pine Valley Mountains bedrock near Sawyer Canyon is quartz monzonite–an intrusive igneous rock consisting mostly of orthoclase and plagioclase feldspars and quartz. It formed below the surface of the ground by the gradual cooling of molten magma (the liquid form of rock that “intrudes” other rocks). Some of the igneous rocks have been classified as “latite.” Latite has the same chemical composition as monzonite, but crystallized at or near the surface, rather than deep below ground. Quartz monzonite and latite may either fracture immediately as they cool and shrink, or later, in response to structural stresses long after they have solidified.

Most of the bedrock surface of the Pine Valley Mountains is virtually impermeable and not available for infiltration–almost all of the infiltration occurs directly into open fractures.
Just as most recharge water movement occurs in the bedrock fracture systems, water discharged by springs and wells is virtually all derived from permeable bedrock fractures.

An Analogous Fractured Bedrock Aquifer System

A similar, but much larger, quartz monzonite intrusive “batholith” occurs in the Sierra Nevada Mountains of eastern California. Those rocks are hosts for a gigantic fractured bedrock aquifer system that is the major supplier of ground water to the Sacramento and San Joaquin valleys of central California.

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HISTORIC PRODUCTIVITY OF SAWYER SPRINGS

Water rights associated with Sawyer Springs were confirmed in the final "Virgin River Decree" of 1931. Award number 121 assigned 2.16 cfs to the owner(s) of Utah Water Right 81-17 with a priority date of May 31, 1910. The average flow of at least 2.16 cfs was repeatedly demonstrated. If not, the award would have been overturned by others in legal contests.

Whited's right to divert water from Sawyer Creek through WR 81-17 runs from January 1 to December 31 of each year. Continuous diversion of 2.16 cfs for an entire year would yield 1563.4 acre-feet. However, the certificated diversion limit for WR 81-17 is restricted to 1214.4 acre-feet per year on 303.6 acres.

Bruce Whited reported average flow from Lower Sawyer Spring of at least 1,000 gallons per minute (2.228 cfs) every year prior to 1994. The USGS reported flow at Ash Springs of 1,100 acre feet per year in October of 1996. That is equal to about 682 gallons per minute, or 1.52 cfs.

Flow observed by Player out of the shallow alluvial aquifer at Upper Sawyer Spring on August 28, 2007 was less than .01 cubic feet per second. The water disappeared into fractured bedrock in the floor of Sawyer Creek above Lower Sawyer Spring. Flow at Lower Sawyer Spring in August and September of 2007 was non-existent.

Flow at Sawyer Springs has been reduced or eliminated only since the Church began pumping wells B and D at high rates.

The following Table shows a range of observed historic flows from Sawyer Springs:

Observed or Certificated Flow	Year(s)	Rate (Gallons per Minute)	Rate (cfs)
Virgin River Decree	1931	969	2.16
Bruce Whited	Before 1994	1,000	2.228
USGS	October 1996	682	1.52
Gary Player (Upper Sawyer Spring)	August 2007	<4.5	<0.01
Gary Player (Lower Sawyer Spring)	August 2007	0	0

OBSERVATIONS FROM A TEST PIT EXCAVATED AT LOWER SAWYER SPRING

Field evidence along a losing stretch of Sawyer Creek shows that some of the water in the shallow alluvial aquifer percolates through fractures into the Pine Valley Mountain fractured bedrock aquifer system along the bed of Sawyer Creek. A similar relationship may exist below ground in Sawyer Canyon wherever saturated alluvial sediments are in contact with underlying fractured bedrock. Some of that percolating water is available for flow out of the fractured bedrock at Lower Sawyer Spring.

The two aquifers at Sawyer Canyon are in direct communication.

A test pit was constructed in the floor of the dry Lower Sawyer Spring catchment basin on September 18, 2007. The purpose of excavating the test pit was to try to find the contact between the shallow alluvial aquifer and the fractured bedrock aquifer.

The first layer of material penetrated was well sorted, fine- to medium grained , grayish-brown sand of the shallow alluvial aquifer. This material is loose and very permeable, and can transmit large quantities of ground water both vertically and horizontally. The sand is underlain directly by deeply weathered, reddish-brown, clay-coated, fractured bedrock at about 3 to 4 feet below the floor of the catchment basin. The contact between the sand and the weathered bedrock is undulating, suggesting uneven erosion of the bedrock surface by running water before deposition of the sand.

The shallow aquifer was dry at lower Sawyer Spring on September 18, 2007.

Weathering of the fractured bedrock took place before deposition of the overlying sand. The grains of alluvial sand are virtually all gray quartz that has eroded off the Pine Valley Mountains. Quartz sand grains are not stained by the clays, even at the contact with underlying reddish-brown clay.

Similar surface exposures of deeply weathered bedrock occur east of Ash Creek along the access road to Church well B. At both the test pit and outcrop locations, an ancient soil (paleosol) of reddish-brown, silty, sandy, clay has developed on the igneous rocks. Massive soils grade downward into boulders and cobbles of fractured rock, all coated by reddish-brown clay. The weathered soils become harder and less clay-rich with depth, suggesting that the broken rock has not been transported by running water, but has weathered in place.

Weathered fractured bedrock like that exposed in the test pit can be observed throughout the area surrounding Sawyer Springs.

Apparent rounding on some otherwise planar fracture surfaces is the result of chemical weathering, with feldspars weathered to secondary kaolinitic clays. The clays are stained reddish-brown by oxidation or "rusting" of iron-bearing accessory minerals. Clays line most of the surfaces of the fractured boulders, but are almost absent on open surfaces that conduct ground water.

Excavation of the test pit continued (with great difficulty) into the weathered bedrock. Water was first encountered in fractured bedrock about 13 feet below the floor of the catchment basin. The water was partially confined by the coatings and discontinuous layers of secondary, weathered clays, and rose slightly (a few inches) above the depth at which it was first found.

Some open fractures in the bedrock store more water than others. The fractures with wider openings allow water to move through easily. They are more "permeable."

A twenty-feet long section of perforated, 2" diameter PVC pipe was installed to a depth of 16 feet below the base of the catchment basin, and the test pit was back-filled around the pipe. Mr. Bruce Whited then installed a pressure sensitive probe in the PVC pipe in order to record changes in the water level with time. The water level probe installed by Whited was first installed on September 19, 2007. By September 22, the water level was observed to be dropping 0.2 of a foot (2.4 inches) per day. Church well B was being pumped at 1700 gallons per minute during that time period.

Monitor wells studied by Whited have proven that ground water levels at and around Sawyer Springs are lowered by pumping in the Church wells.

WATER RIGHTS

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WATER RIGHTS OF MR. BRUCE WHITED IN SAWYER SPRINGS AND ASH CREEK

The water rights of Bruce Whited and Double Duce Stables, LLC, a business entity owned by Whited, were listed in two searches of the WRPLAT program of the Utah Division of Water Rights. The searches showed all water rights in two circular areas:

> (1) Within a radius of 2,000 feet from a point S 911 feet and E 1,150 feet from the North quarter corner, section 35, T. 38 S., R. 13 W. SLBM, and
>
> (2) Within a radius of 5,280 feet from the NE corner of section 35, T. 38 S., R. 13 W.

All of the information supplied for the two searches is presented in a WRPLAT Program Output Listing attached to this report. The following Table summarizes the water rights of Whited and Double Duce Stables, LLC as shown in the WRPLAT searches:

Utah WR Number	Diversion Type	Priority Date	Uses	Rate(CFS)	Owner Name
81-16	Surface	19110415	I	1.600	Whited
81-17	Surface	19100531	I	2.160	Whited
81-18	Surface	19101027	I	2.500	Whited
81-19	Surface	19101027	I	2.490	Whited
81-2620	Surface	1873	I	0.490	Double Deuce
81-55	Surface	19150220	I	0.570	Whited
81-61	Surface	19261223	I	3.000	Whited

WATER RIGHTS USED IN CHURCH WELLS

Church Water Rights Before Change Application a20468

Player first summarized water rights of the LDS Church at New Harmony Valley in a memo to the Natural Resource Group of the Real Estate Division, dated December 3, 1992. In the memo, attached to this report, Player emphasized that the Church owned rights to about 1,800 acre-feet of water, but that the physical availability of usable water was unknown. He recommended that Church employees study the hydrogeology of New Harmony Valley and consider drilling exploratory wells.

Necessity of Change Application a20468

Prior to the drilling and completion in 1993 of Church wells A and B, the Points of Diversion for all of the Church water rights in New Harmony Valley (then 1626.96 acre-feet per year) were described as five (5) wells located in sections 19 and 20 of T. 38 S., R. 12 W. SLBM. These wells produced water of poor chemical quality and at lower rates than the production from well B. In order to move their points of diversion from the area of poor quality water into an area where ground water of excellent chemical quality could be produced, Elliott F. Christensen, Heughs Creek Associates, and the Corporation of the Presiding Bishop LDS Church filed change application a20468 with the Utah Division of Water Rights.

The change application was filed on October 24, 1996, about three years after the completion of Church well B, and after three years of aggressive pumping of the fractured bedrock aquifer in section 35 of T. 38 S., R. 13 W. The change order was approved on August 11, 1997, near the end of the fourth irrigation season in which water was pumped from church well B without legal sanction by the Utah Division of Water Rights.

Estimated Water Production From Church Well B Before Approval of a20468

Well B was originally powered by a diesel engine that could not pump all of the water available from the well. Therefore, water production from well B averaged about 750 gallons per minute during pumping periods in 1994, 1995, 1996, and 1997. If the well was pumped at that rate for an average of 180 days each year, the amount of water pumped before approval of change application a20468 would be:

Q = Rate x Time
Rate = 750 gallons per minute
Rate = 3.314 acre-feet per day
Time = 180 days per year for four years = 720 days
Q = (3.314)(720) = 2386 acre-feet

This amount of water is less than the Church's water rights approved for diversion over a period of four years in sections 20 and 21 of T. 38 S., R. 12 W., but it is water that had not been approved for diversion in section 35 of T. 38 S., R. 13 W.

The Church pumped water it did not own.

Points of Diversion Before Change Application
The points of diversion before approval of change application a20468 were as follows:

Points Underground
(1) S 102 ft W 530 ft from NE cor., Sec 19, T 38S, R 12W, SLBM
Diameter: 10 ins. Depth: 145 ft.
Comment: Schmutz well

(2) S 1588 ft W 1406 ft from E4 cor., Sec 19, T 38S, R 12W, SLBM
Diameter: 14 ins. Depth 200 ft.

(3) S 80 ft W 987 ft from NE cor., Sec 19, T 38S, R 12W, SLBM
Diameter: 14 ins. Depth 274 ft.

(4) N 75 ft E 142 ft from W4 cor., Sec 20, T 38S, R 12W, SLBM
Diameter: 16 ins. Depth 212 ft.

(5) S 89 ft E 1100 ft from NW cor., Sec 20, T 38S, R 12W, SLBM
Diameter: 16 ins. Depth 220 ft.

Points of Diversion After Change Application
The points of diversion applied for in a20468 and eventually approved by the Utah Division of Water Rights (after four new wells had been drilled near Ash Creek) are:

Points Underground
1) S 136 ft E 387 ft from N4 cor., Sec 19, T 38S, R 12W, SLBM
Diameter: 12 ins. Depth: 629 ft.
Comment: Well G, existing well known as Schmutz well

(2) S 1588 ft W 1406 ft from E4 cor., Sec 19, T 38S, R 12W, SLBM|
Diameter 14 ins. Depth 200 ft.

(3) S 80 ft. W 987 ft. from NE Cor., Sec. 19, T 38 S, R 12 W, SLBM
Diameter: 14 ins. Depth 274 ft.

(4) S 969 ft. W 1107 ft. from NE cor., Sec 19, T 38 S, R 12 W, SLBM
Diameter: 16 ins. Depth 800 ft.
Comment: Well F, existing well drilled under 94-81-002-p

(5) S 102 ft. W 530 ft. from NE cor., Sec 19, T 38 S, R 12 W, SLBM
Diameter 10 ins. Depth 145

(6) N 76 ft E 142 ft from W4 cor., Sec 20, T 38S, R 12W, SLBM
Diameter: 16 ins. Depth: 212 ft.
COMMENT: Well H; existing well under these rights (Sod Farm)

(7) S 89 ft E 1100 ft from NW cor., Sec 20, T 38S, R 12W, SLBM
Diameter: 16 ins. Depth: 220 ft.
COMMENT: Well M; existing well under these water rights

(8) S 1760 ft E 2320 ft from NW cor., Sec 29, T 38S, R 12W, SLBM
Diameter: 6 ins. Depth: 520 ft.
COMMENT: Well E;`Taylor Creek` drilled under 93-81-001-P(2)

(9) S 298 ft E 533 ft from N4 cor., Sec 35, T 38S, R 13W, SLBM
Diameter: 6 ins. Depth: 370 ft.
COMMENT: Well A; drilled under 81-1635(a17309)(4)

(10) N 1240 ft E 52 ft from W4 cor., Sec 35, T 38S, R 13W, SLBM
Diameter: 8 ins. Depth: 100 to 700 ft.
COMMENT: Well I; a proposed new well under this application

(11) S 911 ft E 1150 ft from N4 cor., Sec 35, T 38S, R 13W, SLBM
Diameter: 12 ins. Depth: 620 ft.
COMMENT: Well B; drilled under 81-1635(a17309)(3)

(12) S 281 ft E 986 ft from S4 cor., Sec 35, T 38S, R 13W, SLBM
Diameter: 16 ins. Depth: 600 ft.
COMMENT: Well D; drilled under 94-81-009-P

(13) N 569 ft W 456 ft from S4 cor., Sec 36, T 38S, R 13W, SLBM
Diameter: 16 ins. Depth: 590 ft.
COMMENT: Well C; drilled under 94-81-004-P (`Lower Ash Ck.`)

Note that wells (9) and (11) are shown to have been drilled under change application a17309. This application was never approved by the Utah Division of Water Rights and was eventually withdrawn by Church representatives after wells (9) and (11) were drilled without authorization.

Documents filed by the Church show that Church wells were drilled without authorization by the UDWR.

PRIORITY OF WATER RIGHTS

All of Bruce Whited's water rights have priority over water rights held by the Church in New Harmony Valley. Whited's oldest priority date is 1873 (WR 81-2620), while his most recent priority date is 1926. The Church's oldest water right has a date of 1945.

WHAT IS A DROUGHT?

DEFINITIONS OF "DROUGHT" ARE DIVERSE

Definitions of "drought" are many and diverse. However, all refer to a reduction or cessation of precipitation over a period of time. Severity of drought is proportional to average regional climates. For example, a long term, five-inch reduction in annual precipitation would be a drought in the western United States, but only a slightly noticeable respite from almost perpetual rainfall in Sitka, Alaska.

Hydrological drought refers to deficiencies in surface and subsurface water supplies. It is measured as changes in stream flow, lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes, and reservoirs, so hydrological measurements are not the earliest indicators of drought. **When precipitation is reduced or deficient over an extended period of time**, this shortage will be reflected in declining surface and subsurface water levels. (Definition from the National Drought Mitigation Center, University of Nebraska, Lincoln).

LONG TERM PRECIPITATION PATTERNS AT NEW HARMONY

According to records compiled at the Western Climate Center of the Desert Research Institute (DRI), average annual precipitation at New Harmony for the period of record from 1948 to 2006 (through June of 2006) was 17.41 inches. Average annual precipitation for the twelve complete years inclusive from 1994 to 2005 was also17.41 inches. Measured precipitation through the end of June of 2006 was 10.56 inches, compared to the average first half year precipitation of

9.14 inches for the period of record. These climate records show that precipitation at New Harmony since 1994 has been exactly the average of the 58 years of record available for review.

The closest DRI climate station to New Harmony west of the Pine Valley Mountains is at Veyo, Utah. Precipitation at Veyo from 1994 through 2006 averaged 13.94 inches, compared to the average annual precipitation of 13.90 inches for the 50 years of record from 1957 to 2007.

Similar relationships to average climate and precipitation during the period from 1994 through 2006 are shown from the two nearest SNOTEL sites: Long Flat, and Kolob. Long Flat is about five miles WNW of New Harmony in the Pine Valley Mountains. Kolob is about 15 miles ENE of New Harmony on the Markagunt Plateau.

The following Table compares average annual "period of record" precipitation at nearby weather stations to the averages recorded from 1994 through 2005 or 2006:

Weather Station and Source of Data	"Period of Record" Average Precipitation (inches)	Average Precipitation 1994 - 2005 (inches)	Average Precipitation 1994 - 2006 (inches)	Deviation from "Period of Record" Average (percent)
New Harmony DRI	17.41	17.41		0
Veyo Powerhouse DRI	13.90	13.94		0.29
Long Flat SNOTEL	21.8		21.05	- 3.44
Kolob SNOTEL	34.20		34.27	0.2

ARE SAWYER SPRINGS EXPERIENCING A DROUGHT?

Historical water rights at Sawyer Spring were established as 2.16 cubic feet per second by the Virgin River Decree. Modern flow at Sawyer Springs was measured in October of 1996 by the U. S. Geological Survey at about 1.52 cubic feet per second, or about 1,100 acre feet per year, **after Church well B had been pumped for irrigation through most of the summer**. After eleven more years of pumping and average precipitation since 1996, summertime flow in Sawyer Springs is now non-existent. The loss of surface flow at Sawyer Springs has not been caused by drought, but by interference from new, high-capacity wells.

There is no drought at New Harmony.

GROUND WATER RECHARGE AT PINE VALLEY MOUNTAINS

INFILTRATION OF PRECIPITATION

Heilwell and others (2000) measured the horizontal projection of that portion of the surface area of the Pine Valley Mountains that drains eastward toward New Harmony Valley as 25,140 acres. They then reported values for annual precipitation, the volume of precipitation greater than eight inches, and ranges of recharge from precipitation. The following is their summary of conditions influencing recharge into bedrock underlying the Pine Valley Mountains:

> "The Pine Valley....Mountains receive about 47,440 acre-feet of precipitation annually, much of it as snow during the colder months when temperature and evaporation rates are low. The mountains typically have a thinner soil cover than the (New Harmony) valley floor, which allows more rapid infiltration. However, steeper slopes promote more rapid runoff than the flat areas in the valley; thus, slowly melting snow provide(s) the optimum recharge source. The minimum amount of estimated infiltration (for the eastern slope of the Pine Valley Mountains), determined from precipitation-recharge relations developed by Anderson (1995), is about 1,000 acre-feet per year. The maximum amount of estimated infiltration, determined from the Cedar-Parowan basin study, is about 4,000 acre-feet per year."

Heilwell calculated the annual volume of precipitation in the Pine Valley Mountains by multiplying his value for the "area of the basin" in acres times the annual precipitation in feet. The value he used for precipitation in feet must equal the volume of annual precipitation divided by his estimated area of the basin. That equation is:

47,440/25,140 = 1.887 feet, or 22.64 inches of annual precipitation.

According to Heilwell, average annual precipitation at New Harmony town is about 17 inches, while average annual precipitation on the Pine Valley Mountains is about 29 inches. The average of these values is 23 inches, a number close to the value assigned by Heilwell. Precipitation is greater than 23 inches at the highest elevations, and is lower just west of Ash Creek. The average value assigned by Heilwell is acceptable in the absence of closely spaced weather stations on the mountain slopes.

The annual volume of precipitation greater than 8 inches computed by Heilwell was 30,680 acre-feet. Heilwell then related the annual volume of precipitation to infiltration, using methods developed by Anderson (1995), Harill and Prudic (1998), and Bjorkland, Sumsion, and Sandberg (1978). These values for infiltration ranged from 1,000 to 4,000 acre-feet per year.

There may be more recharge into the eastern portion of the Pine Valley Mountains than stated in published estimates by Heilwell.

INFILTRATION FROM INTERMITTENT STREAMS

Most of the streams on the east-facing slope of the Pine Valley Mountains flow only during spring breakup, when surplus water from snow melt that does not directly enter the fracture systems runs off the steep hillsides. Streams may also flow briefly after intense summer rain storms. Heilwell estimated that some infiltration into the fractured bedrock aquifer from intermittent streams may occur. However, he did not quantify his estimate:

> "Other ephemeral (intermittent) streams flow for brief periods when snow is melting or intense rainfall occurs. The amount of recharge resulting from these flows is not known."

Allowance for some infiltration from intermittent streams argues for the use of Heilwell's higher estimate (4,000 acre-feet) for infiltration into the fractured bedrock aquifer.

VOLUME OF WATER IN THE SHALLOW ALLUVIAL AQUIFER

A preceding Table shows that the volume of space available to store water in the shallow alluvial aquifer is somewhere in the range of 7,000 to 30,000 acre-feet. However, the average amount of precipitation recharging the shallow alluvial aquifer each year is much less: between 160 and 320 acre-feet.

Residence Time for Ground Water in the Shallow Alluvial Aquifer

Discussions about the age of water from Sawyer Springs must consider the fact that waters in the shallow alluvial aquifer are probably quite young. All of the stored water (as much as 28,800 acre-feet) would flow into upper Sawyer Spring or percolate into the underlying bedrock fractures in about 90 years if annual recharge from precipitation averaged 320 acre-feet per year. In the minimum volume case, 7,200 acre-feet of stored water would be displaced by 160 acre-feet of annual recharge from precipitation in about 45 years.

Radiological measurements of water from the shallow alluvial aquifer were completed on a sample labeled the "Well D Spring." That water had a percent modern carbon (pmc) of 102.2, and contained 1.64 Tritium Units. Water in the shallow alluvial aquifer is virtually "new."

VOLUME OF WATER IN THE FRACTURED BEDROCK AQUIFER

Ground Water Up Gradient from Sawyer Springs

The altitudes of the highest peaks that mark the basin divide between the western and eastern Pine Valley Mountains range from 9,000 to 10,000 feet above mean sea level, while the average elevation of Ash Creek between Pace Draw and Kanarra Creek is about 5,000 feet. Siler Spring occurs about 30,000 feet WNW of Ash Creek, at an elevation of about 7,500 feet. Therefore, the gross minimum volume of saturated rock between Siler Spring and the bed of Ash Creek is the product of (1) a triangular cross section 2500 feet high at its westernmost edge by 30,000 feet wide from southwest to northeast, and (2) the width of the surface area of the eastern slope of the Pine Valley Mountains (as estimated by Heilwell) projected onto a horizontal plane. The area of the triangular shaped cross section is:

(0.5)(2,500)(30,000) square feet = 37,500,000 square feet, about 1.354 square miles.

Heilwell's surface area available for recharge on the eastern slope of the Pine Valley Mountains projected onto a horizontal plane is:

24,150 acres, or about 1,051,974,000 square feet.

Since the average distance from Ash Creek to an elevation of 7,500 feet is about 30,000 feet, then the width of the recharge area allocated by Heilwell is:

1,051,974,000/30,000 = 35,065.8 feet = 6.641 miles.

The gross volume of that portion of the Pine Valley Mountains fractured bedrock aquifer between the elevations of 5,000 and 7,500 feet, and 30,000 feet to the northwest from Ash Creek to Siler Spring is about:

(1.354 square miles)(6.641 miles) = 8.992 cubic miles

To convert cubic miles to acre-feet:

One cubic mile = (640 acres)(5280 feet) = 3,379,200 acre-feet

The gross volume in acre-feet of that portion of the Pine Valley Mountains fractured bedrock aquifer between the elevations of 5,000 and 7,500 feet, and 30,000 feet to the northwest from Ash Creek is about:

(8.992)(3,379,200) = 30,385,476 acre-feet

Ground Water Down Gradient from Sawyer Springs

This large volume of fractured bedrock does not include saturated portions of the aquifer below an average elevation of 5,000 feet. If the aquifer were to continue downward to an elevation of 4,000 feet under the Pine Valley Mountains, an additional block of rock 1,000 feet thick underlying 24,150 acres would have a volume of 24,150,000 acre-feet.

Adding the two values for gross volume gives the following result:

30,385,476 + 24,150,000 acre-feet = **54, 535,475 acre-feet.**

There is sufficient volume in the Pine Valley Mountains bedrock aquifer to store enough water to satisfy all authorized water users.

Specific Yield of the Fractured Bedrock Aquifer

Heilwell's published estimate for the specific yield of the quartz monzonite aquifer is .03. In an unconfined fractured aquifer, specific yield is roughly equivalent to the volume of the saturated pore space (open fractures). Three percent of the gross bedrock volume up gradient from Ash Creek above an elevation of 5,000 feet is about **911,564** acre-feet. Three percent of all the gross bedrock volume above 4,000 feet is about **1,636,064** acre-feet.

Some of that water is continually flowing through the fracture system down gradient toward Ash Creek. If, in the most conservative case, two thirds of the water in the fracture system above an elevation of 5,000 feet is locally confined or deflected away from New Harmony Valley (effectively reducing the specific yield to .01), then about **303,855** acre-feet of ground water would still be available to flow towards Ash Creek from the west.

The distance along Ash Creek from Kanarra Creek upstream to where Pace Draw enters the Harmony Mountains is about 12 miles. If the postulated available ground water in the fractured quartz monzonite aquifer system is evenly distributed in the subsurface, then, in the most conservative case, the minimum amount of water moving gradually toward each mile of Ash Creek from the Pine Valley Mountains above 5,000 feet elevation would be about:

(303,855)/12 miles = 25,321 acre-feet per mile.

That portion of the Pine Valley Mountains fractured quartz monzonite bedrock aquifer draining towards Ash Creek is thought by Heilwell to be recharged by no more than 4,000 acre-feet per year of precipitation. If all of that water were to be lost by seepage into Ash Creek, then the rate of seepage per mile would be 4,000 acre-feet divided by 12 miles, or 333.33 acre-feet per mile.

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Seepage Measurements Into Ash Creek in 2007

Seepage into Ash Creek was measured by Player during 2007 in a stretch one mile long between Main Street in New Harmony and a diversion structure downstream. The stream gained a total of 3.2 cubic feet per second along that stretch on August 23, 2007. That rate of seepage is equal to **2,319 acre-feet per mile in a year**, or almost seven times more than the estimated average seepage per mile (333.33 acre-feet) if recharge to the Pine Valley Mountains fractured bedrock aquifer is 4,000 acre-feet per year. However, that relatively large amount of water is far less than the minimum amount of water **(25,321 acre-feet per mile)** constantly moving towards Ash Creek through each one-mile-wide block of the fractured bedrock aquifer.

Several possibilities exist that can explain the seepage rate observed in Ash Creek:

1. Rates of gain and loss of ground water to and from Ash Creek are not uniform along all stretches of the creek. This observation has been made by others (Cordova, 1972, and Heilwell, 2000).

2. Some of the water flowing easterly in east-dipping sub-horizontal fractures under the Pine Valley Mountains may be gathered from rocks west of the topographic divide. If that were to be true, then the quantities of water available to recharge the aquifer each year could be much greater than 4,000 acre-feet estimated by Heilwell (2000).

3. Seepage rates vary from time to time during the year.

4. Some of the seepage water may be entering the creek from sand and gravel aquifers that underlie New Harmony Valley east of Ash Creek. Water analyses of Ash Creek reported by Heilwell suggest that some of the water entering the stream by seepage upstream from Death Valley Wash could have its source from unconsolidated aquifers east of Ash Creek.

5. Most of the water moving to the northeast in the fractured bedrock aquifer is deflected to the southeast by the Ash Creek Fault and does not cross under Ash Creek.

In any case, vast quantities of ground water are moving through the Pine Valley Mountains bedrock fracture system toward Ash Creek every day. Much of that water has historically fed lower Sawyer Spring.

Recharge to the aquifers may be much greater than estimated by Heilwell.

Residence Time for Ground Water in the Fractured Bedrock Aquifer

Discussions about the relative age of water from the fractured bedrock that emerges at Sawyer Springs and seeps into Ash Creek must consider the residence time of water in the aquifer. That time can be estimated by comparing the amount of annual recharge to the net volume of the aquifer system.

Estimated annual precipitation on the eastern slope of the Pine Valley Mountains is 47,440 acre-feet. Published values for infiltration into fractured bedrock with thin soils range from 5 to15 percent. At the eastern slope of the Pine Valley Mountains that amount of infiltration would be 2,372 to 7,116 acre-feet. Those values compare reasonably to Heilwell's values for infiltration (1,000 to 4,000 acre-feet).

Heilwell's published estimate for the specific yield of the fractured quartz monzonite aquifer is .03. In an unconfined fractured aquifer, specific yield is roughly equivalent to the volume of the saturated pore space (open fractures). Three percent of the gross bedrock volume above Ash Creek is **911,564** acre-feet. Some of that water is continually flowing through the fracture system down gradient toward Ash Creek. If, in the most conservative case, two thirds of the water in the fracture system is locally confined or deflected away from New Harmony Valley (effectively reducing the specific yield to .01), then about **303,855** acre-feet of ground water would still be available to flow towards Ash Creek from the west.

If the specific yield of the fractured bedrock aquifer is .03, all of the water above an elevation of 5,000 feet in the fractured bedrock aquifer would be replaced in **912** years using Heilwell's lowest estimate of 1,000 acre-feet for annual infiltration. All of the water in the same portion of the fractured bedrock aquifer (**911,564** acre-feet) would be replaced in **228** years using Heilwell's highest estimate of 4,000 acre-feet for annual infiltration.

In the conservative case that two thirds of the water in the fracture system is confined or deflected away from New Harmony Valley (effectively reducing the specific yield of the aquifer to .01), then about 303,855 acre-feet of ground water above an elevation of 5,000 feet would still be available to flow toward Ash Creek from the west. **That amount of water (303,855 acre-feet) would be replaced by water infiltrating at the minimum recharge estimate (1,000 acre-feet) in 304 years, or by the maximum recharge estimate (4,000 acre-feet) in about 76 years.**

The following Table summarizes estimated residence time for ground water in the shallow alluvial aquifer at Sawyer Creek, and for ground water above an elevation of 5,000 feet in the Pine Valley Mountain fractured bedrock aquifer:

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Aquifer Names West of Ash Creek-- "Shallow Alluvial" Aquifer Underlies Sawyer Canyon	Estimated Gross Aquifer Volume (acre-feet)	Aquifer Specific Yield (vol./vol.)	Stored Available "Mobile" Water (acre-feet)	Annual Recharge (acre-feet)	Residence Time (years)
Shallow Alluvial (if 1.5 square miles and 30 feet thick)	28,800	.25	7,200	160	45
Shallow Alluvial (if 2.0 square miles and 30 feet thick)	38,400	.25	9,600	213.38	45
Shallow Alluvial (if 2.5 square miles and 40 feet thick	64,000	.25	16,000	266.72	64
Shallow Alluvial (if 3.0 square miles and 50 feet thick)	96,000	.25	24,000	373.41	64
Fractured Bedrock above 5,000 feet	30,385,476	.01	303,855	1,000	304
Fractured Bedrock above 5,000 feet	30,385,476	.03	911,564	1,000	912
Fractured Bedrock above 5,000 feet	30,385,476	.01	303,855	4,000	76
Fractured Bedrock above 5,000 feet	30,385,476	.03	911,564	4,000	228

The obvious conclusion to reach from data summarized in the previous Table is that water historically produced from the fractured bedrock aquifer at Lower Sawyer Spring is from about two (2) to twenty (20) times older than water in the shallow alluvial aquifer at Upper Sawyer Spring. Age dating of mixtures of waters from the two aquifers will be dependent on accurate determination of the proportions of water from each aquifer present in radiological samples.

Age dating of water is complicated by mixing between the shallow and bedrock aquifers at Sawyer Springs.

Volume of Ground Water in Bedrock Fractures Near Sawyer Springs

Each square mile of the fractured bedrock aquifer contains a measurable volume of water. For example, each slice of the aquifer 100 feet thick under one square mile will contain 64,000 acre-feet of gross volume. If the specific yield of the aquifer is .03, then three percent of that gross volume is 1920 acre-feet.

If all of that water is available for production from wells or springs, then the water level in one square mile (assuming no recharge) would be lowered one hundred feet by production of 1920 acre-feet of water.

Calculations presented above using published data (Heilwell, 2000) showed that the maximum recharge along each of twelve linear miles of Ash Creek (or linear mile of bedrock outcrop parallel to Ash Creek) is about 333.3 acre-feet per year. Therefore, the net reduction in water volume in one cubic mile, after producing 500 acre-feet of ground water in one year, would be 500 - 333.3 = 166.7 acre-feet. This net amount of water depletion would result in lowering the water level in the aquifer by 8.68 feet, on the average, throughout an entire square mile of the fractured bedrock aquifer with a specific yield of .03, or three percent.

If, in the most conservative case, the specific yield of the fractured bedrock aquifer were reduced to one (1) percent by local confining conditions or deflection of ground water out of the hypothetical pumped area by major fracture systems, then the net aquifer volume per a one square mile area 100 feet thick would be reduced to 640 acre-feet. The predicted draw down at a production rate of 500 acre-feet per year with 333.3 acre-feet of recharge and a net depletion of 166.7 acre-feet, would increase by a factor of three, with a minimum draw down of 26.05 feet.

Production of 1,000 acre-feet per year with 333.3 acre-feet of recharge (for a net depletion of 666.7 acre-feet) would virtually dewater the first 100 feet of saturated fractured bedrock aquifer with specific yield of .01 (one percent). Production of 1,500 acre-feet would result in net depletion of 1,166.7 acre-feet, with the water level reduced by 182.3 feet (assuming that the same aquifer properties extended into the next 100 feet-thick slice of the fractured bedrock).

The following Table shows the predicted amount of depletion in a square mile area of the fractured bedrock aquifer, 100 to 200 feet thick, with varied rates of pumping and specific yield:

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Pumping Rate (A.-FT/YR)	Pumping Rate (G.P.M.)	Recharge Rate (A.-FT/YR)	Net Depletion Rate (A.-FT.)	Specific Yield (%)	Net Aquifer Volume (A.-FT.)	Draw Down of Water Level after One Year (Feet)
500	310	333.3	166.7	3	1920	8.68
1000	620	333.3	666.7	3	1920	34.74
1500	992	333.3	1166.7	3	1920	60.76
2000	1240	333.3	1666.7	3	1920	86.81
2500	1550	333.3	2166.7	3	1920	112.85
500	310	333.3	166.7	1	640	26.05
1000	620	333.3	666.7	1	640	104.17
1500	992	333.3	1166.7	1	640	182.3

Volumetric studies suggest that the area influenced by pumping at Church wells B and D may be linear rather than radial. The same conclusion was reached by USGS geologists after a pumping test of well B conducted in 1996.

Alternative Geometry for Fractured Bedrock Aquifer Depletion Around Well B
Church well B is about 150 feet south of Ash Creek. If Ash Creek acts as an aquitard (see below), then most of the depletion of the Pine Valley Mountains fractured bedrock aquifer by Church well B must occur only south and west of Ash Creek.

An alternative model for depletion can be presented by assuming that the area of depletion occurs in a volume of rock two miles long from northwest to southeast, and one-half mile wide from northeast to southwest. A volume of rock with this orientation has the same volume as a square block, one mile on each side. However, the estimated ground water recharge rate from the southwest into the two-mile wide block would be doubled from 333.3 acre-feet per year to 666.7 acre-feet per year.

Modeled draw down from pumping (for example, at Church wells B and D) would be reduced, as shown in the following Table:

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Depletion Rate (A.-FT./YR.)	Pumping Rate (G.P.M.)	Recharge Rate (A.-FT./YR.)	Net Depletion Rate (A.-FT./YR.)	Specific Yield (%)	Net Aquifer Volume (A.-FT.)	Draw Down of Water Level After One Year (Feet)
500	310	666.7	0	3	1920	0
1000	620	666.7	333.3	3	1920	17.36
1500	992	666.7	833.3	3	1920	43.43
2000	1240	666.7	1333.3	3	1920	69.44
2500	1550	666.7	1833.3	3	1920	95.48
500	310	666.7	0	1	640	0
1000	620	666.7	333.3	1	640	52.08
1500	992	666.7	833.3	1	640	130.2

This Table shows that averaged draw down within the two-mile long by one-half- mile wide block of fractured bedrock **with twice the estimated recharge** (compared to recharge into a one-mile long by one-mile wide block of fractured bedrock) would still be sufficient to interfere with Lower Sawyer Spring.

WATER CHEMISTRY

DATA AVAILABLE

Water chemistry helps to identify relationships between water from Upper Sawyer Spring, Lower Sawyer Spring, Ash Creek, other springs in the fractured bedrock aquifer, and ground water in unconsolidated aquifers northeast of Ash Creek. A set of water analyses from 32 wells, springs, and creeks was presented by expert witnesses for the Corporation of the Presiding Bishop of the Church of Jesus Christ of Latter Day Saints in testimony concerning a lawsuit brought by the Washington County Water Conservancy district in 1999. Of the 32 locations sampled, 19 were within the New Harmony Valley and surrounding mountains. Thirteen (13) of the New Harmony locations were sampled in mid-January of 1999, while the remaining 6 locations were sampled on April 6, 1999. Samples were collected and analyzed for “solute chemistry” and “isotopic compositions.” Physical parameters of pH, temperature, and conductivity were also measured, presumably in the field during the sampling events.

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Hydrologists from the U. S. Geological Survey sampled water from Ash Creek, Sawyer Creek, and Kanarra Creek on October 10 and October 11, 1995. They reported field measurements for temperature and specific conductance. An attached spread sheet summarizes similarities and differences in physical, chemical, and radiological measurements from the sampled waters.

Possible Errors in Reported Chemical and Radiological Data

Some contradictions in reported data were evident after sorting the data by category, rather than by sample location. For example, Mtn Well Springs B well has anomalously low reported total dissolved solids at 188 mg/L. Conductivity (also referred to as specific conductance) was 410, a value generally associated with samples from nearby wells and springs with TDS ranging from 264 to 300. Water from Mtn Well Springs B had a “percent modern carbon” (pmc) of 13.68, the lowest such reading of any sample from New Harmony Valley. Two other wells on the east side of Ash Creek had pmc values ranging from 14.6 to 70.81. TDS measured from all of the other wells east of Ash Creek ranged from 564 to 1680 mg/L.

Reported analyses of Tritium Units are also troubling. Low readings (less than 0.20 T. U.) are found from Church well D, the most westerly data point, to the Farm Pivot well, two miles east of Ash Creek, a well producing water having TDS 2.67 times greater than water from Church well D. Moderate readings (from 1.98 to 4.86 T. U.) are found from Farm well #3 to Church well B, and from the Keith Hall well, 6,950 feet northwest of Well B, to well B itself. No horizontal (geographical) or vertical (water level) trend is discernible in Tritium Unit data.

Upper Sawyer Spring

One sample station was labeled “Well D Spring.” Player assumed that this sample station was collected at a shallow (less than 15 feet deep) monitor well constructed in an old concrete block house built over a hand-dug well just east of well D. Water from that hand-dug well issues from the shallow alluvial aquifer of Sawyer Canyon.

Water was sampled on January 18, 1999. Solute chemistry was similar to water sampled from Lower Sawyer Spring the next day. Major differences included pH and temperature, while total dissolved solids and electrical conductivity were also different, but less so. The percent modern carbon (pmc) for Upper Sawyer Spring was reported as 102.2, showing that the water is very young. The amount of Tritium Units (1.64) measured was about half that of the Tritium Units measured in water from Lower Sawyer Spring.

Lower Sawyer Spring

This sample was collected on January 19, 1999. Solute chemistry, ph, and temperature were similar to water sampled from well D, well B, and other nearby springs and wells producing from the Pine Valley Mountain fractured bedrock aquifer. TDS is 268 mg/L. The pmc was 91.62, suggesting mixing of some young water with a smaller fraction of older water stored in the fractured bedrock aquifer. Reported Tritium Units were 3.61.

Comanche Spring

Water from Comanche Spring is chemically similar to water from Lower Sawyer Spring, Ash Creek near wells B and C, and well waters from Church wells B and D, the Keith Hall well, the New Harmony town well, and Mountain Springs well B. The pmc at Comanche Springs is the lowest measured from waters of the fractured bedrock aquifer (80.95), while the measured Tritium Units are low (1.04).

Ash Creek

Water was sampled from Ash Creek at three locations: at well B, at the well C culvert, and at the South Ash Creek gauging Station on January 18 and 19, 1999. Solute chemistry was very similar at sample locations near wells B and C, as was stream temperature. Measured pH values increased downstream from the well B location to the well C location, and pH was still higher at the South Ash Creek gauging station location. TDS declined drastically at the gauging station location, falling from an average of 258 mg/L near the two wells to 120 mg/L downstream. The percent of modern carbon increased from about 95 near well B to 99.51 at the gauging station. Both TDS and pmc data suggest dilution of water downstream from the sample locations of Ash Creek near wells B and C by precipitation.

Ash Creek waters sampled near wells B and C are the most similar physically, chemically and radiologically to waters presumed to be issuing from the fractured bedrock aquifer system at Lower Sawyer Spring and Comanche Spring.

Water from Wells West of Ash Creek

Waters from Church wells B and D are very similar to each other and to waters from Lower Sawyer Spring. Values from the wells for pH are identical, while TDS measurements range from 248 to 264 mg/L. Tritium units are 0.17 in well D, and 2.43 in well B. Percent modern carbon (pmc) in the two wells suggest much closer relative ages of sampled waters: pmc is 87.89 at well B, and pmc is 86.61 at well D.

Measurements of percent modern carbon values (pmc) and Tritium Unit values are not consistent with each other.

Water from Wells East of Ash Creek

Water from these wells, with one exception, have high TDS, ranging from 704 in the "Farm Pivot Well," to 1680 in "Farm #3 Well." Other tested chemical solutes are also present in much higher concentrations than in water from the wells and springs west of Ash Creek, and in Ash Creek near the Church wells B and C.

The only exception is the Mtn Springs Well B, with a TDS of 188. Results from this well are enigmatic, as water from the well is the oldest observed at New Harmony, with pmc of only 13.68, and negative Tritium Units (-0.03). The apparent age of water from the Mtn Springs Well B is about the same as the age of water from the Farm Pivot Well (pmc of 14.6, and 0.11 Tritium Units), while the TDS in the two wells is very different: 188 for Mtn Springs Well B, versus 704 for the Farm Pivot Well.

CONCLUSIONS FROM INTERPRETATIONS OF WATER CHEMISTRY INFORMATION

(1) Waters historically flowing from Lower Sawyer Spring are sourced mostly from the Pine Valley Mountains fractured bedrock aquifer. Mixing with waters from the shallow alluvial aquifer may increase the percent modern carbon (pmc) at Lower Sawyer Spring, compared to water from Comanche Spring.

(2) Solute chemistry and radiological information from water in wells east of Ash Creek show that the ground water under New Harmony Valley has a different primary source and is older than ground water issuing from the fractured bedrock aquifer and the Sawyer Canyon shallow alluvial aquifer in the Pine Valley Mountains.

(3) The chemical and radiological indicators show that ground water from west of Ash Creek may be mixing with ground water from New Harmony Valley near Mtn Springs Well B and the Farm Pivot Well.

(4) Waters from the New Harmony town well and the Mountain Springs B well are warmer than waters from wells further to the west, suggesting slower recharge, longer residence time, and/or a slightly higher geothermal gradient under New Harmony Valley than at the eastern edge of the Pine Valley mountains.

STRUCTURAL GEOLOGY OF NEW HARMONY VALLEY

HURRICANE FAULT SYSTEM

Southern Utah is traversed by the Hurricane Fault, part of the transitional boundary between the Colorado Plateau (uplifted rocks east of the Hurricane Fault) and the Basin and Range structural province of western Utah and Nevada. A major set of north-northeast to northeast-trending faults and fracture systems occurs within and bordering the transitional boundary. A second major set of fractures trends northwest to southeast, almost perpendicular to the set defined by the Hurricane Fault system and the western boundary of the Colorado Plateau.

THE ASH CREEK FAULT

New Harmony Valley is a structural anomaly. Its triangular lowlands separate the Pine Valley Mountains and the Harmony Mountains from the Colorado Plateau. The valley is bounded on the west by a northwest to southeast-trending fault or fracture system that extends from the Hurricane Cliffs all the way to Newcastle, a distance of about 25 miles. The northwest end of the fracture system was observed by Player in 1991 during construction of the Kern River gas pipeline, confirming surface geologic mapping by Sider and others (1990).

A recent publication by the Utah Geological Survey about the geology of the New Harmony (Grant, 1995) shows the existence of faults and fracture systems west of and parallel to Ash Creek. However, Grant's map fails to show a fault under the creek, although that fault and other intersecting fracture systems control the geological, hydrological, and topographical features of the west side of New Harmony Valley.

That fault, herein named the "Ash Creek Fault," branches off of the Hurricane Fault system just east of the earth fill dam under Interstate 15 at the south end of New Harmony Valley. The fault provides a shattered zoned under Ash Creek that continues northwest to the town of New Harmony. North of New Harmony town the fault splits into two sub-parallel fracture zones that underlie Pace Draw and Pinto Creek.

Several abrupt changes in the bearing of the channel of Ash Creek occur between Death Valley Wash and Kanarra Creek. The bends occur at the intersections of the creek with north to northeast trending fractures, suggesting that the Ash Creek Fault is older than some of the fractures that are parallel to the Hurricane Fault. If that is the case, younger movement along the "Hurricane Fault" set of fractures would tend to increase shattering along the Ash Creek Fault, thereby increasing permeabilities at their intersections with the Ash Creek Fault. Figure Two shows a suggested history of the Ash Creek fracture system, showing how younger fractures tend to increase permeability parallel to Ash Creek.

FRACTURES RELATED TO THE CONTROLLING FAULT SYSTEMS

Surface Measurements of Joint Sets

Excellent surface exposures of bedrock fractures are present in outcrops from Ash Creek to the mountains surrounding Sawyer Canyon. A "rose diagram" showing the relative frequency and compass bearing ("strike") of fractures exposed near Lower Sawyer Spring and wells A and B is shown in Figure Three.

ANNOTATED PROOF OF INTERFERENCE AT SAWYER SPRINGS, NEW HARMONY, UTAH

Two sets of fractures are grouped on the diagram. The strike of the most prominent set is parallel to the northeast-southwest trends of both Sawyer Canyon and Death Valley Wash, while the strike of the secondary set is parallel to the northwest-southeast trending Ash Creek Fault. Orientation of both sets is evidence for Grants' theory of regional clockwise rotation of the bedrock masses west of the Hurricane fault during late Tertiary and Quaternary time. Clockwise (eastward) rotation of the Pine Valley Mountains by about ten degrees would explain the slight difference in orientation of the northeast to southwest-trending set of fractures compared to the modern day trend of the Hurricane Fault east of New Harmony Valley.

Linear Features Observed on Maps and Aerial Photographs

In the text accompanying his map of the New Harmony Quadrangle, Grant acknowledged satellite image analysis by a colleague, Nancy Morton-Linck. Her studies revealed a "strong lineament (that) follows North Ash Creek from I-15 to New Harmony, runs through Bald Hill, and exits the quadrangle near its northwest corner."

Plate One shows the faults and linear features mapped by Grant. Plate Two repeats Grant's map, with the addition of Player's interpretation of the fracture systems along Ash Creek near Sawyer Springs.

Whatever the cause of the relative frequency, timing, and orientation of the two major fracture systems, they have intersected with rock-shattering force at Sawyer Springs and in the Pine Valley Mountains west of Ash Creek.

Surface measurements of fracture orientations are consistent with linear features visible on aerial photographs.

HYDROLOGIC IMPLICATIONS OF THE FRACTURE SYSTEMS

Ground Water Flow Direction

The fractures observed on the ground west of Ash Creek and visible on aerial photographs guarantee that water infiltrates and moves down gradient toward Lower Sawyer Spring and the Church wells A, B, and D. Recharge water flows downhill in the southwest to northeast-trending fracture system and reaches well D first, as the well is at an elevation about 200 feet (vertically) above Lower Sawyer Spring. Recharge water reaches wells A and B at about the same time as it reaches Lower Sawyer Spring and Ash Creek, as their static water levels are similar.

The Ash Creek Fault and its associated fracture system have excellent permeability to water parallel to the orientation of Ash Creek. However, except where the fault has been offset by younger fractures oriented approximately perpendicular to Ash Creek, permeability across the fault is very low. Ground water from the Pine Valley Mountains moves relatively rapidly down slope towards Ash Creek, where some is deflected upward into the creek channel. Water then flows to the southeast, both as surface water in the gaining stretches of Ash Creek, and as subsurface flow in the fractured bedrock aquifer. Very little of the water from the fractured bedrock aquifer crosses Ash Creek to recharge unconsolidated aquifers under New Harmony Valley. The Hurricane Fault similarly acts as an aquitard to ground water east of the valley (Heilwell, 2000).

The Ash Creek Fault is analogous to the Hurricane Fault, both acting as boundaries to ground water flow into New Harmony Valley.

PUMPING TEST OF 1996

A pumping test of Church well B in 1996 proved that communication between well B (the pumped well) and well A (the closest monitor well) was virtually instantaneous. Geologists from the U.S. Geological Survey theorized that a permeable fracture or set of fractures acted as an "extended fracture well, " allowing rapid production of ground water through a horizontal distance of 825 feet (Heilwell correspondence to Keith R. Prince, July 1, 1998). The compass bearing between the locations of well B and well A is about N 45 W, virtually parallel to the regional trend of Ash Creek.

Ground water produced from well B entered the "extended fracture well" through linear, rather than radial flow. Figure 3.1 from the USGS correspondence shows a conceptual model of a linear flow system. That figure shows ground water flow lines perpendicular to an "Extended Fracture Well."

Physical Evidence That the Ash Creek Fault is an Aquitard

The pumping test also confirmed that the Ash Creek Fault is an aquitard for water attempting to cross under Ash Creek in a direction perpendicular to the regional orientation of the creek. Heilwell reported the following in his correspondence to Keith R. Prince, July 1, 1998:

> "Of the 10 observation wells measured during the aquifer test, only the recorder well (well A at a radial distance of 825 feet) showed substantial drawdown due to pumping."

All but one of the nine remaining observation wells showed no affects due to pumping. The only other well to show any affect was well C-38-13 27aac-1, "but the affects were too small to analyze quantitatively (same correspondence)." Heilwell furthered stated that:

> "Observation well C-38-13 27 aac-1, at a radial distance of 6,950 feet, may have been slightly affected by pumping...This well is located in about the same orientation as the

> recorder well with respect to the production well, possibly along the same fracture trend (same correspondence)."

The production well and all of the observations wells were shown by Heilwell on a sketch map. Eight of the ten observation wells are across Ash Creek Fault from well B. The two wells on the west side of Ash Creek are well A (the only well to be affected quantitatively by pumping of well B), and well C-38-13 27aac-1 (the only other well to show any affect).

Chemical Evidence That the Ash Creek Fault is an Aquitard

Ash Creek Fault acts as an aquitard, separating waters of drastically different chemical and radiological composition, as discussed above. Major differences occur in the total dissolved solids (TDS), chloride, sulfate, sodium, magnesium, percent modern carbon (pmc), and Tritium Units between waters east and west of Ash Creek. The chemical boundary is equivalent to the physical boundary demonstrated by response of the observation wells during test pumping.

The Ash Creek Fault physically separates waters of the Pine Valley Mountains fractured bedrock aquifer from waters with different chemical quality under New Harmony Valley.

INTERFERENCE AT SAWYER SPRINGS

WATER PRODUCTION FROM CHURCH WELL B

Production records for Church well B were not available to Player for the preparation of this report. However, it is reasonable to assume that almost all of the Church's water rights in New Harmony Valley have been produced from wells B and D since 1994. If that assumption is correct, then the average annual production from west of Ash Creek has been about 1600 acre-feet. Most of the production was from well B, but additional supplies were provided from well D when the pump in well B either broke down, or was being serviced.

Using the conservative assumption that discharge from and recharge to the fractured bedrock aquifer occurs in a one square mile area, two miles long by one half mile wide, then recharge to the area each year would be about 666.7 acre-feet, for a net discharge of 1,600 - 666.7 = 933.3 acre-feet per year. The following Table shows the amount of draw down in one square mile, with varying assumptions of depletion by pumping and specific yield:

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Depletion Rate (A.-FT./YR.)	One Year Recharge (A.-FT./YR.)	Net One Year Depletion (A.-FT.)	Specific Yield (%)	Net Aquifer Volume (A.-FT.)	Average Annual Draw Down of Water Level (Feet)
500	666.7	0	3	1920	0
1000	666.7	333.3	3	1920	17.36
1600	666.7	933.3	3	1920	48.61
500	666.7	0	1	640	0
1000	666.7	333.3	1	640	52.08
1600	666.7	933.3	1	640	145.78

The draw down estimates with specific yield equal to 3 percent are similar to the actual range of draw down near Sawyer Springs. They show that some of the assumptions concerning aquifer properties are accurate, while published estimates for recharge at New Harmony may be too low. The following parameters are most critical:

(1) Annual recharge to the fractured bedrock aquifer; and

(2) Estimates of specific yield.

Adjustments in both recharge rate and specific yield are linear. That is, doubling specific yield would double the net volume of the aquifer, while doubling the rate of recharge would reduce net ten-year depletion by a fixed amount for each case.

Quadrupling the published rate of recharge to 1,333.3 acre-feet per year with 1,600 acre-feet of depletion would result in a net depletion of 266.7 acre-feet. If specific yield remained fixed at 3 percent, then the predicted draw down in one square mile would be only **13.9** feet. Increasing specific yield to 6 percent would double the net volume of the aquifer to 3840 acre-feet, and draw down would be only **6.95** feet.

Accurate predictions of draw down in the fractured bedrock aquifer are dependent on knowledge of annual recharge to the aquifer.

Comparison of Pump Test Results to Estimated Draw Down

Results from the 1996 pumping test can be used to test the depletion estimates and assumptions about recharge and specific yield. Draw down at the "Extended Fracture Well" (825 feet to the northwest of the pumped well) was about 5.5 feet after seven days of pumping, while draw down at the production well was about 17 feet. Heilwell concluded that flow near the well was linear by plotting draw down in the observation well in feet versus the square root of time in elapsed minutes. The resulting set of points fell on a line with a slope of about .056 feet per square root of each minute of elapsed time.

The elapsed time of the test was equal to (7)(24)(60) = 10,080 minutes. The square root of 10,080 minutes is about 100.4. The product of (100.4)(.056) is **5.62** feet, a result very close to the measured amount of draw down: **5.5** feet.

If the test pump rate of about 1050 gallons per minute (4.64 acre-feet per day) were continued for 345 days, a total volume of 1,600 acre-feet of water would be pumped. The number of minutes in 345 days is (345)(24)(60) = 496,800 minutes. The square root of 496,800 minutes is about 705.

The product of (705)(.056) = **39.47** feet, the amount of draw down to be expected in monitor well A after pumping 1,600 acre-feet in almost a year. That number is similar to the amount of draw down predicted by volumetrics (**48.61** feet) when annual recharge is 666.7 acre-feet per two-mile-wide block of the fractured aquifer, and specific yield of the aquifer is 3 percent. An even better volumetric approximation of the draw down (**41.7** feet) is provided if annual recharge is 800 acre-feet per two-mile-wide block of the aquifer, and specific yield remains at 3 percent

If the predicted amount of linear draw down in the "extended fracture well" were to continue as far as Lower Sawyer Spring (about 4,000 feet to the south southeast of well B), then all of the draw down at Sawyer Spring could be explained by pumping at wells B and D.

Note that recharge is not subtracted from depletion to obtain net depletion in the case of a pumping well. Recharge was occurring throughout the duration of the pump test: draw down would have been greater, and the slope of the "draw down versus the square root of elapsed time" line would have been steeper without natural recharge.

Comparison of Measured Ash Creek Seepage to Estimated Draw Down

Stream flow measurements completed by Player (above) showed that Ash Creek gained about 2,316 acre-feet per mile per year in the stretch between New Harmony town and a diversion structure downstream. Chemical analyses of the water in Ash Creek below Death Valley Wash show that most of the ground water seeping into the creek comes from the fractured bedrock aquifer of the Pine Valley Mountains. This amount of seepage per mile may establish a base line for annual recharge in each linear mile of the fractured bedrock aquifer south of New Harmony.

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The following Table shows a range of estimated aquifer draw down for a range of aquifer properties:

Depletion Rate From Pumping Church Wells B and D (A.-FT./YR.)	One Year Recharge into Two-mile-wide Aquifer Block (A.-FT./YR.)	Net One Year Depletion (A.-FT.)	Specific Yield (%)	Net Aquifer Volume (A.-FT.)	Average Annual Draw Down of Water Level in Two-mile-wide Aquifer Block (Feet)
1600	666.7	933.3	2	1280	72.91
1600	800	800	2	1280	62.5
1600	666.7	933.3	2.5	1600	58.33
1600	800	800	2.5	1600	50.0
1600	500	1100	3	1920	57.29
1600	666.7	933.3	3	1920	48.61
1600	1714	0	3	1920	0
1600	800	800	3.5	2240	35.71
1600	500	1100	4	2560	42.97
1600	666.7	933.3	4	2560	36.47
1600	666.7	933.3	5	3200	29.17
1600	500	1100	6	3840	28.65

Note that the recharge rate suggested by seepage into Ash Creek (2316 acre-feet per year per mile) would theoretically allow a large surplus of water to enter the creek near Church well B even while it is being pumped at the rate of 1600 acre-feet per year. However, seepage into Ash Creek no longer occurs near well B while it is pumped. Therefore, the seepage rate into Ash Creek is not uniform all along the southeastern edge of the Pine Valley Mountains, and average annual recharge to the fractured bedrock aquifer near Sawyer Springs is less than 2316 acre-feet per mile.

The next Table summarizes and compares the results of volumetric draw down estimations and projections of the pump test results:

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Depletion Rate (A.-FT./YR.)	One Year Recharge into Two-mile-wide Aquifer Block (A.-FT./YR.)	Net One Year Depletion (A.-FT.)	Specific Yield (%)	Net Aquifer Volume (A.-FT.)	Average Annual Draw Down of Water Level (Feet)
1600	666.7	933.3	3	1920	47.86
1600	666.7	933.3	2	1280	72.91
1600	**Pump Test Draw Down Data Extrapolated to 345 Days**				**39.47**
1600	950	650	2.5	1600	40.6
1600	1000	600	2.5	1600	37.5
1600	1200	400	2	1280	31.25
1600	800	800	3	1920	41.6
1600	900	700	2.5	1600	43.75
1600	752	848	3	1920	44.2
1600	1000	600	2	1280	46.9
1600	376	1224	4	2560	47.8
1600	376	1224	3	1920	63.75
1600	752	848	2	1280	66.3
1600	1128	472	1	640	73.75
1600	376	1224	2	1280	95.6

Once again, it is easy to observe that **variations in assumed annual recharge and specific yield** result in a range of draw down estimations.

The only draw down value in the preceding Table that is tied to observed field data is the "Pump Test Data Extrapolated to 345 Days." Comparison of this value to draw down estimations controlled by Heilwell's published value for specific yield (3 percent) shows that average recharge along a two-mile-wide portion of the fractured bedrock aquifer probably ranges from 700 to 800 acre-feet per year per every two miles, or from 350 to 400 acre-feet per one-mile-wide portion of the aquifer. If the specific yield is 2.5 percent or less, then the recharge each year per every two miles could be as high as 1,200 acre-feet, or about 600 acre-feet per one-mile-wide portion of the aquifer. These higher numbers for recharge are confirmed by the rate of recovery in Church well A after the pumping test of 1996 (see below).

LOWERING OF GROUND WATER LEVELS

The evidence for lowered water levels at Sawyer Springs cannot be ignored. Continuous records of water level changes are not available, but all the available evidence shows that depletion from wells B and D exceeds natural recharge in section 35, T. 38 S., R. 13 W.

Bruce Whited has installed several pressure-activated water level probes in monitor wells and springs near Sawyer Springs. However, long term records are sparse. The reasons for this lack of complete records are two-fold. First, representatives of the Church have periodically removed Whited's probes from some of the wells, citing a lack of written permission to Whited to install the probes on Church owned lands. Second, batteries have failed in some of the recorders.

Water level measurements are now in progress at the Upper Sawyer Springs block house, at a monitor well just north of Lower Sawyer Spring, at a shallow monitor well recently installed in the test pit constructed beneath the dry gathering pond at Lower Sawyer Spring, and at Church well A, the only monitor well that responded quantitatively to pumping of well B in 1996.

Upper Sawyer Spring Block House

Relatively complete records showing the height of the water level above the probe sensor are available from April 8, 2007, through September 8, 2007. The water level declined from 5.9 feet above the probe, to 0.7 feet above the probe in that period. These measurements showed that the water level fell 5.2 feet in 154 days, at an average rate of .0338 feet per day. Water measured at Upper Sawyer Spring is in the shallow alluvial aquifer.

Lower Sawyer Spring Monitor Well

Water levels in Lower Sawyer Spring were measured most recently from April 8, 2007, through July 15, 2007. The water levels declined from 30 feet above the probe, to the depth of the probe in that period.

These measurements showed that the water levels fell 30 feet in 100 days, at an average rate of 0.30 feet per day. Water measured at the Lower Sawyer Spring monitor well is in the fractured bedrock aquifer tapped by Church wells B and D.

Water levels were also measured at the monitor well during 2004 and 2005. Water levels were seen to rise between November 11, 2004 and January 5, 2005 from 23.5 feet to 28 feet above the sensor. Water levels rose 4.5 feet in 50 days day at an average rate of 0.09 feet per day. Neither well B nor well D was operating during that time period.

Readings were not available between January 5, 2005 and July 31, 2005, as the sensor probe had been removed by representatives of the Church after a dispute over access to Church property.

Readings between August 1, 2005 and November 1, 2005 displayed a saw-toothed pattern that directly reflects starting and stopping of the pump at Church well B. “Peaks” on a curve of the water level data represent days at the end of “stopped times,” while “valleys” on the same curve represent the ends of “pumping times.” Upward slopes began whenever the pump was stopped, and downward slopes occurred whenever the pump was running.

Lower Sawyer Spring Test Pit

Water in the Lower Sawyer Spring Test Pit was first encountered on September 18, 2007. The observed rate of decline in the first four days after installation of water level probe was about 0.2 feet per day. Water measured at the Lower Sawyer Spring Test Pit is in the fractured bedrock aquifer tapped by Church wells B and D.

Measured Recovery in Church Well A

Long term draw down measurements at Church well A have not yet been compiled and analyzed. However, excellent data are available for recovery at the well after the 1996 pumping test.

Water levels recovered quickly from a draw down of about 105 feet below ground level to about 100 feet below ground level in 10,000 minutes, or 6.94 days, roughly equivalent to the number of pumping days (7) in the test. After the initial recovery period, water levels in the well recovered more gradually from 100 feet below ground level to an estimated water level of 91 feet below ground level in 80,000 additional minutes, or 55.55 days. The rate of recovery was stable during that time period, averaging **0.162** feet per day. The USGS interpreted this time period as a “recharge event.”

Volumetric estimates of aquifer recharge presented above are very similar to rates of recharge recorded at Church well A. Recharge in the well was first compared to the volumetric recharge in a block of the fractured bedrock aquifer two miles long by one-half mile wide with specific yield of .03, the published estimate of Heilwell. In that case, the net volume of water in a square mile portion of the aquifer, 100 feet deep, would be 1920 acre-feet.

The rate of recharge to the twelve-mile wide portion of the fractured bedrock aquifer needed to raise the water level in a two-mile wide depleted portion of the aquifer with specific yield of .03 by **0.162** feet per day (the rate displayed in Church well A) is 6,800 acre-feet per year. Annual recharge of 6,000 acre-feet would raise the water **0.143** feet per day.

For comparison, Player estimated that the annual rate of recharge in a twelve-mile wide portion of the fractured bedrock aquifer with specific yield of .02 could be as little as 4,800 acre-feet per year. That lower rate of recharge would raise the water level in a two-mile wide depleted portion of the aquifer by **0.171** feet per day. Recharge by 6,000 acre-feet per year into an aquifer with specific yield of .02 would raise water levels by about **0.214** feet per day. Recharge by 7,200 acre-feet per year into an aquifer with specific yield of .02 would raise water levels by about **0.257** feet per day.

If the specific yield of the fractured bedrock aquifer were .025, estimates of daily recovery rate under the same volumetric estimates would range from **0.171 to 0.206** feet per day.

The following Table compares the measured daily recovery rate at Church well A to a range of volumetric estimates of recharge:

Annual Recharge into Twelve-Mile Wide Aquifer Block (A.-FT./YR.	Daily Recharge into Two-mile-wide Aquifer Block (A.-FT./Day)	Specific Yield (Percent)	Net Aquifer Volume (A. FT.)	Daily Recovery Rate (FT./DAY)
4,800	2.192	2	1280	0.171
6,000	2.740	2	1280	0.214
7,200	3.288	2	1280	0.257
6,000	2.740	2.5	1600	0.171
7,200	3.288	2.5	1600	0.206
6,000	2.740	3	1920	0.143
6,800	3.105	3	1920	0.162
7,200	3.288	3	1920	0.171
Measured Recovery Rate at Church well A				**0.162**

Observed recharge rates at Church well A are very similar to volumetric estimates for recharge into a two-mile wide by one-half-mile long portion of the fractured bedrock aquifer with reasonable ranges for specific yield and aquifer recharge.

Measured Recovery at Whited's Lower Sawyer Spring Monitor Well

Water levels in the Lower Sawyer Spring (LSS) monitor well were drawn down below the pressure sensor during the summer of 2007. Once the pump was shut down at Church Well B (on or about October 15, 2007), water levels immediately began to recover.

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Ground water was first detected by the sensor at about mid-day on November 6, 2007. The following Table lists the date, measured water levels, and observed rates of recovery during November and December of 2007, and during the first week of January, 2008:

Date	Water Level at LSS Monitor Well (feet above sensor)	Water Level Change Since Previous Reading (feet)	Cumulative Recharge Since 11/07/2007 (feet)	Rate of Change Since Previous Reading (feet/day}	Cumulative Rate of Change Since 11/07/07 (feet/day}
11/07/07	0.2	NA	NA	NA	NA
12/07/07	9.6	9.4	9.4	0.313	0.313
01/05/08	15.9	6.3	15.7	0.217	0.266

Initial water level recovery readings at the LSS monitor well suggest either greater annual aquifer recharge than estimated by Heilwell, or a lower specific yield (2.0 - 2.5) than estimated by Heilwell (3 percent).

CONCLUSIONS

GENERAL EFFECTS OF INTERFERENCE BY CHURCH WELLS

I. Annual declines in ground water levels at Sawyer Springs are directly related to aggressive pumping of Church wells B and D. Constant pumping rates averaging 1,700 gallons per minute have lowered ground water levels enough to eliminate the surface flow of water from the springs.

II. Considering aquifer properties, rates of depletion, and likely volumes of recharge to the aquifer by infiltration of precipitation, annual depletion from wells B and D (about 1600 acre-feet) is enough to lower water levels in the fractured bedrock aquifer of the Pine Valley Mountains about 40 to 60 feet each year at Lower Sawyer Spring.

III. A test pit excavated beneath the dry bed of Lower Sawyer Spring on September 19, 2007, revealed ground water in the fractured bedrock aquifer at a depth of 13 feet. Water at that depth is 40 feet below the top of the shallow alluvial aquifer at the highest terrace of Sawyer Creek, and about 10 feet below the base of the shallow alluvial aquifer in Lower Sawyer Spring..

IV. Water from the shallow alluvial aquifer at Sawyer Springs drains into the underlying fractured bedrock aquifer when water levels in the fractured bedrock aquifer are lowered by pumping at Church wells B and D.

V. The net volume of water in the shallow alluvial aquifer (about 8,000 acre-feet) and the recharge rate (about 200 acre-feet per year) are so small that the aquifer has been dewatered at Lower Sawyer Spring by pumping at Church wells B and D.

VI. Sufficient ground water is available in the aquifers around Sawyer Springs to satisfy the prior water rights of Bruce Whited, but **only** if the Church reduces the combined pumping rate at Church wells B and D and produces the bulk of its water rights from existing Church wells east of Ash Creek and in the NW corner of section 35.

CLIMATE AND AQUIFER RECHARGE

VII. Long term climate records show that precipitation at and near New Harmony has not changed since the commencement of pumping at Church well B and D. In other words, meteorological drought conditions do not exist at Sawyer Springs.

VIII. Average annual recharge to the fractured bedrock aquifer of the Pine Valley Mountains is greater than the maximum published value of 4,000 acre-feet. Volumetric estimations of recharge, when compared to field data from the 1996 pump test, show that the annual recharge rate per one-mile-wide portion of the aquifer ranges from 350 to 500 acre-feet. Given an estimated width of twelve miles for the aquifer between Kanarra Creek and Pace Draw, annual recharge into that portion of the fractured bedrock aquifer ranges from a minimum of 4,200 acre-feet to about 6,800 acre-feet per year.

REGIONAL HYDROLOGY OF THE PINE VALLEY MOUNTAINS AND NEW HARMONY VALLEY

IX. Ground water from the fractured bedrock aquifer of the Pine Valley Mountains seeps into and locally percolates out of Ash Creek along the western boundary of New Harmony Valley.

X. Structural geology and physical chemistry both indicate that ground water from the Pine Valley Mountains is intercepted by faults and fracture systems at Ash Creek and that large quantities do not flow across Ash Creek to the east.

XI. Ground water east of Ash Creek flows south under New Harmony valley, and is deflected to the southeast by faulting and fracturing under Ash Creek.

RESULTS OF THE 1996 PUMPING TEST

XII. The 1996 pump test identified virtually instantaneous linear fracture flow between the test well (Church well B) and the instrumented monitor well (Church well A).

XIII. Recharge to Church wells A and B is by linear flow in a set of SW to NE oriented fractures that intersects the NW to SE oriented fracture system parallel to the Ash Creek Fault.

XIV. The lack of measurable draw down in monitor wells north and east of wells A and B during the 1996 pumping test proved that ground water flowing northeastward from the Pine Valley Mountains is obstructed by aquitards in the Ash Creek fault zone.

XV. Chemical and radiological differences between waters from (1) wells east of Ash Creek and (2) wells and springs west of Ash Creek are explained by the occurrence of an aquitard along the Ash Creek fault zone.

XVI. Linear draw down in Church well A during the pumping test can be extrapolated to predict draw down after production of 1,600 acre-feet. The extrapolated draw down is equivalent to draw down predictions for a one square mile area of the fractured bedrock aquifer using published aquifer properties and higher estimates for recharge.

XVII. The rate of recovery in the water level by recharge at Church well A after the pumping test of 1996 is virtually identical to rates of recharge predicted by volumetrical methods.

XVIII. flow at Lower Sawyer Spring measured by the USGS in October of 1996 (1.52 cfs) is about equal to the amount of daily recharge to a two-mile-wide portion of the fractured bedrock aquifer (1.565 cfs) with specific yield of .03 and total annual recharge to a twelve-mile-wide portion of the aquifer of 6,800 acre-feet. Measured flow would also be about equal to the amount of daily recharge to a two-mile-wide portion of the fractured bedrock aquifer (1.38 cfs) if specific yield were equal to .025 and total annual recharge to a twelve-mile-wide portion of the aquifer were 6,000 acre-feet.

XIX. Historic flow at Lower Sawyer Spring is the direct result of (1) recharge into the fractured bedrock aquifer by precipitation, and (2) leakage from the shallow alluvial aquifer of Sawyer Canyon. Aggressive pumping of Church wells B and D has lowered water levels in the fractured bedrock aquifer enough to deplete the shallow alluvial aquifer and dry up Sawyer Springs.

Suggested Appendices:
1. Player's Report on New Harmony Hydrology, January 1993
2. Player's Report on New Harmony Hydrology, April 2006
3. Player's Definition of Springs, August 2006
4. Player's Report on LDS Church Water Rights in New Harmony, December 1992

ADDITIONS TO THE "PROOF OF INTERFERENCE AT SAWYER SPRINGS," BY GARY F. PLAYER, DATED JANUARY 7, 2008

The rate of recharge to the twelve-mile wide portion of the fractured bedrock aquifer needed to raise the water level in a two-mile wide depleted portion of the aquifer with specific yield of .03 by **0.162** feet per day (the rate displayed in Church well A) is 6,800 acre-feet per year. Annual recharge of 6,000 acre-feet would raise the water **0.143** feet per day.

For comparison, Player estimated that the annual rate of recharge in a twelve-mile wide portion of the fractured bedrock aquifer with specific yield of .02 could be as little as 4,800 acre-feet per year. That lower rate of recharge would raise the water level in a two-mile wide depleted portion of the aquifer by **0.171** feet per day. Recharge by 6,000 acre-feet per year into an aquifer with specific yield of .02 would raise water levels by about **0.214** feet per day. Recharge by 7,200 acre-feet per year into an aquifer with specific yield of .02 would raise water levels by about **0.257** feet per day. If the specific yield of the fractured bedrock aquifer were .025, estimates of daily recovery rate under the same volumetric estimates would range from **0.171 to 0.206** feet per day.

The following Table compares the measured daily recovery rate at Church well A to a range of volumetric estimates of recharge:

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Annual Recharge into Twelve-Mile Wide Aquifer Block (A.-FT./YR.	Daily Recharge into Two-mile-wide Aquifer Block (A.-FT./Day)	Specific Yield (Percent)	Net Aquifer Volume (two miles by ½ mile by 100 feet times the specific yield) (A. FT.)	Daily Recovery Rate (FT./DAY)
4,800	2.192	2	1280	0.171
6,000	2.740	2	1280	0.214
7,200	3.288	2	1280	0.257
6,000	2.740	2.5	1600	0.171
7,200	3.288	2.5	1600	0.206
6,000	2.740	3	1920	0.143
6,800	3.105	3	1920	0.162
7,200	3.288	3	1920	0.171
Measured Recovery Rate at Church well A				**0.162**

Observed recharge rates at Church well A are very similar to volumetric estimates for recharge into a two-mile wide by one-half-mile long portion of the fractured bedrock aquifer with reasonable ranges for specific yield and aquifer recharge.

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The large, gaping holes in the fracture system have allowed Fremont's Barberry leaves to travel to at least 760 feet below ground without decaying. They could probably allow 15 percent of the moisture to infiltrate the rocks, for a possible recharge of 10,600 acre-feet per year, or about 885 acre-feet per mile (1,770 acre-feet per each two mile) stretch of the mountain front.

This amount of water would be pumped from the Church Well B in about four months, leaving two-thirds of the year for water to re-enter the fractures that had been dewatered.

An alternative approach to determining the recharge area is to estimate the entire area of the Pine Valley Mountains west of Ash Creek above the approximate elevation of Ash Creek (5,000 feet). The area is enclosed on the north by Pinto Road, on the west by Utah Highway 19, along the east by Ash Creek and Interstate Highway 15, and at the south end of the Pine Valley Mountains by Yant Flat. That area can be estimated by reference to the Cedar City 1:250,000 scale topographic map. A conservative estimate is approximately 10 townships, or 230,400 acres.

Increasing this area by 10 percent (to account for slope) gives an area for precipitation and infiltration of 253,440 acres. That area is about ten times the area for infiltration allowed by Heilwell.

The average precipitation in the Pine Valley Mountains for the range of elevations from 5,000 feet to 10,000 feet, east and west of the topographic divide, is about 21 inches, or 1.75 feet. Therefore, the likely volume of precipitation above 5,000 feet is 230,400 X 1.75 = 403,200 acre-feet per year. Infiltration through open fractures (and loose granular soils in the flatter intermontane valleys) provides recharge:

Five Percent Infiltration = 20,160 acre-feet per year
Ten Percent Infiltration = 40,320 acre-feet per year
Fifteen Percent Infiltration = 60,480 acre-feet per year

A valid range for approximate recharge into the Pine Valley Mountains by infiltration above 5,000 feet elevation is:

20,000 to 60,000 acre-feet per year of ground water.

If all of the ground water above 5,000 feet elevation in the Pine Valley Mountains were to flow radially in all directions from the high (10,035 feet) peak just west of Big Cove, than a pie-shaped slice encompassing the mountains from Ash Creek Reservoir to Richie Flat along Pinto Road would be about 70 degrees wide, or virtually 20 percent of the pie. That amount of the ground water could be considered available to flow towards Ash Creek, along the southwestern boundary of New Harmony Valley. Twenty percent of 20,000 acre-feet is 4,000 acre-feet per year, while 20 percent of 60,000 acre-feet is 12,000 acre-feet per year.

The amount of recharge to the Pine Valley Mountains fractured bedrock aquifer that flows towards Ash Creek each year will range from 4,000 to 12,000 acre-feet. If all of that water were to surface in Ash Creek because of the aquitard present at the Ash Creek Fault, then the annualized base flow in Ash Creek above the Ash Creek Reservoir provided from the Pine Valley Mountains fractured bedrock aquifer system, discounting all interference from pumping wells west of Ash Creek, should range from 5.53 to 16.59 cubic feet per second.

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The distance along the Ash Creek Fault system from Richie Flat to the southwest end of Ash Creek Reservoir is about 14 miles. The amount of recharge water estimated to flow towards each mile of the Ask Creek Fault system from the Pine Valley Mountains fractured bedrock aquifer ranges from 4,000 acre-feet/14 miles to 12,000 acre-feet/14 miles, or from 286 to 857 acre-feet per mile.

Actual seepage into Ash Creek was measured by Player during 2007 in a stretch one mile long between Main Street in New Harmony and a diversion structure downstream. The stream gained a total of 3.2 cubic feet per second along that stretch on August 23, 2007. That rate of seepage is equal to **2,316 acre-feet per mile in a year**, or about 2.7 times more than the estimated average seepage per mile (857 acre-feet) if recharge to the Pine Valley Mountains fractured bedrock aquifer flowing towards Ash Creek is 12,000 acre-feet per year.

Several possibilities exist that can explain the 2007 seepage rate observed in Ash Creek:

1. Rates of gain and loss of ground water to and from Ash Creek are not uniform along all stretches of the creek. This observation has been made by others (Cordova, 1972, and Heilwell, 2000).

2. Much of the water flowing northeasterly in east-dipping sub-horizontal fractures under the Pine Valley Mountains may be gathered from rocks west of the topographic divide. If that were to be true, then the quantities of water available to recharge the aquifer each year could be much greater than 4,000 acre-feet estimated by Heilwell (2000).

3. Seepage rates vary from time to time during the year.

4. Some of the seepage water may be entering the creek from sand and gravel aquifers that underlie New Harmony Valley east of Ash Creek. Water analyses of Ash Creek reported by Heilwell suggest that some of the water entering the stream by seepage upstream from Death Valley Wash could have its source from unconsolidated aquifers east of Ash Creek.

In any case, vast quantities of ground water are moving through the Pine Valley Mountains bedrock fracture system toward Ash Creek every day. Much of that water has historically fed lower Sawyer Spring.

Note: these last comments have been incorporated into a letter report entitled "Replacement Water 040308."