Safe Yield Estimate for the Beryl-Enterprise Area

By: James Greer
Date: April 07, 2008

The perennial safe yield of the Beryl-Enterprise area is equal to the amount of groundwater that can be withdrawn from the basin over a period of time without exceeding the long-term recharge of the basin or unreasonably affecting the basin's physical and chemical integrity. The safe yield of the aquifer is estimated as 34,000 acft. This estimate of safe yield was determined by:

1) Researching published studies in the area to develop a water budget.
2) Calculating the change in water stored in the aquifer and the consumptive water use to then back-calculate the recharge to the aquifer.

<u>Publishes Estimates</u>

Studies in the Beryl-Enterprise area include water-resource investigations, geologic and hydrogeologic investigations, recharge and discharge estimations, and other hydrologic studies. From the published reports the amount of natural recharge to the system was tabulated in Table 1. The 34,000 acft of natural recharge is equivalent to the safe yield. The recharge estimate reported by Mower (1982) was verified by the calibration of a numeric groundwater model.

Table 1

Ground Water Natural Recharge For Beryl / Enterprise Area		
RECHARGE	**Acre-Feet**	**Source**
Subsurface Inflow from Mountains/Streams	31,000	(Mower, 1982)
Precipitation on Valley Floor	500	(Mower, 1982)
Subsurface Inflow	320	(Mower, 1982)
Return Flow from Surface Irrigation	1,300	(Calculated[1])
Natural Recharge (rounded)	34,000	

1. The return flow from surface irrigation is calculated using the reported surface diversion from Mower (1982) and equating the return flow using the duty and the consumptive use factor from Hill (1998).

Calculated Estimate

To confirm the published recharge estimate a hydrologic balance equation was evaluated to calculate the annual recharge. For a given system the inflows must balance with the outflows in addition to any change in storage. The inflow to the system ($Q_{recharge}$) can be calculated by subtracting the change in water stored in the aquifer ($\Delta_{storage}$) from the outflows, which in this system is the consumptive use ($Q_{consumptive}$). The hydrologic balance equation is as follows:

$$Q_{recharge} = Q_{consumptive} - \Delta_{storage} \qquad \text{(Equation 1)}$$

Where:

$Q_{recharge}$ is the recharge to the aquifer
$Q_{consumptive}$ is the estimated crop depletions from well withdrawals.
$\Delta_{storage}$ is the calculated change in water stored in the aquifer

Data from years 2001 to 2006 was used in the budget calculations. This range of years was selected for the analysis because of the crop survey data gathered by the Division of Water Rights during the time frame.

Two methods were used to calculate $Q_{consumptive}$. For method 1 the average yearly well withdrawal estimates (87,640 acre-feet) provided by the USGS (Burden, 2006) where multiplied by a consumptive factor of 0.78 (2.49 / 3.2, consumptive use divided by predicted duty) to calculate $Q_{consumptive}$. This calculation resulted in a $Q_{consumptive}$ of 68,195 acft. Method 2 used crop acreages from the Division of Water Rights annual reports, irrigation consumptive use tables (Hill, 1998), surface diversion records (Jim Simkins, Enterprise Reservoir President, and Mason Jones, New Castle Reservoir President, oral communication, 2007) and surface source estimates (Burden, 1982) to calculate $Q_{consumptive}$. The average annual acres of irrigated land for the 2001 - 2006 timeframe was 27,650 acres. Records indicate that on average 6,500 acre-feet of water is diverted from surface sources each year. Dividing the 6,500 acre-feet of water by the consumptive use of 2.49 acre-feet /acres results in an equivalent 2,600 acres of irrigation that is supplied by surface sources on average each year. Thus, the reaming 25,040 acres of irrigation is supplied by underground sources. Multiplying 25,040 acres by the consumptive use factor of 2.49 results in a $Q_{consumptive}$ estimate of 62,348 acft. An average of the two methods gives a $Q_{consumptive}$ estimate of 65,000 acre-feet.

The $\Delta_{storage}$ in the aquifer was calculated using USGS water level measurements (USGS Ground-Water Data online) and specific yield data from a numeric groundwater model (Mower, 1982). Specific yield is the ratio of the volume of water drained to the total rock volume (Fetter, 2001). Water level measurement from the spring of 2001 and 2006 were interpolated to create water level surfaces. The total volume between the two surfaces was calculated and multiplied by a dataset of specific yield values from the groundwater numeric model to determine the $\Delta_{storage}$ for the five-year period. The $\Delta_{storage}$ calculated for the five-year time period was 157,123 acft equaling a 31,425 acft annual average.

$Q_{recharge}$ was evaluated as 33,575 acft from Equation 1 with a $Q_{consumptive}$ of 65,000 acft and a $\Delta_{storage}$ of 31,425 acft (see Table 2). This estimate closely correlates with the reported water budget providing confidence in a safe yield estimate. The final estimate of safe yield is rounded as 34,000 acft.

Table 2

2001 - 2006 Estimate (5 yr)	
Equation Component	**Annual Average (acft)**
$Q_{consumptive}$	65,000
$\Delta_{storage}$	31,425
$Q_{recharge}$	33,575

References

Burden. C.B., and others, 2007, Ground-water conditions in Utah, spring of 2007: Utah Division of Water Resources Cooperative Investigations Report no. 48, 129p

Fetter, C.W., 2001, Applied Hydrogeology, Prentice-Hall, Inc. Upper Saddle River, New Jersey 07458

Hill, Robert W., 1998, Consumptive Use Of Irrigated Crops In Utah, Utah Agricultural Experiment Station Research Report 145

Mower, R.W., and Sandberg, G.W., 1982, Hydrology Of The Beryl-Enterprise Area, Escalante Desert, Utah, With Emphasis On Ground Water; With A Section On Surface Water, Technical Publication No. 73

USGS Ground-Water Data for Utah, 2006, online: <http://waterdata.usgs.gov/ut/nwis/gw>, United States Geological Survey, accessed during July, 2007.