5.0 Case History Examples

In this section, three examples are presented illustrating the step-wise approach developed for determining if ground water can provide the water supply for a given site (Figure 39). Site 1 is located in the lower Capitol Creek valley; site 2 is located in the Lime Creek area, and site 3 is located on the ridge between Upper Snowmass Creek and Upper Capitol Creek. The examples illustrate the variability of drinking water supplies, both in availability and sustainability, dependent on the local hydrogeology and hydrological system. All three sites are vulnerable to ground water pollution. Note, that the map display is in 'Data View' mode (Click View → Data View on the menu bar of the ArcMap window). The GIS layer numbers in the following discussions refer to Figure 38.

![Figure 39. Location of Example Sites.](image-url)
5.1 Example 1 in Lower Capitol Creek Valley

5.1.1 Identify Location on GIS Map

Example 1 is a site located on parcel #264504200004 [at about (Colorado State Plane, Central Zone NAD 83) coordinate 2575210, 1538460], just east of Little Elk Creek subdivision (blue marker dot; Figures 39 and 40). Parcel and subdivision details are found by using the Identify function on the menu bar and selecting the County parcels or County subdivisions layer from the layers list at the top of the Identify Results window (layers 13 and 15, respectively; Figure 40). The coordinates of the site can be found near the lower right hand corner of the map while moving the mouse to the location of the site (Figure 40). The streams layer and the roads layer are shown for orientation. The label feature of the subdivision layer and the streams layer are turned on. The site is located in the valley section of the FDB hydrologic subsystem, and the hydrogeologic conceptual model for this area is shown in Figure 16 (unconsolidated materials located on top of Mancos Shale).
5.1.2 Determine Ground Water Availability

Using the Identify function on the menu bar and turning on the Hydrounits - Potential aquifers layer (layer 23) from the GIS map's table of contents, it is determined that the potential aquifer material is Qal (alluvium), possibly on top of Qgf (Figures 16 and 41). From using the Identify function for the Hydrounits - Top bedrock layer (layer 25), the underlying bedrock unit is determined to be Km (Mancos Shale). From the discussion of the FDB subsystem in chapter 2, it is concluded that there may be a water resource in the Kdb unit at the site (Figure 16). However, the absence of the Kdb unit in the Hydrounits - Top Bedrock layer in the vicinity of the site indicates that there is no alluvium-bedrock aquifer connectivity (figure 42). This means that the surficial aquifer is not connected to or sustained by an underlying bedrock aquifer and that aquifer sustainability is determined solely by surface processes related to nearby streams, ditches, irrigation, and precipitation. Near the site, the Kdb unit is a confined aquifer. The use of the Kdb unit for water supply depends on its thickness and depth, the thickness of the overlying Mancos shale, and the recharge mechanism and rate.
The next step is to determine if the alluvial material is saturated or unsaturated. This determination is made on the basis of information from nearby wells and, because the aquifer is an alluvial unit, the water levels in nearby streams in conjunction with ground elevation at the site.

Layer 19 (drilled wells grouped by depth) is turned on to identify relevant nearby wells. There are 9 wells identified that may provide information (Figure 43). The wells can be selected using the Select Tool from the Tools Toolbar (Figure 43). From the attribute table of layer 19, well depth, depth to static water level at time of drilling, well production (gallon per minute yield), and time of year of drilling can be evaluated with respect to pre-development saturated thickness (Figure 44; see Appendix 2 for explanation of field names). To display only the subset of selected wells, use the Selected button next to the Show 'All' Records button at the bottom of the attribute table (see inserted window in Figure 46). It appears that most wells near site 1 are not drilled to bedrock. Note, that the information available in the attribute table is insufficient to determine bottom elevation and saturated thickness of the potential aquifer.
Most nearby wells are shallow (less than 50ft deep), with a water table ranging from 3 to 24ft below ground surface, and a yield from 10 to 15gpm. (Note, that 15gpm is the maximum permitted yield for household wells and that higher yields are possible). The deep well (permit # 221921) shows a depth to water of 86ft. Pre-pumping saturated thickness ranges from a minimum of 11 to 25ft (i.e., difference between water level and screen bottom). The shallow wells have short screens (2-6ft). Figure 43 shows that 1 well is located in the Qal hydrological unit (14261), 5 wells are located in the Qgf unit (22444, 44396, 56891, 221920, 221921), and 3 wells are located on the border between the two units (37254, 43151, 43152). It appears that shallow well 221920 was drilled and completed (≥15gpm yield), but not screened, and that about nine months later (according to the information in the WCDATE field in the attribute table) the deep well (221921) was drilled at or near the same location and screened at 120-245ft (12gpm yield). The deep well may have reached the Kmf unit and obtained a water supply from that unit.
5.1.3 Determine Ground Water Sustainability

The precipitation layer (layer 4) is turned on to assess the recharge potential from precipitation in the vicinity of the site. The site is located in an area that receives an average of about 17 inches of precipitation per year, or an estimate of 1.7 inches of recharge per year (Figure 45). Calculation of actual recharge amounts (a fraction of precipitation) requires professional judgment using standard practices.
The next step is to determine if the shallow aquifer is hydraulically connected or not-connected with a perennial stream. This step is performed to determine the potential for recharge to the aquifer from a nearby stream. First, layer 7 (streams) and layer 8 (ponds) are turned on (Figure 46). The attribute table of layer 7 contains, among others, a field in the attribute table indicating intermittent stream flow (ephemeral stream) or continuous stream flow (perennial stream) (Figure 46). By analyzing hydrogeologic information from the potential aquifer layer (layer 23) and the county’s streams layer as shown in Figure 46 in the context of the conceptual model of the LCC subsystem, it appears that a hydraulic connection between the unconsolidated aquifer and both Little Elk Creek and Capitol Creek exists. This hydraulic connection may be directly with the alluvium (Qal) or indirectly through the Qgf unit.

![Figure 46. Determine the Presence of a Hydraulic Connection between the Aquifer at Site 1 and Nearby Streams Using GIS Layers 7 and 23.](image)

Although little information is available with respect to ground water levels and flow, topography, and location and elevation of streams (layer 32) indicate that the ground water generally discharges to both Little Elk Creek and Capitol Creek (Figure 47). During spring
runoff, Little Elk Creek may become an effluent stream recharging the shallow aquifer in the vicinity of the site. Pumping at the site may reverse local discharge to the stream and the stream may become effluent for most of the year.

Layers 5, 6, 9 are used in conjunction with layer 22 to determine if the shallow aquifer near site 1 is recharged by irrigation practices, which may not sustain a ground water supply if water uses and water-rights ownership change. Figure 48 shows that the site is surrounded by irrigated acreage, although the development of the Little Elk Village subdivision has removed some irrigated acreage to the west of the site. Figure 49 shows the network of ditches in the vicinity of the site. As the irrigated acreage and the ditches in the vicinity of the site are located directly above the unconsolidated sediments, it is expected that irrigation return flow and ditch leakage recharge the underlying aquifer. Note, that the ditch layer includes active and non-active ditches, but the distinction between active and inactive ditches, as well as size of the ditches, cannot be determined using this GIS layer. Note, also, that calculation of actual recharge amounts requires professional judgment using standard practices.

Figure 47. Determine Potential Recharge from Nearby Stream(s) Using GIS Layers 7 and 32.
5.1.4 Determine Ground Water Vulnerability

Natural protection from overlying confining units, such as the Mancos Shale, is important for maintaining natural water quality. However, all ground water in the area with unconsolidated sediments, and bedrock aquifer outcrops or subcrops, is vulnerable to contamination from the land surface. Because the surficial aquifer and the shallow water table near site 1 is unprotected by a natural barrier, the ground water vulnerability in the area is considered high. Calculation of actual risk (both qualitatively and quantitatively) requires professional judgment using standard practices.
Figure 49. Determine Potential Recharge from Leaking Irrigation Ditches in the Vicinity of Site 1 Using GIS Layer 9.
5.2 Example 2 in Lime Creek Area of Upper Capitol Creek Valley

5.2.1 Identify Location on GIS Map

Example 2 is a site located on parcel #264517400001 [at about (Colorado State Plane, Central Zone NAD 83) coordinate 2571035, 1526125], near St Benedicts Monastery (blue marker dot; Figures 39 and 50). The coordinate location can be found near the lower right hand corner of the data frame. Parcel and subdivision details are found by using the Identify function on the menu bar and selecting the County parcels or County subdivisions layer from the layers list at the top of the Identify Results window (layers 13 and 15, respectively; Figure 50). The coordinates of the site can be found near the lower right hand corner of the map while moving the mouse to the location of the site (Figure 50). The streams layer and the roads layer are shown for orientation. The label feature of the subdivision layer and the streams layer are turned on. The site is located in the valley section of the UCC hydrologic subsystem, and the hydrogeologic conceptual model for this area is shown in Figure 11 (unconsolidated materials located on top of Mancos Shale).

Figure 50. Locate Site 2 Using GIS Layers 13 and 15
(layers 7 [streams] and 12 [roads] are used for orientation).

5.2.2 Determine Ground Water Availability

Using the Identify function on the menu bar and selecting the Hydrounits - Potential aquifers layer (layer 23) from the layers list, it is determined that the potential aquifer material is Qal (alluvium), possibly on top of Qgf (Figures 11 and 51). From using the Identify function for the Hydrounits - Top bedrock layer (layer 25), the underlying bedrock unit is determined to be Km (Mancos Shale) (Figure 52). From the discussion of the UCC subsystem in chapter 2, it is concluded that there is no water resource in the bedrock at the site (Figure 11). Thus, there is no alluvium-bedrock aquifer connectivity. This means that the surficial aquifer is not connected to or sustained by an underlying bedrock aquifer and that aquifer sustainability is determined solely by surface processes related to nearby streams, ditches, irrigation, hillslope runoff, and precipitation.

The next step is to determine if the alluvial material is saturated or unsaturated. This determination is made on the basis of information from nearby wells and, because the aquifer is an alluvial unit, the water levels in nearby streams in conjunction with ground elevation at the site.
Layer 19 (drilled wells grouped by depth) is turned on to identify relevant nearby wells (Figure 53). The nearest well that may provide information is well # 580 located 3300ft SSE of the site (Figure 53). This shallow well (50ft deep) is in the alluvium near the boundary between outcropping bedrock and the alluvium. The well may have been drilled to bedrock. In the absence of depth to static water level information, no judgment can be made with respect to pre-development saturated thickness based on this well. The site is about 800ft from Lime Creek, an intermittent stream. Site elevation is about 15ft higher than streambed elevation. Because the stream is not perennial, this information is not sufficient to assess saturated thickness at the site.

In conclusion, there are 2, possibly 3, potential aquifer units near the site: 1) alluvium, 2) gravels, and 3) landslide deposits. It is unknown if these units are saturated, and the saturated thickness can not be determined with the available information. Thus, the availability of a ground water resource is not determined. However, for the discussion in the next section, it is assumed that there is a ground water resource available.
5.2.3 Determine Ground Water Sustainability

The precipitation layer (layer 4) is turned on to assess the recharge potential from precipitation in the vicinity of the site. The site is located in an area that receives an average of about 19 inches of precipitation per year, or an estimate of 1.9 inches of recharge per year (Figure 54). Calculation of actual recharge amounts (a fraction of precipitation) requires professional judgment using standard practices.

The next step is to determine if the aquifer is recharged from a nearby stream. First, a determination is made if the shallow aquifer near the site is hydraulically connected or not-connected with a perennial stream, or a stream that carries water almost continuously. By combining hydrogeologic information from the potential aquifer layer (layer 23) with the county’s streams layer (layer 7), as shown in Figure 51, and checking creek elevations and site elevation (layer 33; Figure 55), it appears that a hydraulic connection exists between the unconsolidated aquifer and Lime Creek. The distance between the site and Capitol Creek is
about 2100ft and the elevation difference is about 150ft. Therefore, although Capitol Creek appears to have a hydraulic connection with the alluvium (Qal) and/or the Qgf unit, the stream only drains the area around site 2, and cannot be a source of recharge.

Although little information is available with respect to ground water levels and flow, the locally rather flat topography, and the location and elevation of nearby streams (layer 33) indicate that the water table at site 2 is shallow, and that ground water generally discharges to both Little Elk Creek and Capitol Creek (Figure 55). During spring runoff, Little Elk Creek may become an effluent stream recharging the shallow aquifer in the vicinity of the site. Pumping at site 2 may reverse local discharge to the stream, and the stream may become effluent and more intermittent.

Layers 5, 6, 9 are used in conjunction with layer 22 to determine if the shallow aquifer near site 2 is recharged by irrigation practices, which may not sustain a ground water supply if water uses and water-rights ownership change. Figure 56 shows an extensive irrigated acreage and a dense network of ditches in the vicinity of the site. As irrigated acreage and the ditches are
situated directly above the unconsolidated sediments, irrigation return flow and ditch leakage recharge the underlying aquifer. Note, that the ditch layer includes active and non-active ditches, but the distinction between active and inactive ditches, as well as size of the ditches, cannot be determined using this GIS layer. Note, also, that the determination of the sustainability of the ground water resources in this area is a quantitative problem that requires professional judgment using standard practices.

5.2.4 Determine Ground Water Vulnerability

Natural protection from overlying confining units, such as the Mancos Shale, is important for maintaining natural water quality. However, all ground water in the area with unconsolidated sediments, and bedrock aquifer outcrops or subcrops, is vulnerable to contamination from the land surface. Because the surficial aquifer and the shallow water table near site 2 is unprotected by a natural barrier, the ground water vulnerability in the area is considered high. Calculation of
actual risk (both qualitatively and quantitatively) requires professional judgment using standard practices.

Figure 56. Determine Potential Recharge from Irrigation Return Flow and Leaking Ditches at Site 2 Using GIS Layers 5, 6 and 9. (Note, layers 5 and 6 have been moved down in the Table of Contents for improved legibility of Figure).
5.3 Example 3 on Ridge Separating Upper Snowmass and Upper Capitol Creek Valleys

5.3.1 Identify Location on GIS Map

Example 3 is a site located on parcel # 26453201001 [at about (Colorado State Plane, Central Zone NAD 83) coordinate 2578150, 1511933], in the Harvey Snowmass Creek Ranch subdivision on the ridge between Snowmass Creek and Hunter Creek (blue marker dot; Figures 39 and 57). Parcel and subdivision details are found by using the Identify function on the menu bar and selecting the County-Parcels or County-Subdivisions layer from the layers list at the top of the Identify Results window (layers 13 and 15, respectively; Figure 57). The coordinates of the site can be found near the lower right hand corner of the map while moving the mouse to the location of the site (Figure 57). The streams layer and the roads layer are shown for orientation. The label feature of the subdivision layer and the streams layer are turned on. The site is located in the western hillslope section of the USC hydrologic subsystem, and the hydrogeologic conceptual model for this area is shown in Figure 7 (gravels on top of Mancos Shale).

Figure 57. Locate Site 3 Using GIS Layers 13 and 15
5.3.2 Determine Ground Water Availability

Using the Identify function on the menu bar and selecting the Hydrounits-Potential aquifers layer (layer 23) from the layers list, it is determined that the potential aquifer material is Qgf (unconsolidated gravels), and is in direct contact with the adjacent Qgf unit (landslide materials; Figures 7 and 58). From using the Identify function for the Hydrounits-Top bedrock layer (layer 25), it follows that the underlying unit is Km (Mancos Shale) (Figure 59). From the discussion of the USC subsystem in chapter 2 it is concluded that there may be a water resource in the Kmf (Fort Hays Limestone) unit near the site (Figure 7). However, the Kmf unit is steeply dipping down to the synclinal axis located to the north of the site, away from the outcrop located 2000ft south of the site. (Figure 59; see also cross-section C-C’ on the Highland Peak Geologic Quadrangle map; Bryant, 1972). According to the Bryant's cross-section, the thickness of the Mancos Shale above the Kmf at site 3 is at least 2000ft. Note, that by turning on the Faults layer (layer 21), the location of the synclinal axis north of the site becomes visible.
From the presence of the thick Mancos shale unit underneath the surficial aquifer materials at the site, and the location of the Mancos Shale outcrops directly west of the site as well as between the site and the Km f outcrop, it is suggested that there is no surficial aquifer-bedrock aquifer connectivity (Figure 7). This means that the surficial aquifer at the site, if saturated, is not connected to or sustained by an underlying bedrock aquifer and that the sustainability of the surficial aquifer as a water supply is determined solely by surface processes.

In the direct vicinity of the site, the Km f and Kdb units are under confined conditions. The relevance of these units as a water resource depends on unit thickness and depth, the thickness of the overlying Mancos shale units, and the recharge mechanism and rate. These units may have some local significance in the direct vicinity of the outcrops south of site 3.

![Figure 59. Determine the Hydrogeological Unit Underlying the Unconsolidated Aquifer at Site 3 Using GIS Layer 25.](image)

The next step is to determine if the alluvial material is saturated or unsaturated. This determination is made on the basis of information from nearby wells and, if applicable, the water levels in nearby streams in conjunction with surface elevation at the site.
To identify relevant nearby wells, layer 19 (drilled wells grouped by depth) is turned on (Figure 60). The wells can be selected using the Select Tool from the Tools Toolbar (Figure 60). To display only the subset of selected wells, use the Selected button next to the Show "All" Records button at the bottom of the attribute table (see insert in Figure 60). The nearest well that may provide information is well # 78772 located about 2500ft east of the site (Figure 60). This well is one of a cluster of shallow wells (<50ft deep) in the QIs located near the boundary with the Snowmass Creek alluvium. Depth to static water level in these wells range from 12 to 17ft; pre-development saturated thickness ranges from at least 20ft to at least 23ft, based on the depth of the wells. However, the elevation at the site is 8610ft, while the surface elevations at the existing wells are at least 550 ft lower (Figure 61). Therefore, these wells can not be used to determine hydrologic conditions at the site. Using a similar analysis, it is concluded that Snowmass Creek with an elevation near the site of about 8040ft, and the confluence of Johnny Draw and Hunter Creek near the site at an elevation of about 8480ft cannot be used to determine hydrologic conditions at the site (Figure 61).
In conclusion, there is a potential shallow aquifer in the Quarternary gravels. It is unknown if this unit is saturated at the site, and the potential saturated thickness has not been determined. Thus, the availability of a ground water resource is not determined. However, for the discussion in the next section, it is assumed that there is a ground water resource available.

5.3.3 Determine Ground Water Sustainability

The precipitation layer is turned on (layer 4) to assess the recharge potential from precipitation in the vicinity of the site. The site is located in an area that receives an average of about 21 inches of precipitation per year, or an estimate of 2.1 inches of recharge per year (Figure 62). Calculation of actual recharge amounts (a fraction of precipitation) requires professional judgment using standard practices.

The next step is to determine if the aquifer may be recharged from a nearby stream. First, a determination is made if the shallow aquifer near the site is hydraulically connected or not-
connected with a perennial, or a stream that carries water almost continuously. By analyzing hydrogeologic information from the potential aquifer layer (layer 23) and the county’s streams layer (layer 7) as shown in Figure 58, and checking creek elevations and site elevation (layers 33 and 34; Figure 61), it is concluded that the lower lying Snowmass Creek, Hunter Creek, and Johnny Draw can only drain the area around site 3 and cannot be a source of recharge to the surrounding alluvial units.

![Figure 62. Determine Recharge from Precipitation at Site 3 Using GIS Layer 4](image)

Although little information is available with respect to ground water levels and flow, topography and location and elevation of streams (layers 33 and 34; Figure 61) indicate that ground water generally discharges to the surrounding streams. Pumping at site 3 will have minimum influence on stream flows.

Layers 5, 6, 9 are used in conjunction with layer 22 to determine if the shallow aquifer near site 3 is recharged by irrigation practices, which may not sustain a ground water supply if water uses and water-rights ownership change. Figure 63 shows an extensive irrigated acreage
supplied by an irrigation ditch in the vicinity of the site. The ditch brings water from the streams located west of the site to the irrigated area on the flat ridge top near the site. As irrigated acreage and the ditches are situated directly above the unconsolidated sediments, irrigation return flow and ditch leakage recharge the underlying aquifer. Note, that the ditch layer includes active and non-active ditches, but the distinction between active and inactive ditches, as well as size of the ditches, cannot be determined within this GIS layer.

In conclusion, if a ground water resource exists at site 3, it is only locally recharged by precipitation (rain and snow melt), irrigation return flow, and leaking ditches. Determination of the sustainability of a potential ground water resource in this area is a quantitative problem that requires professional judgment using standard practices.

Figure 63. Determine Potential Recharge from Irrigation Return Flow and Leaking Ditches at Site 3 Using GIS Layers 5, 6 and 9. (Note, layers 5 and 6 have been moved down in the Table of Contents for improved legibility of Figure).
5.3.4 Determine Ground Water Vulnerability

Natural protection from overlying confining units, such as the Mancos Shale, is important for maintaining natural water quality. However, all ground water in the area with unconsolidated sediments, and bedrock aquifer outcrops or subcrops is vulnerable to contamination from the surface. Because the presence of the unprotected surficial aquifer materials near site 3, the vulnerability of a ground water resource in this area is considered high. Calculation of actual risk (both qualitatively and quantitatively) requires professional judgment using standard practices.
6.0 Conclusions and Recommendations

6.1 Conclusions

Under an agreement with Pitkin County, Hydrologic Systems Analysis, LLC (HSA) of Golden, Colorado, in cooperation with Heath Hydrology, Inc. (HHI) of Boulder, Colorado, created a GIS-based, step-wise, ground water resources evaluation procedure for use as decision/land use management tools by Pitkin County. The procedure, supported by a GIS map and supporting databases, guides the site-specific analysis with respect to: 1) ground water resources availability in terms of sufficient quantities for the purpose of its usage, and economical exploitability (e.g., at reasonable depth and with sufficient permeability); 2) long-term sustainability of the utilization of the resources for water supply (i.e., presence of long term continuous recharge mechanisms, and absence of excessive water table fluctuations, for example, due to spring runoff, upland flood irrigation, and drought); and 3) the vulnerability of the resources to contamination. In addition, the GIS map provides information with respect to wells for which augmentation is required, and shows well applications approved (i.e., permitted wells, drilled or not drilled) or denied, and wells actually drilled. Note, that availability and sustainability should be judged in relation to yield requirements, presence of other resource usages, ecological requirements, water right issues, and physical constraints, such as limitations on drawdown.

Key elements in this project are the adaptation of the step-wise ground water resources evaluation procedure developed in a previous HSA/HHI study for Pitkin County, as well as the hydrologic systems analysis and the formulation of conceptual models for the study area. The GIS map and supporting databases focus the non-public lands area of the Capitol Creek, Snowmass Creek, and East Sopris Creek watersheds. The incorporated databases include delineated hydrogeological units created by HSA/HHI by combining published hydrogeologic information with the results of the hydrologic systems analysis, as well as databases from Pitkin County, the Colorado Division of Water Resources/Colorado Water Conservation Board, and the Natural Resources Conservation Survey (USDA).

Based on field work and hydrologic systems analysis, five general conceptual models are identified within the regional scale context of the CSC area: 1) Upper Snowmass Creek (USC) Subsystem near the White River National Forest boundary; 2) Lower Snowmass Creek (Watson Divide area) (LSC) Subsystem; 3) Upper Capitol Creek (UCC) Subsystem; 4) Lower Capitol Creek (LCC) Subsystem; and 5) Ft. Hays/Dakota-Burro Canyon Bedrock (FDB) Subsystem. Each of the five subsystems has a unique set of natural system parameters defining recharge and discharge, ground water levels and fluctuations, ground water flow velocities and direction, and ground water storage. In addition, each of these subsystems have important anthropogenic hydrologic system parameters, including ground water recharge from irrigation and irrigation ditches, and ground water discharge from wells. If water rights and allocations should change for these ditches, the hydrodynamics of the Quaternary glacial and alluvial aquifers would change, and water supplies from ground water may decline or vanish.

Three case history examples are presented to illustrate the analysis procedure, using the GIS map and databases provided with this report. Site 1 is located in the lower Capitol Creek
valley; site 2 is located in the Lime Creek area, and site 3 is located on the ridge between Upper Snowmass Creek and Upper Capitol Creek near Hunter Creek. The examples show the existing uncertainties in evaluating local ground water resources due to data limitations, and illustrate the variability of drinking water supplies, both in availability and sustainability, dependent on the local hydrogeology and hydrological system. All three sites are vulnerable to ground water pollution. The examples demonstrate the utility and advantages of the GIS-based analysis procedure and its advantages over simple, one-layer paper maps showing, for example, some general ground water characteristics, and demonstrate the need for site-specific hydrogeologic investigation to obtain quantitative resource management answers and well design parameters.

6.2 Discussion

Pitkin County has six regions that contain parcels of potentially developable land: 1) Upper Roaring Fork Drainage; 2) Town of Aspen; 3) Middle Roaring Fork Drainage; 4) Castle, Maroon, and Woody Creeks, and Frying Pan River; 5) Snowmass and Capitol Creek Drainage; and 6) Crystal River Drainage. Three levels of information are required in order to fully understand the ground water-derived drinking water availability, sustainability, and vulnerability in these areas: 1) Hydrologic Systems Analysis (HSA); 2) Database and GIS development; and 3) Acquisition of site-specific hydrologic parameters. The hydrogeologic information processing and analysis begins at the conceptual level integrating regional, subregional, and local information, followed by database development and GIS evaluation. Finally, hydrologic parameters are needed at each specific site based on due diligence.

Examples of Hydrologic Systems Analysis are found in chapter 2 of this report, as well as in the MRF and URF reports by Kolm and van der Heijde (2006), Kolm and Gillson (2002) and Kolm and others (1998). The ultimate goal of this analysis is a conceptual model describing how the hydrogeologic framework and hydrologic system functions. Such a conceptual model forms the basis for the preparation of hydrogeological and hydrological GIS layers. Database development and GIS Evaluation are described in this report.

Hydrologic parameters, including quantitative measures of aquifer thickness, water table levels (depth to water table), hydraulic conductivity, recharge amounts and ground-water flow paths, are the result of in-depth site analysis and testing. The goal of the third aspect of this analysis is site-specific drinking water well yields and water quality, and the impact of the drinking water well on surrounding wells and ecosystems. The existing data could be analyzed for specific sites and generalized to hydrogeologic regions. However, each new site will need due diligence by the land owner, and the results of their studies can be integrated into the existing data and each hydrogeologic region can be updated continuously.

6.3 Recommendations

The Upper Roaring Fork Drainage area has a complete HSA, but lacks the delineation and digitalization of hydrogeologic units. The hydrogeologic data layers could be improved upon by separating the potential unconsolidated aquifers from the bedrock aquifer. The hydrologic
parameters for the State Route 82 corridor would need to be evaluated as these were not assessed as part of the North Star study. The priority for this work is low compared with the assessment needs of other areas.

The Town of Aspen area has no formal HSA completed, and the region is complex due to urbanization, shallow aquifers of various types (moraines, outwash plains, alluvium), and a complex, faulted bedrock system (Leadville Limestone). Some of the GIS database development is completed, but additional data layers and evaluation are needed – particularly with respect to the hydrogeologic database. The hydrologic parameters for the Town of Aspen area would need to be evaluated as these were not assessed as part of any of the previous studies. The priority for this work is high compared with the assessment needs of other areas.

The Middle Roaring Fork Drainage area has a complete HSA, and most of the GIS database development and evaluation is completed. The hydrologic parameters for the Middle Roaring Fork Drainage area would need to be evaluated as these were not assessed in-depth as part of the current study. The priority for this work is low compared with the assessment needs of other areas.

The Castle, Maroon, Woody Creeks, and Frying Pan River areas have no formal HSA completed, and the region is complex due to some urbanization, shallow aquifers of various types (moraines, outwash plains, alluvium), and a complex, faulted bedrock system (including the Leadville Limestone and the Dakota Fm., and Tertiary intrusive rocks). Some of the GIS database development is completed, but additional data layers and evaluation are needed – particularly with respect to the hydrogeologic database. The hydrologic parameters for the Castle, Maroon, Woody Creeks, and Frying Pan River areas would need to be evaluated as these were not assessed as part of any of the previous studies. The priority for this work is moderate (Castle and Maroon Creek, and Frying Pan River areas) and high (Woody Creek area) compared with the assessment needs of other areas.

The Snowmass and Capitol Creek areas has a complete HSA, and most of the GIS database development and evaluation is completed. The region is complex due to the presence of shallow aquifers of various types (moraines, landslide deposits, outwash plains, alluvium), and a complex, faulted bedrock system. The hydrologic parameters for the Snowmass and Capitol Creek areas would need to be evaluated as these were not assessed in-depth as part of the present study. The priority for this work is low compared with the assessment needs of other areas.

The Crystal River area has no formal HSA completed, and the region is complex due to some urbanization, shallow aquifers of various types (moraines, outwash plains, alluvium), and a complex, faulted bedrock system (possibly including the Leadville Limestone, the Dakota Fm., and Tertiary intrusive rocks). Some of the GIS database development is completed, but additional data layers and evaluation are needed – particularly with respect to the hydrogeologic database. The hydrologic parameters for the Crystal River area would need to be evaluated as these were not assessed as part of any of the previous studies. The priority for this work is high compared with the assessment needs of other areas.
In all of these areas, the completion of HSA and GIS database and evaluation should be concurrent and of higher priority before the hydrologic parameters analysis being undertaken. The higher priority areas are based on the rate at which urbanization is occurring and corresponding demand for permits.

The GIS-based ground water resources assessment procedure can be enhanced by unifying the existing and future ground water GIS maps, and the development of custom tools in ArcToolbox. These tools will facilitate consistent and complete execution of the assessment procedure and eliminate the extensive use of the information toolbar.
7.0 References


