The Proposed Dry Wash Reservoir:
Size and Shape

Prepared by Wayne D Pennington
for the Ivins City Council meeting of March 21, 2021

This report is intended to provide the Ivins City Council and others with information that will assist them in making decisions regarding the proposed Dry Wash reservoir. I have tried to make it entirely fact-based, and will only introduce my own opinions where appropriate, and explicitly or [parenthetically] identify them as such.

Executive Summary:

A reservoir proposed for Dry Wash has undergone studies by geotechnical engineers and environmental specialists, proposed as the third phase (after Graveyard Wash) of the St George Water Reuse Project. In 2004, they specified that a reservoir at Dry Wash should not exceed 3,040 ft for safety concerns; any larger reservoir would need to be created by a dam further upstream, which was not included in the Environmental Assessment.

In 2021, the Washington County Water Conservation District (WCWCD) agreed to a reservoir of 1000-1200 acre-ft (smaller than the 1335 acre-ft specified by the EA), but the Ivins City Council approved consideration of a larger reservoir. The WCWCD then proposed a 1500 acre-ft reservoir with 3,044 ft high-water level, violating safety concerns expressed by earlier studies due to incompetent rock (soil) at that elevation at the dam site. [I believe that the proposal by the WCWCD likewise violates the conditions of the geotechnical and environmental studies.]

The maximum capacity for a reservoir with a dam at the proposed location and a high-water level of 3,040 ft is 1335 acre-ft (excavation could increase the capacity). But a reservoir with these characteristics would still create problems due to a broad, shallow area on the western flank, creating a mudflat when the reservoir is low, and allowing wind to pick up dust and other materials, carrying it to populated areas. Mitigation of this problem will require adjustments of dike location, high-water level, and excavation and relocation of the excavated material in strategic locations.

There may be many ways to resolve these issues; one approach, which will allow a trail with open space, is presented in this document. That reservoir model would have a capacity of about 1000 acre-ft (after excavation), which is a size that had in 2021 been stated as acceptable by the WCWCD, and would permit the needed access/egress of westernmost Ivins through the future Anasazi roundabout.

I. Council Decisions to Make and Issues to Address

In my opinion, the Ivins City Council will need to decide:

- Whether or not to support a reservoir at this site.
    - If a reservoir is not supported by the Council, then
        - How to address legal issues; and
        - How to participate with the WCWCD in meeting their needs.
    - If a reservoir is supported by the Council, then
        - What size reservoir is to be allowed;
        - Other constraints on reservoir appearance, maintenance, and so on,
        - Any additional research or fact-gathering that may be needed prior to construction; and
        - How to fit the reservoir into the City's master plans, etc.

The remaining sections of this report will concentrate on the technical issues relating to the **size and shape** of the reservoir under different configurations that have been proposed. Other people are likely to address the additional issues (residents' health, structural appearance, obligations of the city, etc.) in the near future.

II. A History of the Dry Wash Reservoir Proposal Relating to Size

2000 – The Federal Settlement:
As part of a settlement between the US Government, the City of St George, the WCWCD, several other entities and the Shivwits Band, 2000 acre-ft/yr of reuse water was promised to the Band (formalized in Public Law 106-263, on August 18, 2000). The St. George Water Reuse Project Agreement was created and funded, to include a pipeline from the wastewater treatment facility in Bloomington to the Shivwits reservation. This pipeline, now in place, follows Old Hwy 91 for much of its length, and two reservoirs, Graveyard Wash and Dry Wash, were proposed along the pipeline to provide storage for water produced by the Bloomington facility, to be released for irrigation purposes when needed. Note that the Shivwits Band need not take delivery of all the water at the reservation site, but may sell it to others whether or not it reaches the reservation first.

2004 – Studies Conducted:
Following up on that Agreement, a Geotechnical Feasibility Study (Geotech Study) was conducted at each proposed reservoir site, and a single Environmental Assessment (EA) was produced for the two sites, relying heavily on the two Geotech Studies. All three reports were completed in 2004.

The EA specified that the project take place in three stages in the following order:

(1) Upgrade the treatment facility and build the pipeline;
(2) Build Graveyard Wash;
and finally, if needed,
(3) Build Dry Wash.

The following map shows the Dry Wash area, with various high-water levels and some other features displayed.

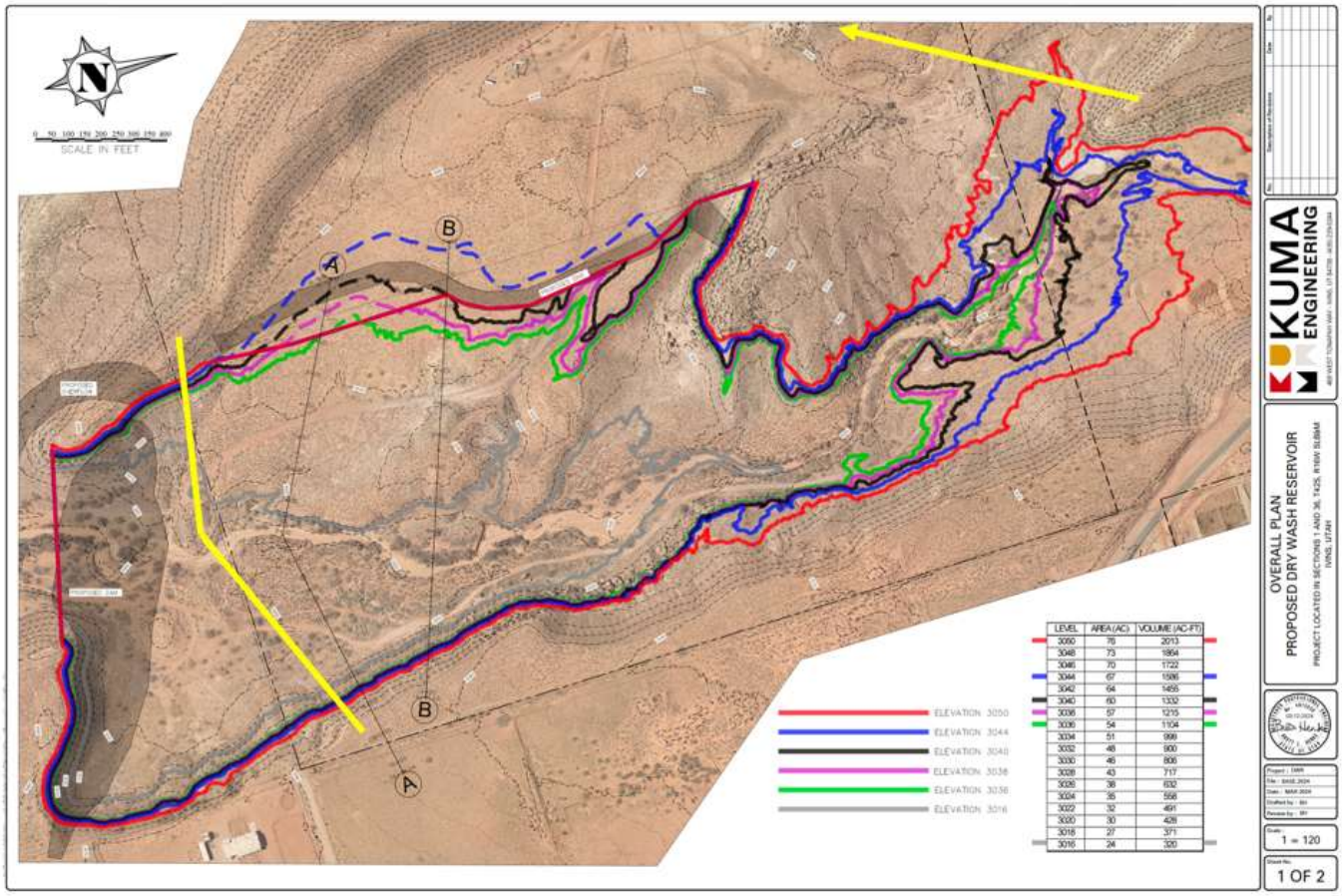

Figure 1: Map of the Dry Wash area. The various colored contours indicate various high-water levels (3036-3044), and the conservation or low-water level (3016). The 3050 ft contour shows the top-of-dam (flood level) proposed by the WCWCD. The dam is presumed at the location of the straight line to the south (left) and a dike is presumed where a straight line is seen along the western (top) edge of the reservoir. Shaded areas show locations of the dam, dike, and spillway as suggested by a sketch recently made available by the WCWCD. The yellow lines show locations of an alternate dam and dike siting reviewed by the Geotech Study but not accepted by the EA. Discussions of these features appear in the text below. (If viewed on a computer, zooming in may be useful.[1])

<u>Geotech Study Limits High-Water Level to 3,040 ft (above sea level):</u>

The Geotech Study clearly identified 3,040 ft elevation (black line in Figure1) as the maximum height for a reservoir with a dam at this Dry Wash location, saying (p.17) "it is our opinion that the **high water level should not extend above elevation 3040 feet**." It also states (p. iv) "Efficient storage with a dam at this location is **limited to about 1300 acre feet due to the competent bedrock elevation**." In Chapter 5 (p.21), the Geotech Study emphasizes: "it is our opinion that the high water level **should not extend above elevation 3040 feet**. **This results in a maximum storage capacity of about 1300 acre feet**..." This conclusion is based on the poor quality of rock (soil) above 3,040 ft in the formations

comprising the right (western) abutment, and particularly in borehole DH 03-4, which had presumably been precisely surveyed in, following standard practice.

EA also Limits High-Water Level to 3,040 ft:
The EA also specified **a high-water level of 3,040 ft**. Additionally, the EA calculated a **capacity of 1335 acre-ft** of water, and an inundated **surface area of 63 acres** (p. 11 Appendix C). These values are all internally consistent, and verified to be consistent by modern mapping methods (see the table inserted in Figure 1 for confirmation).

Geotech Study Considered Alternate Dam Locations; EA Rejects Them:
The 2004 Geotech Study considered a number of locations for the dam site. The only location that would yield a capacity greater than 1335 acre-ft is further upstream, together with a large dike, as shown by the yellow lines in Figure 1. This configuration was implicitly rejected by the EA, which considered and specified a dam at the location shown by shading in Figure 1. [Any claims that the EA or other environmental studies allowed a larger reservoir are apparently conflating the studies done for alternate, upstream, dam locations with the one that was finally accepted by the EA.]

2021 – WCWCD Actions Begin:
In early 2021, the WCWCD approached SITLA for purchase of land to establish the reservoir, and negotiated with Terry Marten for additional property, arguing in favor of a reservoir containing 2000 acre-ft of water (rather than the 1335 acre-ft reservoir specified by the EA), but agreeing to move forward with a proposal for a reservoir with **1200 acre-ft** capacity. The WCWCD Board minutes for the meeting on November 17, 2021 state:

> ***Consider resolution approving and commencing Dry Wash Reservoir as a district project –*** Zach told the board he has been working with the City of Ivins and been talking to Terry Martin [sic], one of the major landowners. They are bringing this resolution to the board to update them on what has been done and to proceed with this project if the board wants to move forward. SITLA has some of the property needed for the project on hold for the district right now but would like an answer from the district as soon as possible.
>
> …
>
> In the original environmental documents, it showed a larger reservoir than this but they have shrunk it down from 2000 a.f.[acre-ft] capacity to 1200 a.f. to accommodate the property owners. [Note: I could find no justification in the EA for their stated 2000 acre-ft negotiating position. This seems to be a reference to a design with the dam further upstream, not considered by the EA.]
>
> …
>
> The resolution tonight is just to allow the district to move forward.
> ***Ken Neilson moved to approve resolution approving and commencing Dry Wash Reservoir as a district project.*** [The motion passed unanimously.]

2021 – Ivins City Council Actions:
The subject was brought to the Ivins City Council the following day, November 18, 2021. The discussion was long, and is well documented on the City website. Some relevant passages in the meeting minutes include:

> Zach Renstrom clarified that Terry Marten does not want a reservoir there at all. Terry Marten wanted nothing and the District wanted 2000-acre feet and they settled on 1000-acre feet.
>
> ...
>
> Mayor Hart commented that with the outstanding issues of the cost of the land a water conservation acre feet [sic], there needs to be another sit down but this needs to move forward with the final parts of a willing seller situation and then work out the price through the appraisals.

The City Council met again, after negotiations between the District and Terry Marten, on December 2, 2021, and passed the following resolution (noting that the language concerning condemnation was procedural, and not hostile):

> **Resolution No. 2021-17R,** a Resolution of Ivins City, Utah, requesting that the Washington County Water Conservancy District acquire by condemnation all land necessary to construct the negotiated sized Dry Wash reservoir that would hold approximately **1900 acre feet of water**. [Passed unanimously.]

Recollections of the negotiations in the intervening two weeks vary, but the facts remain: the Geotech Survey and the EA clearly specify that the reservoir high-water level would be 3,040 ft above sea level, and that the capacity would be 1335 acre-ft. An agreement for a reservoir that would be 1000 –1200 acre-ft had been made. [Why that agreement appears to have changed between the two Council meetings is not clear to outside observers.]

2023-2024 – WCWCD assumes 3,044 ft high-water level
Following the 2021 Ivins City Council approval to begin work toward a larger reservoir, the WCWCD ultimately converged on a design that used a 3,044 ft high-water level, and that would hold 1500 acre-ft, while inundating 67(?) acres, after accounting for a dike that cut off an additional 5 acres. The WCWCD has justified this design, most recently at the February 21 Talkabout, by claiming that the 2004 study used poor-quality 20-ft contour-interval topographic maps [but the boreholes would have been surveyed in precisely, and higher-quality maps had indeed been used by a 1997 study and the Geotech Study in 2004], and that the inundated surface area should be the controlling factor, from which the high-water level should be computed [but the Geotech Study clearly stated that the capacity, and by extension the surface area, was computed based on the upper limit to the high-water level, which in turn had been controlled by rock quality].

2024 – Moving Forward
[In the following discussion, I will assume that the EA-specified high-water level of 3,040 ft, with capacity of 1335 acre-ft, is the maximum that is allowable, or indeed, safely

accomplished, at this location. The WCWCD proposals that are based on greater high-water levels are neither consistent with the EA nor, in my opinion, safe engineering standards. I should note here that additional information may eventually become available: the WCWCD has spent nearly $1 million for studies including borehole and other testing, but those results have not yet been made available (ref. WCWCD Board January 4, 2023).]

In earlier reports, I suggested a high-level elevation of 3,038 ft in order to provide a bit more freeboard avoiding the poor-quality abutment above 3,040 ft, but mostly in order to minimize the surface area exposed to alternate submergence and subaerial exposure. While I still consider the 3,038 ft high-water level to be the maximum level that is safe, I would like to investigate other, lower, elevations as well.

[In this exercise, I seek to encourage design of a shape and size of reservoir that will minimize the potential hazards to the people of Ivins while maximizing the benefit of the reservoir to the citizenry and to the water supplies of Washington County. Others may feel that there is no place for a reuse reservoir in the neighborhoods of Ivins, while others may feel that the largest possible reservoir should be implemented, regardless of neighbors' property rights or quality of life; those issues will be left for others to discuss.]

Because much discussion has recently been focused on the size of the area beneath the reservoir that will be alternately submerged and exposed, the next section deals directly with the issue of subaerial exposure of inundated lakebed.

III. Areas of Submergence and Subaerial Exposure

The area that results in subaerial exposure is simply the difference between the surface area of the reservoir at high-water level and the surface area at low-water level. The low-water level is presumed here to be 3,016 ft, as specified by the EA, which covers a surface area of 24 acres. The table[1] contained in Figure 1 displays the appropriate values.

For the WCWCD-proposed high-water level reservoir at 3,044 ft, the area exposed to drying out is 43 acres. [The difference between this value and my earlier figure of 47 acres is the area excluded by the presence of the dike in the current assumption.] The area exposed at low-water level by a reservoir with 3,040 ft high-water level covers a surface area of 36 acres; incrementally lower high-water levels progressively decrease the size of the exposed area. We should note that the WCWCD is planning to excavate some of the basin (reservoir bottom) to help increase capacity and to provide material for construction of the dam and dike; if additional material can be excavated and strategically placed along the shoreline, capacity can be increased while decreasing the surface area, a desirable consequence from all points of view, and one that the WCWCD has expressed interest in.

The problem of subaerial exposure is concentrated on the western side of the reservoir, as can be seen in Figure 1 and in the cross-sections shown in Figure 2.

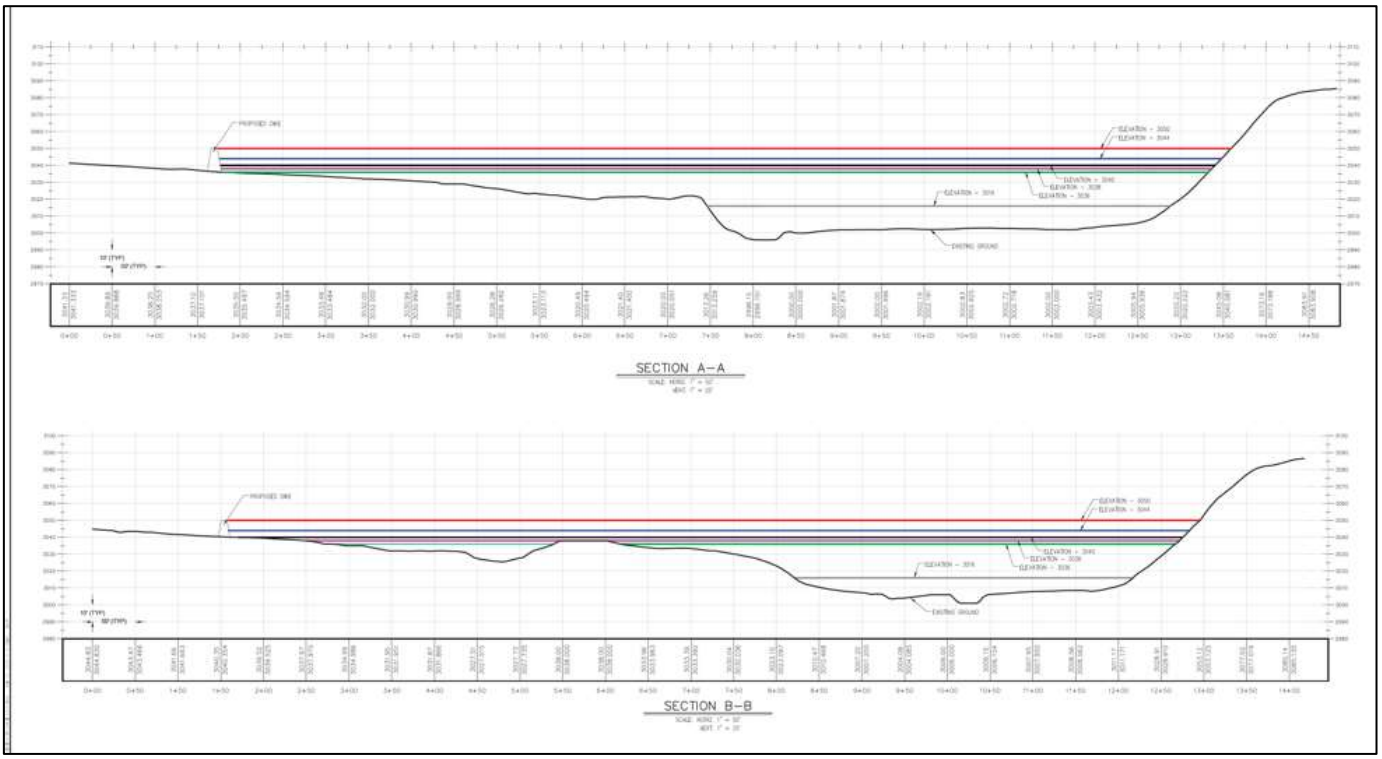

Figure 2: Two cross-sections A-A and B-B identified on the map in Figure 1 by faint lines crossing the reservoir. Note the broad, shallow western flank of the reservoir, and the modest reduction in area submerged as high-water level is decreased. Vertical exaggeration is 2:1.

The problem with alternately submerging and exposing reservoir lakebed is that dried-out sand, dust, and other materials that lie on that lakebed may be picked up by strong winds and carried to nearby residences or businesses. While I have previously described the problem in terms of surface area, with the recent availability of these high-quality maps, we can further clarify the issue here, making use of Figure 3, below.

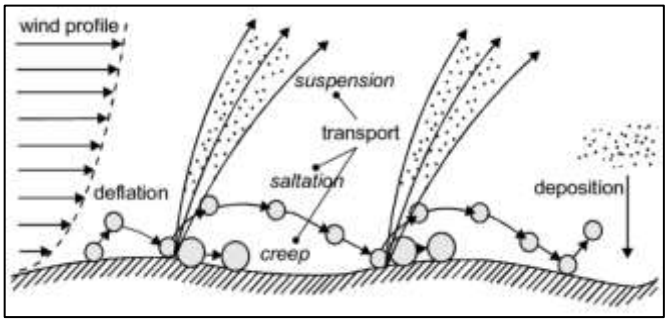

Figure 3: Cartoon demonstrating "saltation" and production of airborne particles. Each time a sand grain lands, more sand is ejected and finer products become airborne. The longer the distance over which this can operate, the more particles become airbone. (https://www.researchgate.net/figure/Schematic-representation-of-the-main-phases-involved-in-the-wind-erosion-process_fig1_226336093)

When wind passes over a barren sandy surface, as the lakebed will be after one or more cycles, with all vegetation destroyed, it can pick up particles. Smaller, lighter particles are easiest to pick up and carry long distances. Sand can be picked up, but may not be carried very far before it lands (crashes) back down on the dried surface. When the sand lands, it

dislodges more particles -- sand, dust, etc -- each of which will also be picked up by the wind and carried some distance. Each "jump" of a sand particle may result in the dislodging of multiple new sand particles when it lands. One sand particle dislodges, say, four sand particles (in addition to the silt and dust which become airborne), and these in turn dislodge 16, and these then dislodge 64, and so on. There is a scientific name for this process – saltation. Saltation is greatest when the downwind length, or "fetch," of the exposed surface is longest. That is, if an exposed area is long and narrow, but the wind is in the "short" direction, not much sand, silt, dust, etc, will become airborne; but if the wind is blowing in the "long" direction, it will eventually pick up a lot of material and carry it along.

What this means is that the smaller alternately exposed areas near the upstream end of the reservoir will not result in much airborne dust, due to the their shorter lengths and enclosure by steeper walls. But the broad, shallow flank on the western side of the reservoir will, for nearly any wind direction, present a hazard due to windborne particles if the fetch is long enough. One of our objectives in reservoir design should be to minimize the fetch, the distance along which wind can produce saltation and pick up material.

IV. Recommended Solution(s)

This reduction in alternately exposed and submerged areas, or length of fetch, can be accomplished in a few ways, but the most beneficial for Dry Wash would be to move the dike further toward the center of the reservoir, while reducing the high-water level to some lower level, in the meantime excavating the material from the western floor of the reservoir and placing it landward of the dike. [This was the basis for my earlier proposal for a high-water level of 3,038 ft, leading to a capacity of 1215 acre-ft before excavation; this would help, but not completely mitigate the issue.]

The placement of the excavated material can be arranged to maximize some benefit, such as raising the level of residential lots behind the dike so that they are less likely to be subject to ill effects from rising water tables caused by the reservoir. Some could be placed immediately behind the dike to allow for a continuous trail along the waterfront. Some could be placed between the dam and Old Hwy 91 to create a berm that would hide the dam itself from view. Some could be used to establish barriers (or levees) that would break up the fetch across the exposed area.

A recent proposal provided by Terry Marten, is presented here. Figure 4 shows a closeup of the dam area itself, and Figure 5 shows a larger overview of the reservoir area.

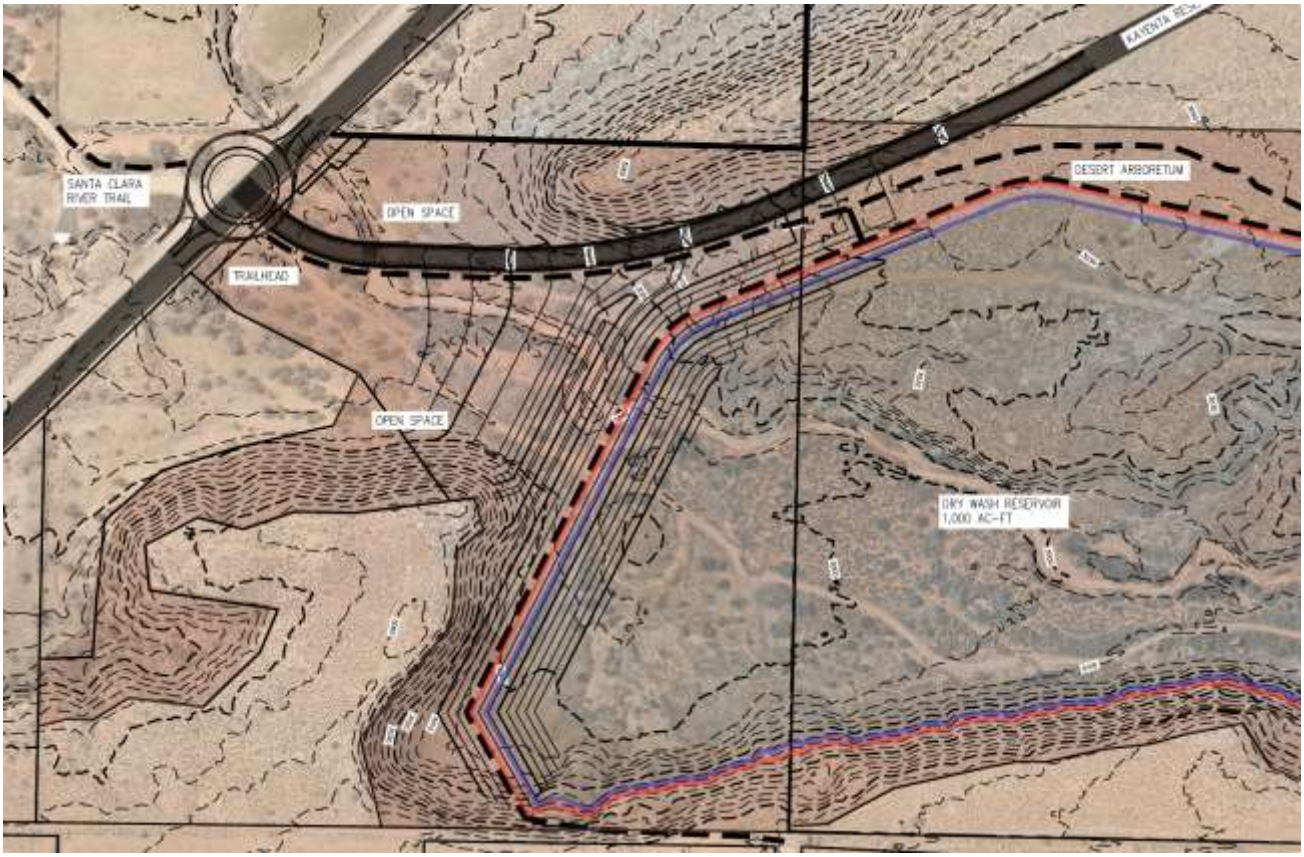

Figure 4: Closeup of dam area in new proposal. The dam and dike have been merged together, allowing a space between the dam and the western ridge for a road. This road would provide access between westernmost Ivins and the future Anasazi roundabout, as the Ivins Master Transportation Plan has long anticipated. The spillway (flood control) would be placed in the dam structure. The reservoir would have a capacity of 1000 acre-ft after excavating about 200-300 acre-ft of material.

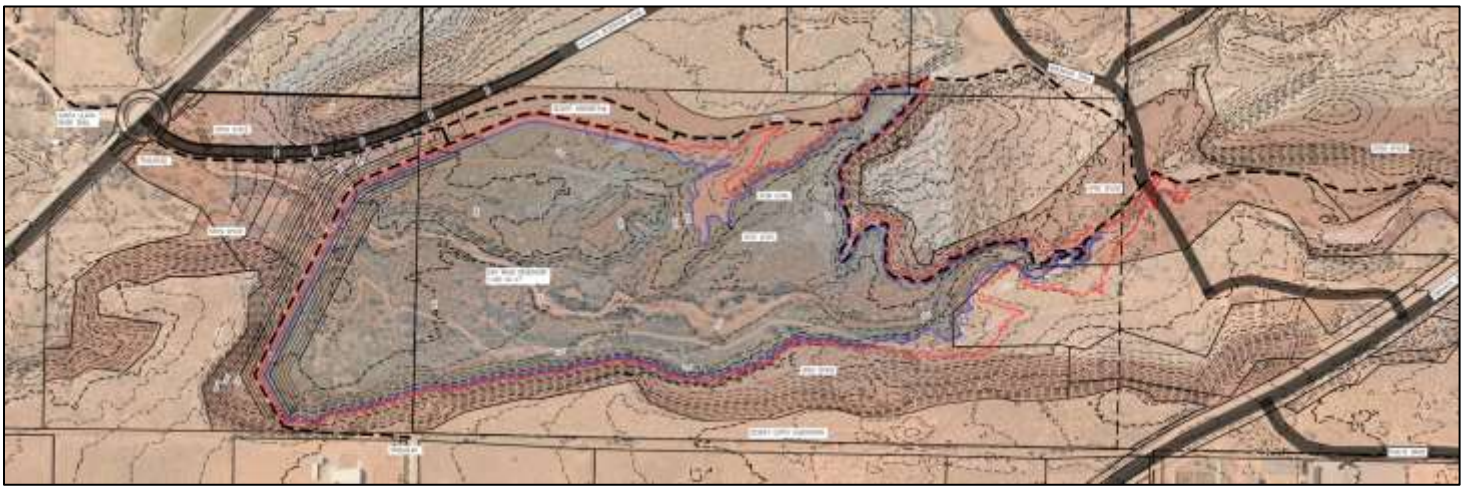

Figure 5: New proposal for the reservoir showing proposed open-space with trail system. The trail system (dashed black line) and open-space (darker brown shading) can be accessed from Kwavasa Drive, Old Hwy 91, and Center Street, making it readily available to all Ivins residents. The fetch within the exposed western slope is significantly reduced, and could be further minimized by establishing man-made levees that would break up the area into smaller sub-basins.

There are a number of benefits to neighboring communities, and some are listed here.

- The decreased high-water level and the greater distance between the reservoir and low-lying land to the west (top in the figures) greatly reduces, and perhaps eliminates, the risk to those homesites of ground-water encroachment. Likewise, the reduced high-water level reduces the additional hazard due to landslide potential for the lots on the ridge to the east (bottom in the figures).
- The threat of windblown dust carrying material that has precipitated from the reuse water is minimized by shortening the distance along which wind may pick up material. Careful engineering and landscape design would be instrumental in accomplishing this.
- The establishment of an open space with trail system is something that Ivins City and Kayenta Development have long wanted; this proposal provides both. An interested entity might establish a "desert-riparian arboretum" along the western shoreline. As noted in the figure caption, access to the trail system could be provided at Center Street, Old Hwy 91, and Kwavasa Drive, making it perhaps the most accessible foot-trail system in the area.

In November 2021, the WCWCD had deemed a reservoir of 1000 to 1200 acre-ft to be acceptable. This reservoir model fits that requirement (after excavation).

Cost issues will naturally need to be addressed, and are beyond the scope of this report. But the dam and dike would be smaller than in the current WCWCD plan, and significant cost savings would result from that reduction in volume. There may be a local market for the excavated material. In any case, I strongly recommend that the WCWCD and Ivins community work together (while Graveyard Wash is being constructed) to find a solution that meets the needs of water delivery, retaining attractive open space, and reducing or eliminating risk to local population.

V. Terminology and conversion factors:

Dam: The structure built at the **downstream end** of the valley or wash that would be the normal outlet for a stream or river.

Dike: The structure built along the **flanks** of a valley or wash to prevent water from flowing beyond it as the reservoir is filled.

Acre-ft: 326,000 gallons (one acre filled to one foot depth); a golf course uses about 400 acre-ft/yr, and a soccer field about 30 acre-ft/yr (with large variations)

Acre: 43,560 sq ft (equal to a square plot of land 209 ft on a side; roughly 1.3 football fields)

Footnote:

[1] It has been pointed out that the table in Figure 1 may not be legible, and is now printed here (added 25 March, 2024):

LEVEL	AREA (AC)	VOLUME (AC-FT)
3050	76	2013
3048	73	1864
3046	70	1722
3044	67	1586
3042	64	1455
3040	60	1332
3038	57	1215
3036	54	1104
3034	51	999
3032	48	900
3030	46	806
3028	43	717
3026	38	632
3024	35	558
3022	32	491
3020	30	428
3018	27	371
3016	24	320