RIO RUIDOSO ASSESSMENT

JULY 30, 2010

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Introduction

Assessment

Stream Dynamics Inc. was requested to perform a watershed assessment on the Rio Ruidoso and four tributaries. An assessment was performed in late spring and summer 2010 and presented to the Rio Ruidoso Restoration Committee on July 30, 2010. Each creek was assessed for its ecological condition, recreation potential, and urbanized features.

The assessment was performed as follows. An aerial overflight was performed and photos taken at GPS points to create a GIS map of aerial watershed photos. Each point on the GIS map has a hyperlink to a photo at that location. Each committee member was interviewed and a ground survey taken at selected areas of their interest. Each reach of creek was ground assessed by GPS and over a thousand ground photos taken at GPS points in the watershed. In addition, Stream Dynamics reviewed the relevant information on the existing environmental conditions on the Rio Ruidoso and its tributaries.

An assessment report was written on the conditions of each reach within the watershed and major concerns noted for each reach. A list of proposed projects was prepared for the committee as well as a list of proposed selection criteria for these projects. Stream Dynamics will rank all river improvement projects according to the approved criteria and report to the committee with cost estimates within one month of approval of the criteria.

Overview of Rio Ruidoso Impairments

The assessment of the Rio Ruidoso and its tributaries found seven major resource impairments in the watershed that affect river function and health. These impairments were found at many locations during the assessment and will be explained in detail here.

1) Entrenchment of Channel and loss of floodplain
Floodplains play an important role in river health and stability. Floodwaters flow onto the floodplain, where they are slowed by willows and other vegetation and soak into the ground, feeding the stream flow after the flood. In normal flow, water enters floodplains at the top of the meander bend and flows through the sediment, taking about a week to exit on the downstream end. This water plays a very important role in keeping perennial creeks and rivers flowing year-round.

Floodplains also support important vegetation, such as willows, cottonwoods and riparian grasses, and are the most productive areas on the landscape due to the water availability and good soil. Many historic and recent channel modifications happened because agricultural fields or houses were built in the floodplain on the bank of the river or creek. To keep the field or house out of the floodwaters, fill was placed on floodplain and it ceased to function as a floodplain.

Gavilan Canyon Creek is entrenched for much of its length

Once a creek or river is confined and its floodplain filled, floods can no longer spread across the floodplain, instead, they flow very deeply in the channel. Instead of a flood being 3 feet deep and 50 feet wide it is 8 feet deep and 20 feet wide, and the pressure of the deeper water times the increased velocity forces the bed of the channel to erode. This erosion moves upstream in a headcut (head-ward cut), a waterfall in the channel that removes material and lowers the bed of the channel. Once the channel begins to erode downward it becomes a gully; the creek or river is now gullied, or entrenched. Each flood has less access to the floodplain and more force on the bed, this feedback loop continues to cut downward from flood events until the channel uncovers bedrock and can cut no deeper.

This headcut on Cedar Creek is an erosive dropoff that moves upstream, lowering the channel and the water table as it progresses.

Gullies heal themselves by cutting at their banks, widening, and creating meanders and floodplain at the new channel elevation. Meandering would begin to lengthen the channel and lessen the slope. This, combined with the additional width, eventually crosses a geomorphic threshold, allowing sediment to build up on the channel bed again. The inside of each meander bend becomes the new floodplain. This normal erosional process often affects properties that have been built on the banks of the gully, which leads to bank protection to protect the property. This bank protection, however, prevents the watercourse from healing itself with the natural process of meandering.

2) Bank Protection

Once the floodplain has been filled, or lost to the creek through gullying and entrenchment, bank erosion can happen during flooding or to natural meandering. This bank erosion is a healing process by which the river tries to create more floodplain. However, if there is infrastructure on top of the bank that is eroding, this is a problem that needs to be fixed. Natural channel design restoration projects use a number of structures, including **Vanes** to address bank erosion. Natural channel design theory proposes that solid concrete or gabion bank protection speeds the flow of the water and causes scour at the bank, this leads to under-cutting of the gabion basket, which therefore is be stable over the long-term. A vane diverts the point of maximum depth and shear stress away from the bank and allows for deposition of sediment, protecting the bank.

Undercut Gabion revetment on Eagle Creek

Rock vane at Two Rivers Park
This protected the bank from erosion during the 2008 flood

3) Vegetation

There are other problems associated with the gabion shot-crete bank protection structures. There is not enough room within the confined channel for floodplains to form. Vegetation will not be established within the walls due to the scour forces of the channel, and the baseflow channel of the creek will remain wide and shallow, and poor fish habitat. The growth of riparian and wetland vegetation on the banks of a creek narrows and deepens the channel, and creates better habitat for fish. The presence of the walls will also prevent the growth of willows or cottonwoods that would shade the banks and lower the water temperature in the river or creek.

A common situation in Ruidoso is the Mowed Floodplain, where the landowner kills the willows and riparian vegetation to make the banks neat and tidy. If they could be educated on the value of a narrow buffer strip with willows and plants, they could have a neat lawn and a healthy, narrow creek with shading for fish habitat.

Mowed vs un-mowed floodplain near Rainbow RV park,
a narrow buffer strip on the stream bank would improve fish habitat.

4) Urbanization and Runoff

All of these problems, bank erosion, gullying, vegetation problems, are exacerbated by the large amount of runoff from Urbanization. Paved or dirt streets, parking lots, as well as the rooftops of houses all shed water easily. This water flows in Ruidoso very quickly to the creek and leads to pollution in the creek from trash and oil on the street, and surfacing from dirt roads. In addition, this rapidly increased surge of water leads to erosion of the river banks and beds.

Urbanized runoff sending muddy sediment directly into the Rio Ruidoso

5) Culverts and Bridges
Culverts confine the stream channel in a narrow pipe and shoot the water out of the downstream end, causing problems both upstream and down. A very common problem with culverts is that they are installed too low, causing a headcut on the upstream end that lowers the channel, causing entrenchment and removing access to the floodplain, as explained in item 1 above. The downstream end becomes a scour pool, which removes material from the bed and banks of the channel, causing downstream erosion as well. The scour pool of the culvert also creates a fish barrier for fish moving upstream.

Gavilan Canyon Road bridge over Rio Ruidoso, showing fish barrier and scour pool

Bridges
Bridges have the potential to be a less harmful way to cross a creek, but far more expensive. The most damage done from bridges is not from narrowing of the channel, it comes from narrowing of the floodplain. In large floods, this narrowing of the floodplain by the bridge causes the water to shoot out from under the bridge and scour the channel downstream. In fact, this damage may only be seen in very large floods, as smaller floods pass without damage. Another effect of bridges can be to flatten the bed of the channel. If the river originally had a pool in that location, the pool is lost, and sediment will begin to build up in the flat, shallow water. A bridge can ruin the riffle-pool sequence and form of a channel without doing any other damage. Fortunately, careful design considerations can address all of these problems with culverts and bridges.

6) Intentional Straightening of the Channel
Due to bank erosion or damage from the 2008 flood, many landowners have intentionally straightened the channel of the stream in front of thier property. This was done extensively on the Rio Ruidoso. This is usually a mis-guided attempt to 'move the water' and hurry it downstream. Straightening a channel has many negative effects. First, the straight channel is shorter and steeper, and a headcut could form and create a gully upstream (in the case of channels that to not have beds made of large boulders or bedrock). The original bank erosion was probably caused by an excess of sediment

building on the floodplain, or lack of riparian vegetation protecting the banks. The proper solution would be to address this extra sediment. Bank erosion can also be addressed by planting vegetation or the installation of bank Vanes.

Straightening the channel can cause it to be wide and shallow in some cases. Note: improper livestock grazing is also contributing to the problem here

Depending on the stream classification (beyond the scope of this report), another effect of straightening the channel can be to destabilize the bed and flatten the channel. Often the new, straight channel is cut wider than the original natural channel, again to "move the water". This wide channel segment does not have the efficiency to move the sediment arriving to it from natural erosion of the mountain watershed above, and sediment builds up in the new, flat bottom channel. This sediment deposition can actually raise the flood stage, and disrupt the flow of the water. This can cause more bank erosion downstream, with a greater need for more bank protection after the channel straightening then before. The most obvious channel straightening has occurred on the cattle ranches along the Rio Ruidoso downstream from the Downs, with disasterous results. Individuals who do not have proper training in stream assessment, natural channel design, and river restoration cannot be expected to undestand the long term effects of expedient channel manipulations.

7) Grade Controls, Irrigation Diversions and Check Dams

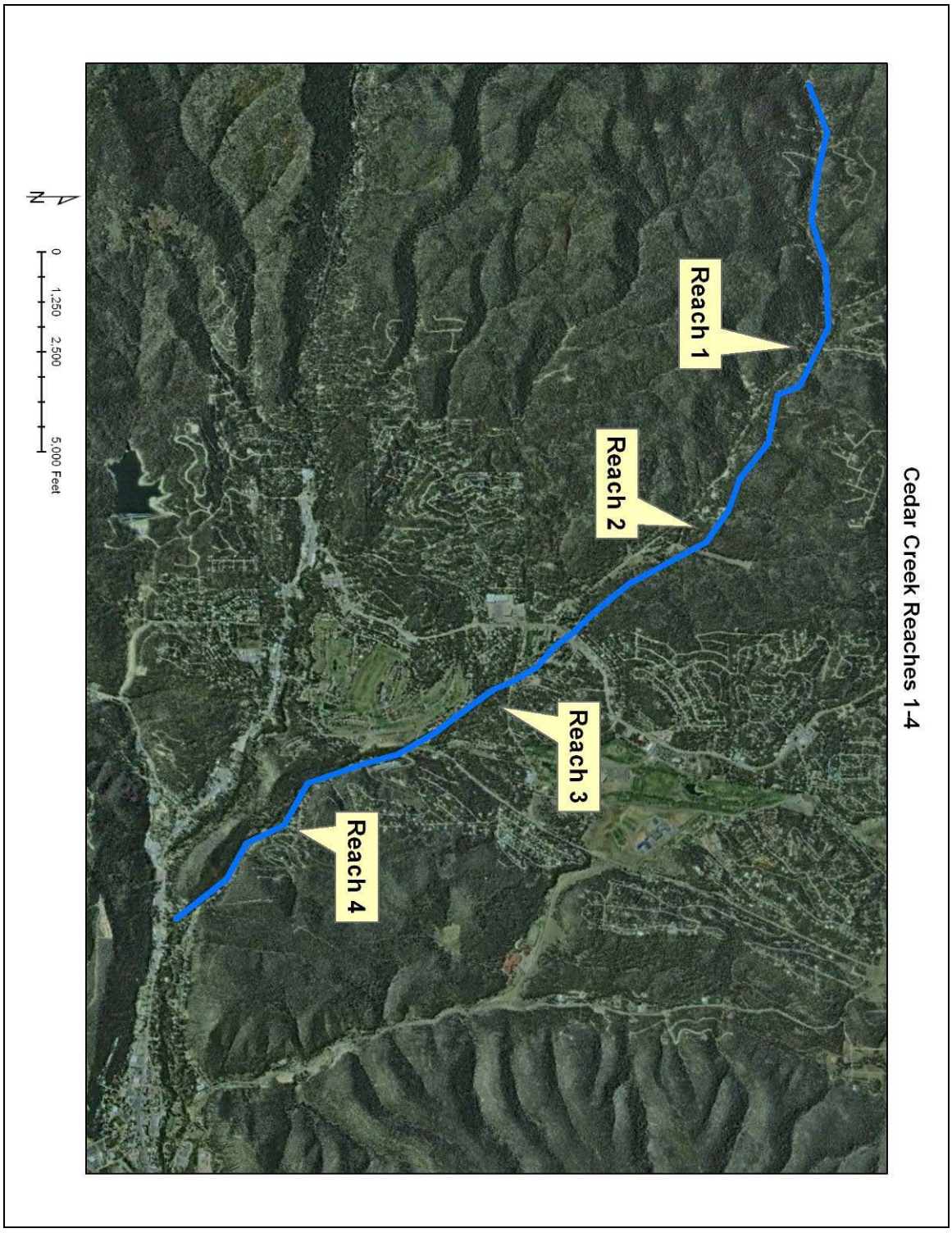
There is an abundance of grade control structures on the Rio Ruidoso and its tributaries, from hand-built rock or wood grade controls on Carrizo Creek to large irrigation diversion structures on the Rio Ruidoso. Rigid grade controls are usually harmful to the channel in several ways. Rock waterfalls can be found in the upper reaches of the tributaries and the main stem and are appropriate in that location. When used in a reach that is meandering, they are often installed in the pool, not the riffle of the creek, and cause a large amount of erosion due to their location. A small rock check dam can cause enough scour on the downstream side to become a fish barrier, especially if it doesn't create a pool where the fish can get a "run at it".

Photo taken from just below the irrigation diversion on the Stansell Ranch, looking downstream at bank erosion and scour

When a large irrigation diversion is installed on the Rio Ruidoso, several things happen. First, the river is most likely straightened to ensure that the water flows as desired. This causes a steeper slope in the vicinity of the straightening. Second, the grade control is usually placed higher than the original channel to raise the water high enough to flow in the irrigation ditch This creates a waterfall effect downstream,which causes scour.

In a very large flood such as the 2008 flood, the entire bed of the Rio Ruidoso was mobilized to a depth of 3-4 feet. The installation of a 2 foot high check dam or irrigation diversion became to the river a 6 foot deep waterfall. The acceleration, and the resulting scour from quick water that is now falling over a 6 foot waterfall was immense. During the flood, the three large irrigation diversions in the Ruidoso Downs area all had very long and deep scour holes below them. (These are no longer noticeable to the casual observer, because they have subsequently filled in with small sized sediment). In addition, both the left and right banks were blown out downstream for several hundred feet and the original channel obliterated. The sediment from this blow out also flowed downstream and affected the form and health of the channel for hundreds of feet downstream. Natural Channel Design has a solution to this problem. It is to redesign the grade control structure, and construct a short stream channel segment immediately downstream that has the appropriate energy dissipating features.

Stream Reach Assessment



Cedar Creek

Cedar Creek is a small tributary to the Rio Ruidoso that flows through Paradise Canyon into the Rio Ruidoso at Mid-town. Cedar Creek is perennial, however, the flow in most of the creek is too little to support fish habitat. Cedar Creek is moderately undisturbed from the Forest Service boundary downstream to Hull Road and the beginning of Paradise Canyon. Paradise Canyon reach is very modified by development and has a great deal of damage and ongoing degradation. There are four reaches presented in this report, presented from upstream to downstream.

Reach 1; Forest Service boundary through private properties

Cedar Creek begins at several springs near the Forest Service boundary at the end of the road. It flows several miles through private cabin properties until it reaches another parcel of Forest Service Property near the Lincoln National Forest office. This reach probably never provided permanent fish habitat, based on several interview with property owners who have been in the area since the 1950s. The assessment determined four resource impairments to the health of Cedar Creek in Reach 1.

1. Culverts from private driveways

The major impact to Cedar Creek is the installation and positioning of culverts of private driveways in this reach. Many of these culverts were placed too low in the profile of the Creek, leading to headcutting of the bed of the Creek upstream. Downstream from many culverts, the acceleration of the flow is causing large scour holes to cut into the bed, also lowering the channel elevation by many feet.

The general effect of the culverts on Cedar Creek is to turn the Creek into a gully, which has no floodplain, poor vegetation, and a lowering water table. Once the gullying process begins, high flows are captured in the channel and cannot spread across the former

floodplain. This carves the channel deeper and deeper, contributing to erosion, poor habitat, poor vegetation health, and instability of the channel. Gullies generally continue to cut downward until they reach a stable point, such as bedrock or the upstream elevation of the next culvert downstream.

A solution to this problem would be to install properly designed culvert inlet structures on the upstream side of each culvert to prevent headcutting upstream, and to install splash pads on the downstream side of each culvert to prevent scour erosion and formation of gullies downstream.

2. Road location in valley

Cedar Creek Drive causes a large amount of resource damage on Cedar Creek. One major problem, common in Ruidoso, is that the road runs up the center of the valley and the Creek was pushed to one side. This forces the creek to carve a new channel, restricts the floodplain, and lowers the water table. Restricting the floodplain can also cause the creek to begin gullying as described in the previous section.

This problem is difficult to fix at present, but could easily be prevented in new development by moving the road to the toe of the hillslope and leaving the creek in the middle of the valley. Minimizing the number of creek crossings could help limit headcutting and gullying.

3. Road Drainage

Rainfall runoff from Cedar Creek Drive is poorly managed and rainfall flows directly into the creek through culverts or roadside ditches. This increase in hydraulic connectivity increases the amount and speed of runoff water reaching the creek compared with natural conditions. Also, the major source of sediment in the creek is road base course, which may be smothering aquatic life under bars of gravel.

A solution would involve proper treatment and storage of runoff water from the road to keep this water on the landscape as long as possible and soak it into the groundwater. Culverts entering the creek could have properly designed splash pads to reduce erosion and store water from small flows. This water could become a resource to keep Cedar Creek perennial, rather than a pollutant that causes erosion.

4. Ecological Conditions

The Ponderosa Pine Forest in Cedar Creek has many large Old-Growth trees and seems healthy. However, fire suppression over the last 100 years has prevented frequent, small wildfires that would have killed small trees and kept the forest floor open and grassy. Now, the small trees are causing a fire danger which, if left unchecked, would burn many cabins down and cause a great deal of damage to Cedar Creek as well.

A less well-known effect of overgrowth in the forest is the effect on the vegetation in the creek. A healthy riparian corridor along a creek may have large pines on the bank, but also has patches of sunlight which support the growth of willows and riparian vegetation on the banks of the creek. Willows and riparian vegetation stabilize the creek, build

floodplains, and prevent erosion, as well as purifying the water by the uptake of nutrients. If the situation remains unchanged, there will not be enough light to grow any vigorous vegetation on the banks which would provide protection from both flooding and gullying.

Selective thinning of smaller pines for fire control, as well as planting willows on selected banks could help Cedar Creek heal itself from erosion and gullying. This would also narrow the creek and lower water temperature. The extra light by itself would foster the growth of riparian vegetation and give stability to the creek.

Reach 2; Forest Service to Mechem Drive

This reach begins at the trash pickup location at the downstream end of the private properties and runs until Mechem Drive. This property belongs to the Lincoln National Forest. This reach has a great potential to become habitat for wildlife because of its undeveloped nature. Several pairs of breeding ducks with ducklings were seen in this reach, and there are several areas of healthy wetlands. The assessment identified four resource impairments in this reach.

1. Trash compactor location

The trash pickup location at the top of this reach is a major impairment to Cedar Creek. The creek was pushed to the left (north) side of the valley to create room for the parking lot and several major headcuts were created. Far too much room is given to the parking lot and turn-around for the garbage truck. Much less room is required, and some of this space could be used for riparian floodplain and an infiltration basin for the parking lot itself.

In addition, the runoff from this large parking lot runs directly into the creek and contributes trash and pollution to the water. Reducing the size of the parking lot and adding a small infiltration basin could prevent much of this pollution from reaching the creek.

2. Irrigation ditches and entrenchment, headcutting

This portion of Cedar Creek was used for irrigation and the old irrigation gate can be found on the creek near to the trash compactor. It is very common in New Mexico to find that a creek was pushed from the middle of a valley to one side to allow more room for growing crops. The common result of this is entrenchment; long ago gullying that has cut down to bedrock. Cedar Creek has cut to bedrock in several areas in this reach and is still cutting in other areas. There are many active headcuts damaging healthy reaches with riparian vegetation and lowering the water table. The active headcuts should be properly treated to prevent gullying upstream. Areas between the bedrock could be treated with Induced Meandering techniques to create more floodplain and channel length.

3. Culvert elevations
Several roads cross Cedar Creek to Forest Service camping and picknicking areas. All of these culverts were placed too low and cause erosion upstream and scour downstream. Properly designed culvert inlet structures and splashpads would mitigate this damage and prevent further gullying. The headcutting upstream from these culverts should be properly treated to prevent gullying.

4. Culvert location at Mechem Drive
The box culverts at Mechem Drive were placed much lower than Cedar Creek upstream and caused a massive, four foot deep headcut. This headcut will advance upstream and destroy wetland and the healthy channel until it hits a bedrock area far upstream. A properly designed culvert inlet structure could stabilize this area and prevent resource damage on Cedar Creek upstream.

Reach 3; Mechem Drive to Hull Road

This Reach begins at a small golf course at Mechem Drive and flows to Hull Road and the top of Paradise Canyon. The portion of the Creek on the golf course is completely altered into a series of detention ponds with concrete waterfalls. Downstream from Cree Meadows Drive, Cedar Creek flows unaltered in a natural condition to Hull Road. Two resource impairments were found in the assessment.

1. Detention ponds on golf course

The golf course reach is completely altered with Cedar Creek running through four detention ponds behind concrete grade controls. The banks of the creek are mowed, which prevents natural riparian vegetation from growing and shading the creek. Because the grade controls are too large to be modified, the only suggestion in this area is to stop mowing the banks of the creek to allow natural vegetation to stabilize the creek and filter the water.

2. Headcuts between Cree Meadows Road and Hull Road

This reach is shady and forested and runs between private properties to Hull Road. Cedar Creek is relatively healthy, with riparian vegetation and small pools. However, this reach has cut to bedrock in many places and is not at its full potential. As more and more bedrock becomes exposed, the riparian vegetation dies and more of the creek becomes shallow and exposed. Small rock structures to hold water and grow vegetation could raise the water table and prevent further headcutting. This work could be done by hand in a workshop using volunteer labor and educating the community on watershed health.

Approaching Hull Road, much of the sediment that washed off of the bedrock upstream has been captured behind the under-sized culvert and has created a 1-2 acre wetland. A few small treatments by hand could re-wet another acre of this wetland and raise the water table. The clogged culvert should be cleaned out and drop inlet installed to raise and protect the grade of the creek.

Reach 4; Hull Road to Rio Ruidoso through Paradise Canyon

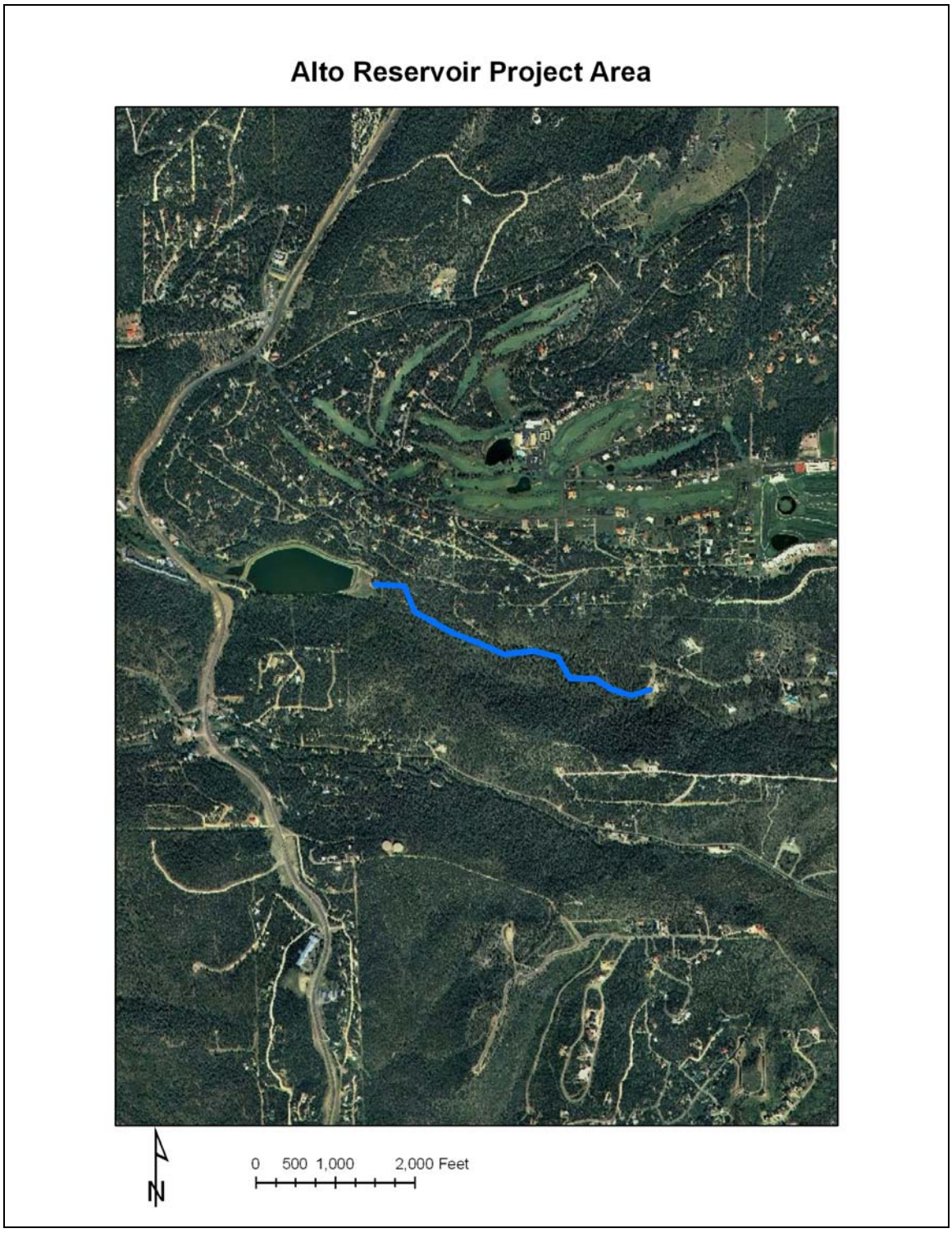
The Paradise Canyon Reach of Cedar Creek is the most impaired section of Cedar Creek. At one time, Paradise Canyon must have deserved its name. At the present, however, Cedar Creek is in a deep gully with little floodplain, poor habitat, and no riparian vegetation. The repairs to culverts and road crossings after the 2008 flood have caused even more resource damage. However, there are a few pools in Paradise Canyon that have fish in them and may be worth restoring. A crossing at Hart Road is a particular problem that prevents fish from migrating upstream. The assessment found three resource impairments in this reach that affect the functioning and health of the Creek.

1. Intentional shortening of channel
Several portions of the creek near the top of Paradise Canyon at Hull Road were intentionally cut off and the creek was shortened. The creek formerly meandered across the valley, but was forced against the right bank and caused to steepen. The steep portion of the creek has now downcut into a gully. Many active headcuts are moving upstream and continuing to lower the water table and impact the creek. Some of these headcuts are four feet deep and moving upstream rapidly. These headcuts affect the health of the banks of the creek, undermine foundations of houses on the banks, and ruin fish habitat.

With some large treatments using machines, much of the middle of Paradise Canyon could be fish habitat and enjoyed by the landowners on the left bank of the Creek. However, due to access issues and land ownership, a project was not proposed for this site.

2. Driveway crossings and culverts
Several road and driveway crossings have culverts that were installed too low and have caused gullying and downcutting. The road crossing at Hart Bridge is particularly bad and creates a barrier to fish found downstream in Cedar Creek. Upstream, it is clogged with rock and threatens to wash out the road. This would have to be rebuilt to allow for passage of fish upstream to the rest of Cedar Creek.

3. Trash in creek
Several properties in this reach have dumped auto parts into the creek and are continuing to do so. These areas are polluting the creek with oil, transmission fluid, and other runoff from small junkyards. The worst areas should be cleaned up and the trash removed from the creek.



Alto Reservoir

The Alto Reservoir is a drinking water reserve for the Village of Ruidoso. It is fed by Eagle Creek, which becomes dry not far downstream from the reservoir. However, the reach just below the reservoir is fed by groundwater seepage below the dam and is perennial.

Below the reservoir, Eagle Creek flows through about a ½ mile of public land until the private land boundary. This area is one of the few publicly accessible areas on public land near the Village that has a high potential to be a park with trail access. Many other areas with equal potential and beauty have large amounts of private development and are not appropriate park areas. In addition several beautiful waterfalls on bedrock create pools in the creek near the private land boundary. A loop trail to see the waterfalls would be a worthwhile 1 mile walk from the Alto Reservoir.

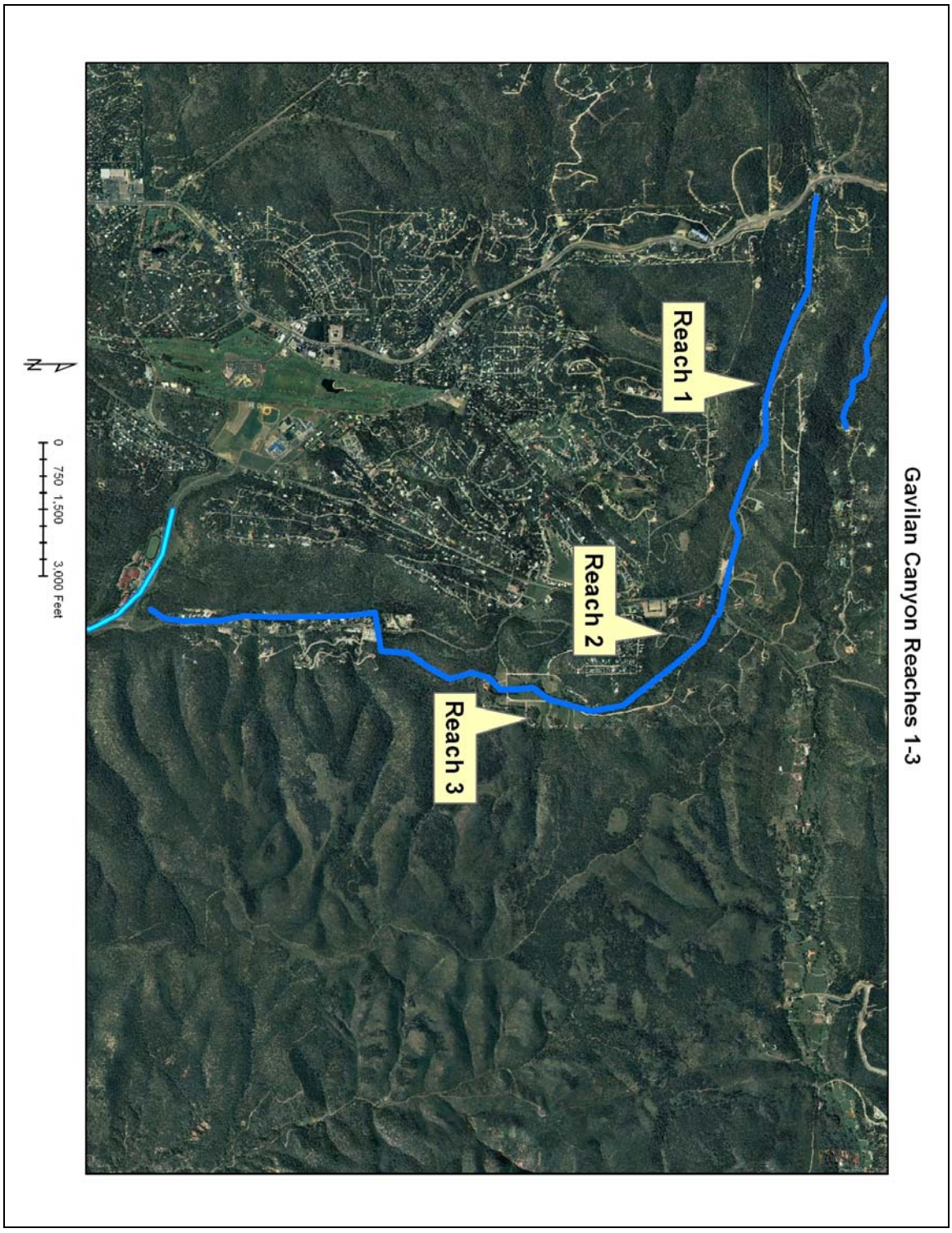
Access Road

Presently, access to the area is down the extremely steep access road used by the reservoir operators. This would be too steep for small children or the elderly. The road then crosses the creek several times, causing resource damage with small or improperly placed culverts. This road could be moved out of the floodplain onto the left (north) side of the creek to continue to give fire protection access.

The main resource damage in this reach is caused by the road crossings. Either the road could be moved, or treatments could be installed to prevent headcutting and gullying from the poorly placed culverts.

Trail location

The best location for a trail is on the south bank next to the overflow from the dam. A trail would have to be cut into the hillside and switchbacked down the hill, where it could meet an existing trail on the south bank of the creek. The trail could return up the north side of the creek and then climb the switchbacks up the hill. Trail building work is appropriate for older youth crew such as high school students or Eagle Scout projects.



Gavilan Canyon Creek

Gavilan Canyon Creek is an intermittent creek that is south of Eagle Creek and north of Cedar Creek. The assessment was performed from Mechem Road downstream to the confluence with the Rio Ruidoso. There was a mile of perennial reach just below

Mechem Road, then Gavilan Canyon Creek was mostly dry until Ruidoso High School and Bog Spring. Gavilan Canyon Creek was divided into 6 reaches for assessment.

Reach 1; Mechem to Gavilan Canyon Road

Gavilan Canyon Creek below Mechem Road has steep sides and became a gully during historic times. This reach has perennial water and wetland vegetation. Three resource impairments were identified in the assessment of reach 1.

1. Trash in creek

Several neighborhood trash dumpsters have been raided by bears and trash scattered over a large area. This trash is then carried downhill to the creek by rainfall runoff and left in the creek. While this trash is most likely picked up by Village staff periodically, the trash in the creek remains. A river clean-up day could focus on particular areas on the creek that have this problem.

2. Embankments on private property

Several locations on Gavilan Canyon Creek have private property that encroaches on the creek. Private landowners have increased their flat, usable area into the creek by adding fill, garbage, and debris. Several locations area very trashy and are causing resource damage to the creek. Education and outreach to the landowners to encourage them to apply for permits before placing fill within the flood prone area of a creek to avoid possible prosecution and fines.

3. Headcuts

A number of headcuts were identified in the assessment that were moving upstream and gullying the creek. Some were cause by human impacts, such as road culverts, and some were caused by dead trees in the creek constricting the flow. All of these headcuts could be fixed by hand during a workshop, or by a youth restoration program.

Reach 2; Jehovahas Witnesses

Gavilan Canyon Creek crosses Gavilan Canyon Road, dries out, and becomes intermittent. Some perennial water was flowing for several hundred feet of the creek. Three resource impairments were identified.

1. Creek in culvert

The Jehovah's Witnesses Kingdom Hall was constructed very close to Gavilan Canyon Creek. In fact, the entire creek is culverted under the parking lot of the Kingdom Hall. This may cause resource damage in a large flood or prevent sediment from moving from upstream to downstream in the creek.

2. Illegal ponds in creek

There are several illegal ponds dug into the creek in this dry portion of the creek. The areas we identified are dirt ponds with no rock armoring and poor compaction, most likely built by the landowner on a lark. Every pond appears as if it will break in the first large flood and would certainly not survive any overflow of the pond. Building ponds in watercourses without a permit is against federal law. When the ponds break, the water and material may wash downstream and cause damage to road crossings or downstream landowners.

3. Un-used road crossings and culverts

Several road crossings with culverts are clearly not used any more, but the culverts are plugged and are causing resource damage and gullying. These should be removed with a backhoe and the road crossing material removed; no other treatment is needed.

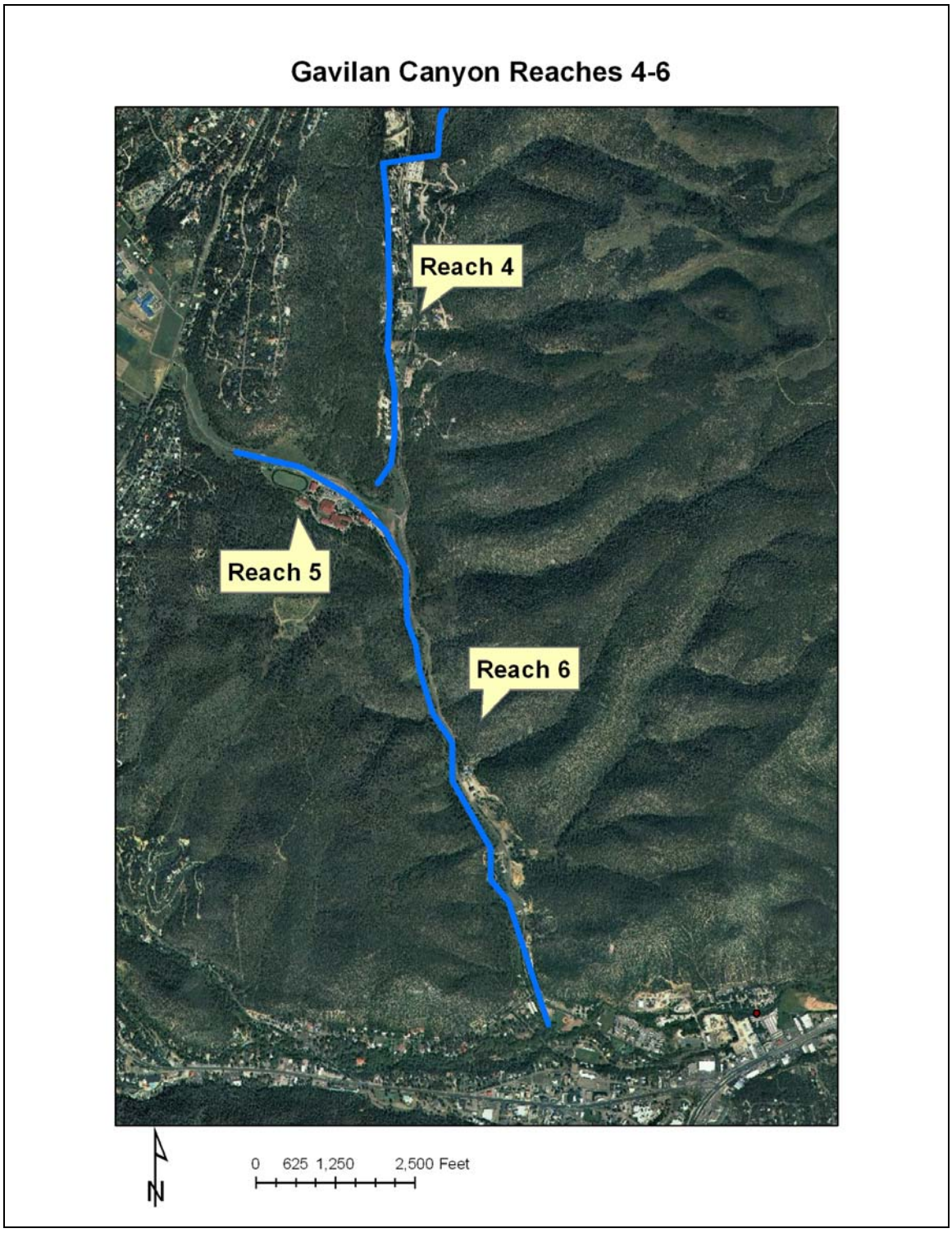
Reach 3; Homestead Road

The creek remains dry in this reach and is surrounded by larger properties on Homestead Road. Three resource impairments were identified.

1. Illegal ponds
Several more illegal ponds were dug on the creek and built out of un-reinforced earth. These ponds will not survive the first large flood and appear to be recently built. When they break, water and soil will flow downstream and may threaten the next road crossing.

2. Small culverts
Downstream this far in the watershed, the size of a 2 to 5 year flood will be large. However, most of the culverts in this area use one 2 or 3 foot diameter culvert. The creek is entrenched deep in the landscape and the embankments around the culverts are very tall. No sediment is passed by the creek through these small culverts, which become ponds during a flood. Downstream, this lack of sediment is causing gullying and drying out of the Gavilan Canyon Creek.

3. Runoff from Upper Gavilan Canyon Road
A large amount of erosion is caused by a tributary flowing in from the right bank. This runoff flows from Gavilan Canyon Road and causes resource damage to the creek for almost one thousand feet. Diverting and spreading water higher up in this road drain would reduce the runoff and the damage it causes.



Reach 4; Gavilan Canyon Road to High School

This reach is dry with several spring areas that support perennial water on the creek for several hundreds of feet. There is a great deal of development on the banks, with houses on both sides of the creek and many driveway culverts. There are three resource issues identified in the assessment of reach 4.

1. Culverts
Many driveway crossings were built by private landowners, the culverts are very small, and are causing upstream and downstream erosion in the creek. Properly installed culvert inlet structures and splash pads would prevent this gullying to the creek.

2. The small spring areas with water flow could be repaired and fixed with small rock structures built by hand during workshops, which could help keep the water onsite and make this spring area longer and wetter.

3. Large headcuts
One old road crossing near the crossing at Gavilan Canyon Road has a 10 foot headcut that is eroding upstream. There is easy access nearby for an excavator to fix this resource damage with a rock drop structure.

4. Entrenched creek
This portion of the creek was also entrenched historically, and now is surrounded by private property and armored in this location. Because of this, reach 4 is prevented from being healthy or wet and has a low potential for restoration.

<u>Reach 5; High School, Bog Spring</u>
The Ruidoso High School was constructed on a former wetland/wet meadow ecosystem called Bog Spring. At the present time, a large flow (2 cfs) of clean, spring water runs in the ditch along Warrior Road. It appears as if this ditch is regularly sprayed with herbicide to prevent the growth of wetland vegetation. This water could be used as a resource to create wetland habitat and small ponds for wildlife. In addition to creating a beautiful entrance to the school, these ponds could be used for environmental education at the High School and Middle School. Three resource issues were identified near Ruidoso High School.

1. Draining of wetland
The upper portion of Bog Spring starts close to Hull Road. Very quickly, the spring area drains into a gully and flows in the roadside ditch on Warrior Road. Some potential exists in the long jump area of the track to create small wetland pond areas that would be amenities and grow shade trees and vegetation.

2. Parking lot runoff
The large impervious surface of the parking lot adds a large amount of runoff to the spring. There are several areas between parking lots that could be converted into runoff treatment zones to control and filter runoff before it runs into the Bog Spring.

3. Entrenchment
Downstream from the High School parking lot, Bog Spring flows into a gully trench rather than spreading across the former wetland. The lowest point in the valley is a dirt access road on the location of the former channel. Many opportunities exist to create ponds and wet areas at this site. Downstream from the site, a large bedrock outcropping could anchor the bottom of this wet area and allow the water to flow into Gavilan Canyon Creek safely without erosion or damage to the road bed.

<u>Reach 6; High School to Rio Ruidoso</u>
This reach is perennial due to the flow from the Bog Spring at the High School. The water in much of the reach is clean and fresh, and may be able to support fish. At present, no fish were found. The assessment identified five resource impairments found commonly in this reach. This reach is a "Gem" and could have a trail along the west bank to allow enjoyment by the community.

1. Entrenchment
This portion of Gavilan Canyon is very entrenched from its former elevation before Anglo settlement. This impairment was probably due to a great amount of logging and grazing upstream, followed by large flood events on the denuded landscape. Presently,

this reach is hemmed in by the Gavilan Canyon Road and a dirt bank on the west bank. Very small floodplains are present where the creek can form pools and riffles. In most of the reach, however, the creek is on bedrock in many locations. Very little can be done at present to widen the floodplain, but in a few areas Induced Meandering can widen the banks and create sediment to fill in the gully.

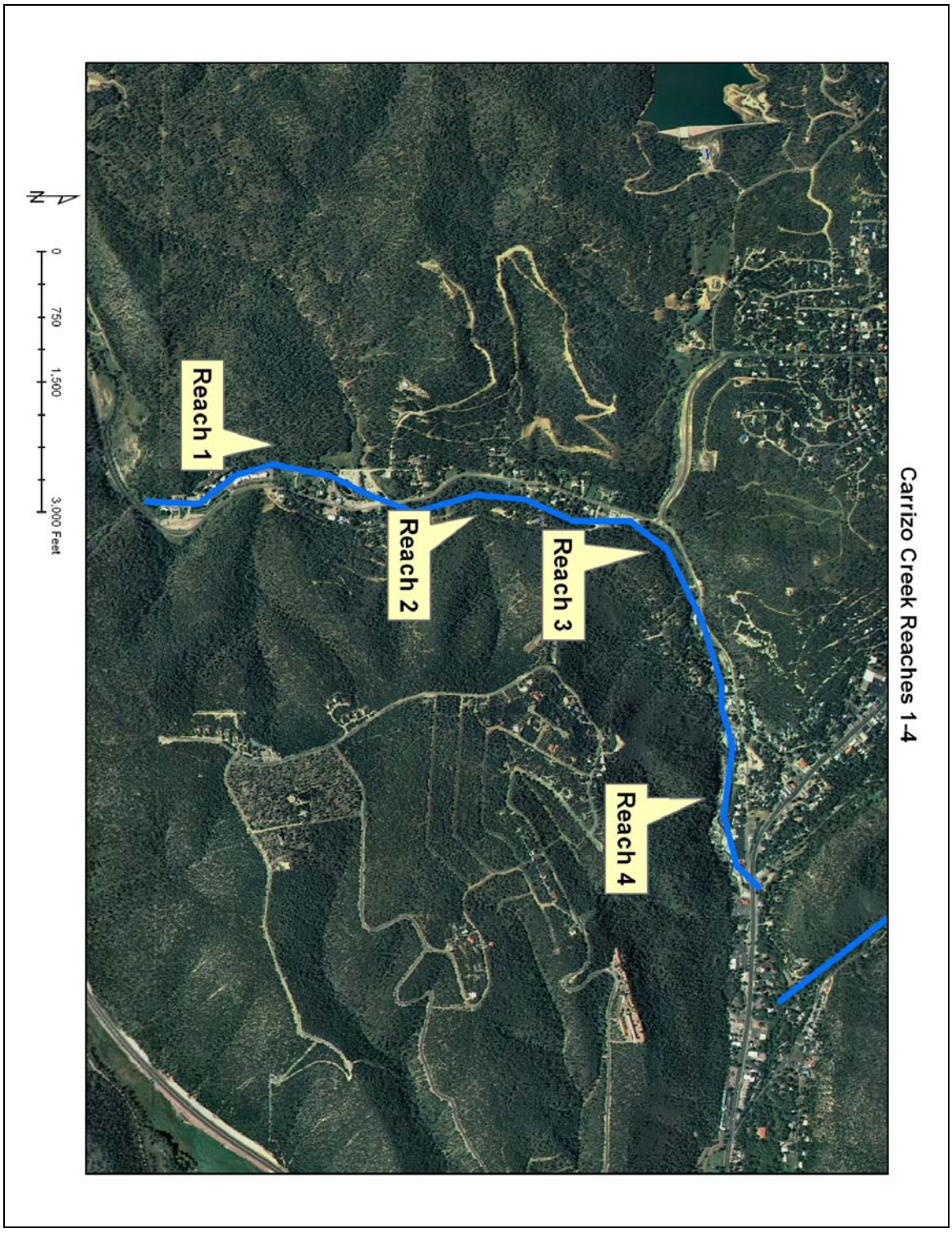
2. Waterfalls
The bedrock areas the creek has cut into form many large and small waterfalls that have the potential to act as fish barriers if this reach were to be stocked. Two large waterfalls present 10 foot drops to the creek, and cause a large amount of erosion downstream due to the force of water over the drop. There is no 'solution' to the waterfalls, but they are fish barriers and are important to the health of the creek.

3. Water quality
About half way down the creek, the water quality diminishes quickly. It may be a consequence of runoff from Gavilan Canyon Road that flows untreated into the creek. However, the Human Society is also in this general location, and there could be an affect of runoff from the dog runs. The amount of algae becomes greater, and the water quality diminishes so that it couldn't support fish.

4. Automobiles in creek
Another notable feature of Gavilan Canyon Road is the large number of automobiles in the creek. Seven automobiles of various ages are sitting in the creek with their engine and transmission fluids leaking into the water. This information is contained in the GIS layers taken during the assessment survey. It would take a large winch or an excavator with a chain to remove the automobiles from the creek.

5. Confluence with Rio Ruidoso
The culvert under Meander Loop is too small and set too low. This has sent a headcut upstream several hundred feet and created a fish barrier. In addition, the 'ballfields' site

has constructed embankments to prevent the creek from forming a natural delta fan. A fan would create good habitat for wildlife and would store water in the banks of the Rio Ruidoso. This work was probably done to create a trail access for fishing; however a trail could exist without harming the delta. In addition, the concentration of Gavilan Canyon Creek in one location causes a headcut at the point where it enters the Rio Ruidoso, and is contributing sediment to the river.



Carrizo Creek Reaches 1-4

Carrizo Creek

Carrizo Creek flows from Mescalero Lake to the Rio Ruidoso at Two Rivers Park. The creek is dry just downstream from the lake, however, it resurfaces due to groundwater seepage above the reservation boundary. Carrizo Creek has perennial flow and is the best fish habitat found during the assessment, including the Rio Ruidoso. Carrizo Creek has

the unusual feature of containing a lot of lime, which deposits travertine on rocks and structures in the creek, even wooden check dams.

Carrizo has the potential to be fish habitat throughout the entire reach, except for a large number of human modifications such as culverts, grade controls and check dams. However, large portions of this creek are healthy and the unhealthy areas are easy to repair. Carrizo also has a fairly regular flow due to its source as seepage from Mescalero Lake. Carrizo Creek was divided into four reaches for assessment.

Reach 1; Mescalero to Rainbow Lake

Reach 1 is very modified by human encroachment and urbanization. The creek is perennial, but has very little fish habitat due to poor shading, poor vegetation and the general lack of a healthy floodplain or channel. This portion of the creek is mostly on private property and may be difficult to restore due to property issues. Three resource issues were found in the assessment

1. Culverts as fish barriers

There are many culverts under driveways to private property across the creek. They are almost always too low and too small and cause gullying both upstream and downstream from the culvert. In addition, most of the culverts act as fish barriers on a creek that has good fishing downstream. Proper treatment would involve installing properly designed culvert drop structures and splash pads, and in some cases, installing the culvert at a less steep grade to allow fish passage upstream.

2. Encroachment onto floodplain (rainbow lake picture)

Many of the private properties have added fill to the floodplain to create flat ground for lawns or building pads. This has entrenched the creek and destroyed the floodplain along the creek. Dirt fill has also killed much of the bank vegetation and keeps the creek in full sunlight throughout this reach.

3. Mowed floodplain
Many landowners along this reach mow or spray their floodplains with herbicide to kill the vegetation. Willows and riparian vegetation play a very important role in stream stability, flood attenuation and fish habitat. In several places, the floodplain is mowed to a lawn, which kills the riparian vegetation and does not provide the same quality habitat as native vegetation. There is even evidence of herbicide used on willows, which were holding a very tall fill bank from falling into the stream. Now the bank is unstable and the willows are dead.

Reach 2; Rainbow Lake to Grindstone Canyon
After the Rainbow Lake RV park, the creek flows through a poorly set and rusting culvert under Carrizo Canyon Road. This rusting culvert is a fish barrier and needs to be replaced before it collapses. However, this reach is mostly private and untouched, and is either fish habitat or could easily be fish habitat. The assessment identified three resource impairments in this reach.

1. Entrenched Creek
Carrizo Creek used to flow at a much higher elevation, probably before Anglo settlement many years ago. Old irrigation diversions and irrigation ditches on the banks provide evidence that agriculture probably pushed the creek to one side of the valley and caused downcutting and entrenchment.

The upper half of this reach, just downstream from the Carrizo Canyon Road culvert, has dropped 10 feet and has almost no floodplain, pools, or fish cover. However, there is great shade and only one landowner of this property. At the downstream end of this healthy reach of private property, a large amount of fill in the channel creates a fish barrier and pollution in the creek. The property to the south has a paddock with livestock and a drainage pipe into the creek. This area is the biggest barrier to fish passage in the entire creek. A large project with the cooperation of the landowners would have to be initiated to remove the fill, add grade controls, and create fish habitat.

2. Mowed floodplains
Downstream, there is a fish barrier culvert and then a long reach of well maintained private properties with a healthy portion of Carrizo Creek. One issue is that the floodplains in this area are also mowed, which opens the creek to light and increases water temperatures, hurting fish habitat. However, these areas are not entrenched and have healthy floodplains, so they are stable.

3. Great habitat and reference reach for Carrizo Creek
The portion of the creek from the confluence with Grindstone Canyon to Tomahawk Road is very healthy with a large floodplain, strong willow component and very deep pools. This is the best reach on Carrizo Creek and supports many fish.

Reach 3; Tomahawk Trail to Quarry
This reach has good fishing and healthy areas on the creek with well maintained private properties. Two resource impairments were identified in this reach.

1. Culverts and fish barriers
The culvert at Tomahawk Trail flows from an extremely healthy area with willows to a healthy private reach. Unfortunately, it is a barrier to fish on the downstream side and needs a splash pad grade control to lessen the drop out of the culverts.

2. Grade Controls as fish barriers
There are many hand made or installed grade controls in this reach that have been cemented by travertine (limestone) and look like bedrock. However, on further investigation, some of these check dams have wood in them that is covered by a layer of travertine rock. Many of these are very stable, but are causing one or two foot waterfalls that could be fish barriers. Hand built rock structures to raise the glide of the pools below these check dams would remove the fish barrier.

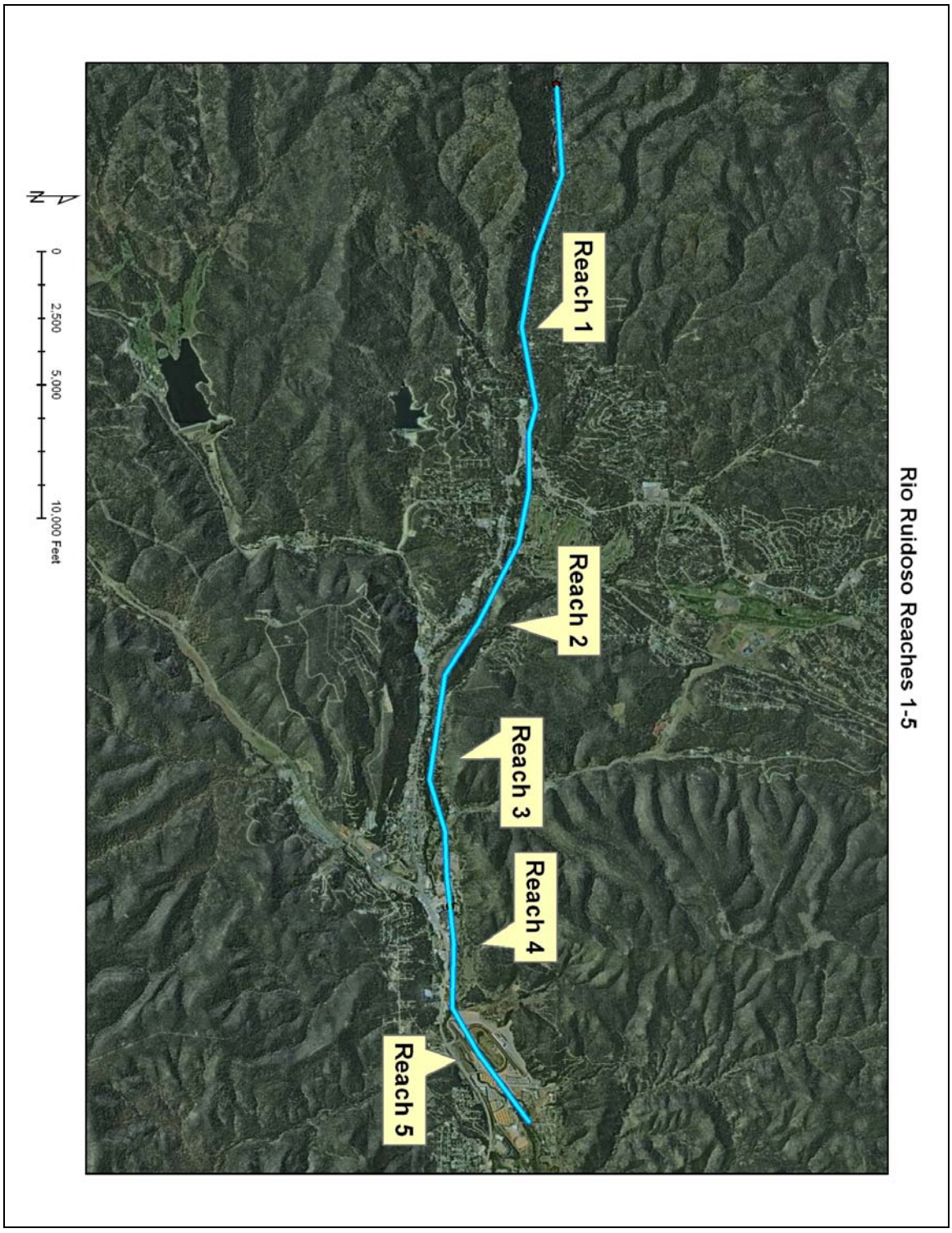
Reach 4; Barney Rue to Rio Ruidoso
This reach is very unhealthy after the two good reaches upstream. It begins at Barney Rue Sand and Gravel Quarry and flows through the go-cart track to Sudderth Road. Three major resource impairments were identified in this reach.

1. Grade Controls at Barney Rue
There is a major rock grade control on the Quarry upstream of the bridge. This is constructed of a number of rocks dumped in the creek and is a 2 foot drop that is a fish barrier. The quarry could run very well without affecting Carrizo Creek if there was no fill on the floodplain, however, the creek has been intentionally confined by fill, causing the need for this grade control. There is also hydraulic fluid flowing from a broken jackhammer/backhoe flowing into the creek.

This landowner may be contacted and even shown how to construct a better grade control. They obviously maintain this reach to hold the grade of the creek, and upstream of this grade control is a long pool with many fish. Barney Rue also has tons of hand-sized rock that could be used for hand-built restoration structures all over the Rio Ruidoso watershed.

2. Headcut at tree, four foot fish barrier drop
Just upstream of the go-cart track, there is a large cottonwood that has fallen into the creek and created a four-foot waterfall. This is a temporary barrier to fish passage and will soon cut through and send a headcut upstream. The treatment would be to build a rock grade control cross vane to drop this grade safely.

3. Reach through Go-Cart Track
The reach through the Go-Cart Track is surprisingly healthy and has fish living in it. There is shotcrete on both banks and probably under the creek as well, but grass and soil have colonized the banks. Small modifications with rocks by hand could ensure that this habitat stays healthy and that there is fish passage upstream from the Rio Ruidoso.



Rio Ruidoso:

The Rio Ruidoso was assessed from the Mescalero Apache Reservation boundary downstream to the Dripping Springs fish ponds. This river suffered from a 100 year flood event in spring of 2008. A great amount of damage, both natural and human-enhanced, was caused by this flood. Unfortunately, the modifications to the banks after

the flood have caused the river in the Upper Canyon through mid-town to become permanently altered, and may prevent this portion of the river from ever becoming a healthy ecosystem again.

The resource impairments will be split into two types, before flood (development) and after flood (responses).

Upper Canyon
This reach has many private residences on the banks of the river and in its floodplain. The river has been moved out of its original channel in several locations but was in fairly good condition before the flood.

Pre-flood conditions:

Encroachment on River
There has been a large amount of development in Ruidoso on the banks of the Rio Ruidoso. To keep the foundations of the house or building dry, the floodplain of the river has been filled in and lost to the river. This lack of a floodplain caused the flood event to be much higher by confining the flood. The presence of buildings or houses in the 100 year floodplain caused the water to spread even wider and flood buildings that would have been safe if the banks of the river had been left undeveloped.

Lack of bank vegetation
There is a notable lack of either willows or riparian bank vegetation in the Upper Canyon. This may be due to the large amount of shade from Ponderosa pines and Douglas Firs, but is probably an affect of human management of their river bank. Many informants informed the assessment team that landowners preferred to "see the river" and that they cut vegetation in order to see the water. Unfortunately, willows and riparian vegetation provide shade, bank stability, flood attenuation, and food for fish, and a creek without vegetation on its banks is very unhealthy and in a downward trend.

Urbanized Runoff
The entire Upper Canyon is filled with roads and driveways with very little area for water infiltration or storage. Most of the area has direct hydraulic connectivity with the creek, causing floods to peak quickly and pollution to enter the creek even after a small rainfall. This is a systemic problem, but landowners could be encouraged to contain their own roof and driveway runoff on their property.

Post-flood conditions

The 100 year flood obviously affected the 100 year floodplain where many houses and buildings were situated.

Gunnite bank protection after flood
The gunnite bank protection placed after the flood was a attempt to protect properties from the next flood. However, this 20,000 linear feet of bank protection has changed the Rio Ruidoso forever in unfortunate ways.

This material will not:

- Grow bank vegetation such as willows to shade the creek
- Allow water storage in the banks
- Allow the river to deposit sediment and become narrower and deeper
- Allow the river to create floodplains by natural meandering and small amounts of bank erosion
- Provide fish habitat by the creation of undercut banks
- Allow pools to form in the creek by natural processes of sediment movement

This installation will:

- Keep the river 20 feet wide and 2 inches deep at low flow, which creates poor fish habitat
- Ruin landowners aesthetic appreciation of their natural river
- Hurry water downstream and dry out Ruidoso
- Cause more flood danger downstream by the lack of a floodplain and floodplain vegetation to buffer flood forces

Cobblestone and filter fabric bank protection after flood
This material was used as an alternative to the Gunnite bank protection. It has the advantage of being more natural looking, however it will not hold. The cobblestones are not large enough to hold against a moderate sized flood as they are sitting on smooth filter fabric. The filter fabric will prevent any vegetation from growing and holding the cobbles in place.
If the cobblestones had been used alone, the natural growth of vegetation could have held the material in place against many flood events. However, the assessment predicts that this material will wash away in a moderate flood and create hazards downstream.

Reach 2; Mid-Town
Mid-town has many of the problems listed in the Upper Canyon. Three major resource impairments were identified in this reach.

1. Encroachment on River
The river in mid-town has encroachment both from commercial and residential development. In both cases, the banks are raised, the floodplains are filled in, and the Rio Ruidoso is entrenched in a flood conveyance channel. There is little chance for the river to flood a floodplain or grow bank vegetation on a floodplain.

2. Bank protection
Many of the same solutions used on the Upper Canyon, such as the Gunnite banks, were installed in mid-town. These will cause the same amounts of resource damage and prevent the river from adjusting to the after-effects of the flood. Some areas were protected by gabion baskets without gunnite, these prevented flood damage, but also force the Rio Ruidoso into an un-natural, unhealthy channel shape.

3. Urbanized runoff from Sudderth
The mid-town reach has the problem of suffering from a huge amount of un-diluted runoff from Sudderth and the entire town of Ruidoso uphill from Sudderth. There are few if any areas of stormwater detention. This allows stormwater to flow very rapidly to the river through culverts or along road-side ditches. This rapid flow causes a large increase in flood peak elevations, as well as introducing a large amount of street pollution such as turbidity and nutrients into the Rio Ruidoso.

Reach 3: Two Rivers Park to Close Road
The river restoration project at Two Rivers Park was completed several months before the 2008 flood. Many of the structures survived the flood intact, while others were

damaged to some degree. In general, the project survived the flood without needing any major bank protection measures installed, and there is a good opportunity to repair the damaged structures and plant riparian vegetation in Two Rivers Park.

Downstream from the Park to Close Road, a number of measures were taken to protect banks by either installing the gunnite bank protection, or using rip rap and boulders as bank protection. This reach has rather poor habitat and a moderate potential for restoration. Where enough room exists between the installed bank protection measures, the river is attempting to meander, sort sediments, and create pools and riffles. These areas should be planted with willows to encourage this meandering and the development of a small floodplain. Three resource impairments were identified in this reach.

1. Bank protection
Many banks were either protected before the flood with gabions or had the gunnite gabions installed after the 2008 flood. These locations have poor fish habitat, no floodplain, and a poor potential for restoration. In addition, the private property boundaries may complicate the completion of a project by restricting access to the river.

2. Widening of creek by bulldozers
The Rio Ruidoso in this reach has been bulldozed and the channel widened after the 2008 flood. The channel of the river is very wide and the sediments are unsorted gravel. This substrate on the channel bottom is un-sorted and poor habitat for fish. The widening of the river channel has caused the water to be very shallow and exposed to light. The solution to this issue is to plant willows where developing meanders are forming to encourage shading of the river and the development of a normal channel pattern and a riffle-pool bed shape.

3. Fish barrier at Gavilan Canyon Road bridge
There is a large scour pool at the Gavilan Canyon bridge that prevents fish passage upstgream. A well designed new bridge installation with consultation by a river hydrologist could address this problem and permit fish passage.

<u>Reach 4: Close Road to Avalon</u>
This reach is the first location on the Rio Ruidoso where there is not a large amount of development on both banks. The Cemex cement plant is on the south bank, and large pieces of rubble have fallen into the river and created scour pools for fish habitat. The property downstream from the cement plant is a Frisbee golf course and has some public access.

This area is the closest reach to the Village of Ruidoso that has the potential to be a very healthy reach with excellent fishing. One notable issue in this reach is that this is the first reach below Mechem that is not incised or entrenched historically, and the floodplain is still within reach of the river at all flood elevations. This reach has seven resource impairments that could easily be fixed to create an extremely healthy river.

1. Fish barrier at Close Road Bridge

The Close Road bridge creates a large scour hole downstream that is a fish barrier to migration upstream. This could be easily fixed with a well-designed bridge that addresses the scouring downstream.

2. Bank erosion
Just upstream from La Quinta Inn, there is a tall bank with erosion next to a 'Special Trout Water" sign. This bank should be fixed with vanes, not gabions, to ensure that the channel remains in a natural condition with deep pools for fish.

3. Grazing and vegetation
This area is still being used as a ranch (as well as a Frisbee golf course) and there is heavy grazing of the banks and the river. This prevents the growth of willows and riparian vegetation on the banks that would narrow the river, create meandering, and provide excellent fish habitat. If portions of the river channel were fenced from grazing, this area would rebound quickly and heal itself. The areas of the banks that are heavily grazed have no vegetation, as the damage from the 2008 flood with heavy grazing has prevented any grass from re-colonizing. Therefore there is little forage on these banks and small loss to the rancher if Cattle could be given access in particular areas between the fencing (road crossings) for water.

4. Point bar cutoff
There is one point bar cutoff that the landowner dug with a bulldozer to protect against bank erosion. There are several ways to fix this involving a well-designed and implemented stream restoration project that would return the river to its original channel and while preventing bank erosion.

5. Avalon Road
The area near Avalon Road has a great amount of bank modifications on the south bank downstream of the bridge. These have entrenched the channel and cut off flooding from the floodplain. The "ponds" on the bank at Avalon Road were the original channel of the

Rio Ruidoso when it flowed around the Ruidoso Downs rather than through the middle of the track. Some aggressive, Natural Channel Design-based restoration could restore the channel to a healthy elevation and create good fish habitat.

6. Walmart runoff
The majority of the run-off from Walmart cascades down the bank and flows unimpeded into the Rio Ruidoso. A small gabion has been installed to ensure that this runoff does not flow into the ponds (old channel) on the floodplain and be treated by natural processes. This site is an excellent location for a demonstration project treating stormwater runoff from Walmart.

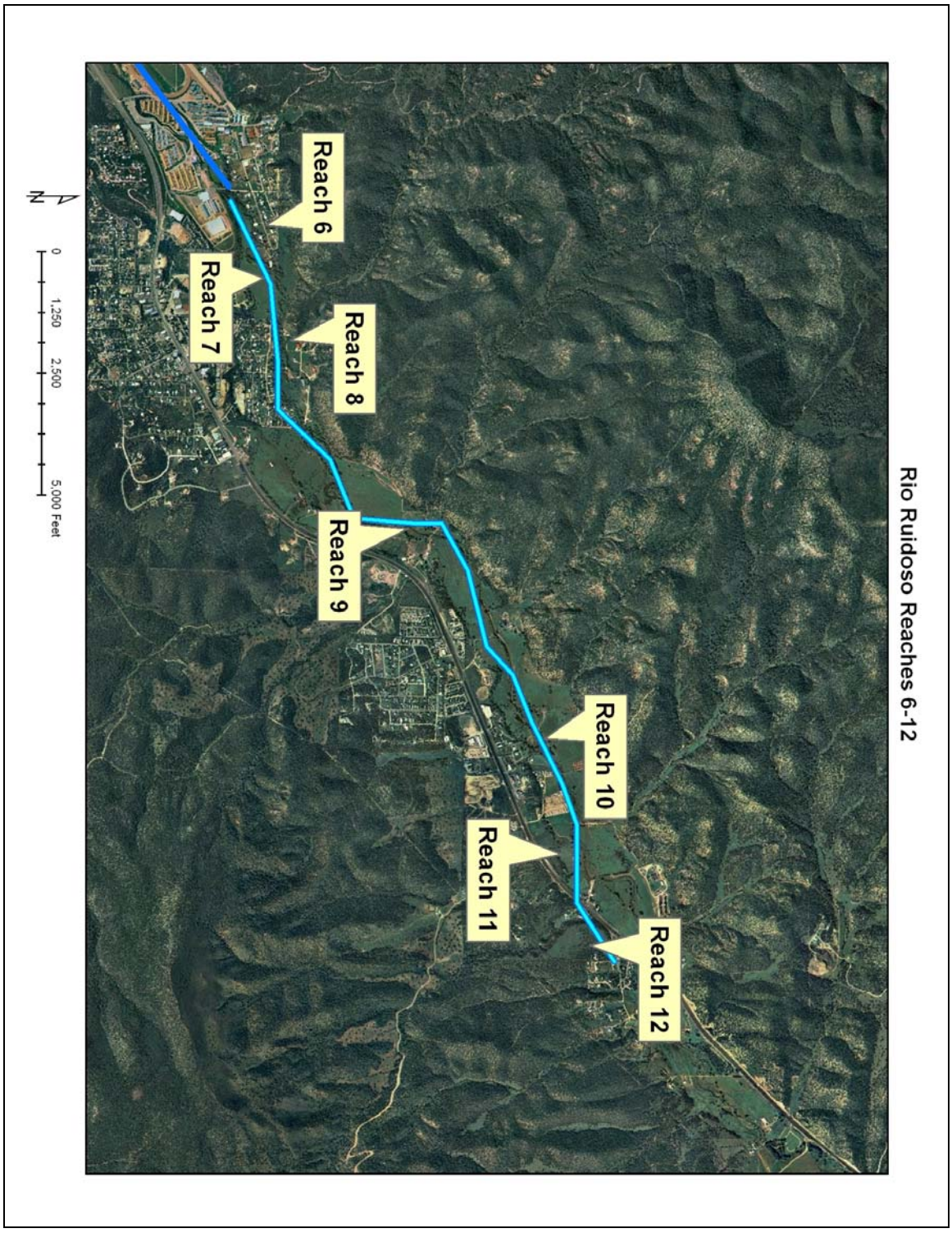
7. Drop inlet at Ruidoso Downs
This reach flows unimpeded to two culverts under the track at Ruidos Downs. It is obvious that these culverts were partially plugged in the 2008 flood. A well designed culvert inlet structure (Cross Vane) could ensure that these culverts do not plug again in a moderate sized flood.

<u>Reach 5; Ruidoso Downs Reach</u>
The Rio Ruidoso was moved from its historic channel on the south side of the track to the middle of the track. Straightening the channel required the installation of a large grade control to control the elevation of the river when it was straightened and steepened.
A large portion of this reach is undisturbed excellent habitat with breeding ducks and willows lining both banks. Two resource issues were found in this assessment.

1. Mine sediment and lower banks to floodplain
The Rio Ruidoso plugged the culverts at the upper track crossing and filled the channel with sediment. This sediment has been piled on the banks just downstream from the crossing at the upper end of the track property. This gravel should be hauled off-site and sold, and the banks returned to floodplain elevation.

2. Grade control fish barrier

The grade control that was installed to hold the elevation of the river during the re-alignment has created a large fish barrier. A complete removal and re-design would be necessary to allow fish passage upstream. However, two very healthy reaches upstream and downstream would be connected biologically.



Reach 6; Downs to Riverside Park

This reach was most likely dug and constructed to allow the river to be moved to the middle of Ruidoso Downs. The river is stable, but not healthy. One positive resource is the large amount of trees on the bank that shade the channel and keep the water temperature low. Two resource issues were found in this reach.

1. Channel entrenchment
The channel was either dug or forced into an entrenched form. The river is a straight gully and barely flooded out of its banks during the 2008 flood. The form of the river is stable with some deep pools, but without significant bank erosion, the channel cannot develop floodplains, riffles and pools. Any pool forming structures installed in this reach would not hold due to the lack of a floodplain to spread and buffer floodwaters.

2. Property boundaries
There are houses and properties on both banks that prevent any channel widening or allowing the river to create a floodplain.

Reach 7; Private land above irrigation diversion (name of Beavers)
The healthiest reach so far was found on private property below All American Park. The river is not entrenched and has very healthy meandering and deep pools. The river in this area has the elevation stabilized by a large irrigation dam downstream. This reach is a reference for healthy river function near Avalon Road. One resource impairment was found in this reach.

1. Shade and cottonwood trees
This reach was probably grazed for a long time by cattle, which eat willows and young cottonwoods. There is a lack of large trees for shading the creek and keeping water temperature low. Planting of cottonwoods, walnuts, and boxelders would provide a large benefit to the health of the river in this reach.

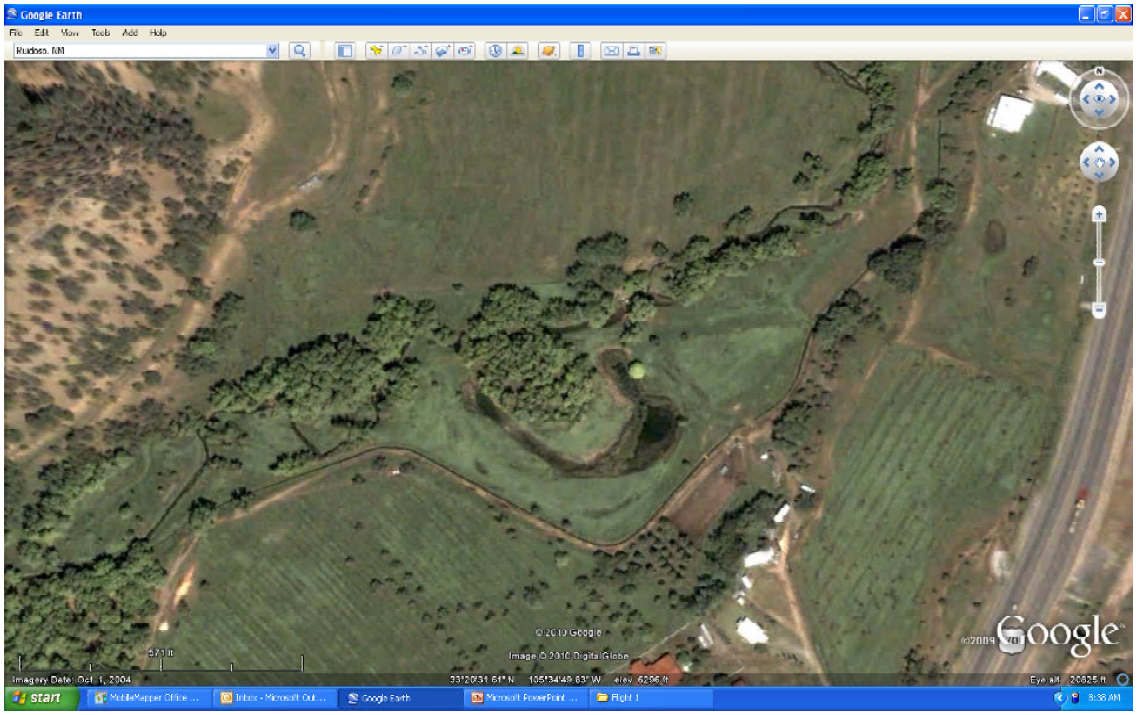
Reach 8; Log Crib Dam to Parker Road
The healthy reach above drops to an entrenched gully after a large log crib dam irrigation diversion. This dam is probably historic, and is a huge, nearly impossible to fix barrier to fish migration upstream. The river downstream has little floodplain, is relatively unhealthy (few pools), and has many private properties on both banks that would prevent significant restoration. Two major resource impairments were found in this reach.

1. Entrenched
The log crib dam created a waterfall with a large ten foot drop. The force of the water flowing over this has cut the channel very deeply downstream and has entrenched the river.

2. Custom grade controls
Due to the lack of a floodplain and the gullied form of the channel, several landowners have added custom rubble grade controls to prevent erosion near their properties. If the channel cuts very deeply by a property, it would probably initiate bank erosion that could threaten the property. These grade controls could be replaced with well built cross vane grade controls that would not act as fish barriers.

Reach 9; Parker Road Downstream on Stansell Ranch
This reach is private property with an active grazing program. Some areas on this ranch are fairly healthy upstream from the first irrigation diversion, while others are the worst functioning reaches in the Rio Ruidoso with the largest pollution problems. Several irrigation diversions create fish barriers and cause significant erosion below the large waterfall drop at the diversion dam. Three major resource impairments were identified in the assessment.

1. Meander cut-offs (aerial photo)
Two meanders of the Rio Ruidoso were cut off, one intentionally. The upper meander cut-off was done to prevent bank erosion, but has the potential to be restored to the previous state. This could store water on this property and create healthy fish and wildlife habitat. The second cut-off occurred after the 2008 flood and could also be restored with natural channel design restoration techniques.



2. Irrigation diversions
Two irrigation diversions create large waterfall fish barriers and caused significant damage to the river form and function after the 2008 flood. These waterfalls may not have been significant before the flood, but after the flood the banks downstream blew out and flooded the river with sediment.

3. Grazing management
This property is grazed by a small herd of Angus cattle. On the lower half of the ranch, below the second diversion, the blown out banks, excess sediment, and overgrazing has created the worst reach on the Rio Ruidoso so far. There is significant nutrient and bacterial input from the cattle herd, which was standing in the river when the assessment occurred and defecating into the Rio Ruidoso.

Restoration of the Rio Ruidoso in this area would require immediate fencing of the river from the cattle so that the river banks could heal by growing vegetation. This area provides no forage, so there would be little loss to the rancher except water for the cattle. In addition, an natural channel design based restoration project would have to be constructed to restore the river from the second irrigation diversion to the property line.

<u>Reach 10: Circle E, Beall Family Parnership</u>
The reach below the Stansell Ranch is managed very differently with horses and Llamas, neither of which eat willows or riparian bank vegetation. Due to this, the Rio Ruidoso in this reach is extremely healthy and provides a reference reach for the Stansell Ranch upstream. The river was able to adjust to the 2008 flood without significant resource damage. There is a beautiful duck pond on the south bank that is excellent habitat and a wildlife resource. One resource issue was identified in the assessment.

1. Shade by trees and willows
This reach is lacking willows and cottonwoods, probably because they were grazed-out by cattle in the past. This would be an easy project to be planted by volunteers or the landowners.

Reach 11; Lazy H to Hwy 70
The reach below the Lazy H irrigation diversion was blown out in the 2008 flood. There was significant sedimentation on the river due to the damaged banks. This reach is not entrenched, and if grazing were eliminated, would become an excellent reach with good fish habitat. However the lack of riparian vegetation and willows, as well as active modification of the channel (meander bulldozing), have created a wide, flat river channel with poor fish habitat. Three resource issues were identified in this reach.

1. Fish barriers
The irrigation diversion is another fish barrier and needs to be re-designed or modified to allow fish passage upstream. In addition, where the channel is overgrazed and 100 feet wide, fish passage is limited during low flows on the Rio Ruidoso in Spring and Fall.

2. Overgrazing
The Williams (?) property is heavily grazed and a meander cut off was bulldozed to straighten the river. This area is heavily grazed and the river is about 100 feet wide due to the grazing and sediment deposition in this modified portion of the channel. The Lazy H ranch is moderately grazed and has the potential to be restored easily by restricting grazing in the floodplain and replanting willows.

3. Bank vegetation
There is a healthy amount of bank vegetation near the sewage treatment plant due to a very high water table. This supports wetland vegetation that can thrive under heavy grazing pressure. The lowest portion of this reach is fairly healthy and the channel is narrow.

However, this entire reach has no willows and very few cottonwoods, as they have been grazed out of the system. Any cottonwoods seedlings that get established are quickly eaten by cattle.

Reach 12; Dripping Springs Fish Ponds

This reach is between HWY 70 and the outfall for the sewage treatment plant on the Dripping Springs RV Park Property. A river restoration project could be built but would require the active participation of both landowners. Two resource issues were identified on this reach.

1. Diversion

The irrigation diversion at the lower end of the property flattened the grade, which is causing the river to erode against the bank of the RV park. The extra sediment will continue to accumulate and cause bank erosion. In addition, the landowner sees willows as an impediment to the river, however they would protect him from erosion.

2. Road crossing

There is a private road crossing that is continuing to keep the river too wide to move sediment. This will continue to cause damage and force the river north into the RV park.

Proposed Projects

Stream Dynamics, Inc. Design / Build policy
Since successful application of watershed restoration techniques and water harvesting earthworks are intimately related to the specifics of each site, the policy of Stream Dynamics, Inc. is to follow through the entire process from assessment, through design, construction, monitoring, and maintenance. Qualified stream restoration contractors have years of training and experience working on creeks. This includes Level IV training from Dave Rosgen, watershed and wetland training from Bill Zeedyk, rainwater harvesting training from Brad Lancaster, and a few others. When non-specialized contractors are involved, the projects are built incorrectly and fail. When designing and constructing watershed restoration and water harvesting earthworks, the devil is in the details. When we leave the details to others who are not trained in these matters, it invariably results in problems.

Therefore, if Stream Dynamics, Inc. does not build a project that we have designed, we will supervise the construction of our design. This insures fidelity to the design concept, allows us to learn from the project results, and represents a commitment to both the watershed and the landowner to adjust and repair any work until it is functioning properly within the landscape. If any of the projects proposed below are designed and built by people who do not have the proper training, Stream Dynamics, Inc. cannot guarantee the sucess of the projects.

Creek Projects by Watershed

Gavilan Canyon Creek

<u>High School Wetland (Bog Spring) near Gavilan Canyon</u>
The High School buildings, parking lot and athletics field were constructed on a wetland that was drained for this purpose. There is still room, however, to recreate a functioning wetland habitat alongside the school, turning an ugly and eroding gully into a beautiful entrance to the school that is also an outdoor classroom for watershed and wetland education.

Stream Length treated: 5000 feet

<u>Gavilan Creek Delta at Ballfields</u>
This project would restore the delta zone of this tributary of the Rio Ruidoso. Deltas are important landforms that clean excess sediment from a tributary before allowing the water to enter the receiving stream. This delta has been narrowed with fill and encroached by the parking lot. This project would widen the floodplain of the Gavilan creek delta zone and protect the ballfield from flooding with an offset levee. The parking lot which drains directly to the river is creating resource damage. The parking lot would be modified to create water harvesting tree basins, and the parking spaces would be formalized in rows under the trees. In addition, a water harvesting detention basin could be built near the Gavilan Canyon Road bridge to filter and detain runoff before it enters the river.

Stream Length treated: 1000 feet

Cedar Creek

Private land reach

This project would correct many driveway culverts that are fish barriers that create headcuts and bank erosion. This problem starts at the upper Forest Service boundary and goes all the way to the Rio Ruidoso. Culvert treatments would include Rosgen Cross Vane drop inlets at the upstream end of culverts that have been set too low, constructed riffles (rock rundowns) at the downstream end of culverts which are set too high or have a waterfall on the downstream end. These simple treatments would prevent erosion on the upstream or downstream end of the culvert and prevent it from becoming a fish barrier.

Stream Length treated: 10,000 feet

Forest Service reach from private land to Mechem Drive

This project would treat and restore many legacy headcuts and meander pattern problems in this reach. Except for a few roads in the campground area, there is very little infrastructure that would be affected by raising the water table or by raising the flood stage. Also, this is one of the few places where stream restoration work can be done on Federal lands. The Forest Service is generally open to cooperating with other stakeholders on such a project, especially if stakeholders provide the funding.

Stream Length treated: 7000 feet

Hart Road to the Ruidoso River

A particularly important reach to address the fish barrier problem is from Hart Road to the Rio Ruidoso. This would restore the lower portion of Cedar Creek to properly functioning fish habitat and create a hatchery for the fishery in the Rio Ruidoso.

Stream Length treated: 3500 feet

Carrizo Creek

Carrizo Creek from Rainbow Lake RV Park to Barney Rue Sand and Gravel

Carrizo Creek is a very good fishery and has the potential to become much better. This creek has perennial, stable flow due to seepage from Mescalero Lake. The large amount of lime in the water keeps the pH stable and maintains water quality. This includes reaches 2 and 3 on the reach assessment.

A large project or separate projects could address the main issues on the middle reach of Carrizo Creek. The largest fish barrier is due to encroachment from private properties in the middle of this reach. There are many potential fish barrier culverts that would be treated, as well as check dams that block fish passage. Other important issues are public outreach on mowing floodplains and addressing a number of headcuts that lower the water table and harm fish habitat.

Stream length treated: 7000 feet

Eagle Creek below Alto Reservoir

This project would construct a loop trail from the reservoir downstream to several beautiful waterfalls on bedrock. A loop trail to see the waterfalls would be a worthwhile one mile walk from the Alto Reservoir. The best location for a trail is on the south bank next to the overflow from the dam. A trail would have to be cut into the hillside and switchbacked down the hill, where it could meet an existing trail on the south bank of the creek. The trail could return up the north side of the creek and then climb the switchbacks up the hill.

Project length: 5000 feet

Rio Ruidoso

Engineering of Bridges

Stream Dynamics, Inc. proposes that each new bridge project be engineered by a professional stream restorationist who is also a Professional Engineer. The cost of this work will be counted as restoration dollars, but not the cost of the bridge itself, unless the engineer's design increases the cost of the bridge, in which case only this additional cost will be counted as restoration dollars.

Two Rivers Park

This project consists of River Restoration repairs to the Two Rivers Park project, including a riparian vegetation planting component. In addition, construct the expansion of Two Rivers park as originally proposed.

Stream length treated: 3000 feet: 1500 feet at Two Rivers Park and a 1500 foot extension

Avalon Road / Walmart parking lot

This project site is an excellent choice because several important issues can be addressed at one site. Runoff from the Walmart parking lot contains lots of dirt from the hillside above. This goes directly into the river with disastrous consequences for fish habitat. The entire route of the storm water all the way to the river needs to be taken care of in a responsible fashion, starting in the subdivision on the hill above Walmart. The excavation for the parking lot cut into a hillside that contained a natural drainage, turning it into an erosive waterfall.

On the floodplain of the river, there is an excellent opportunity to create water harvesting detention basins for a final cleaning of the water by sending it subsurface into the river during all but the very largest storms. Planting native riparian species on the right bank will take advantage of the additional water from the detention basins, protect the banks of the basins with their roots, and stabilize the river bank as well.

Stream length treated: 500 feet

Cement Plant to Avalon Road

This project would restore the best potential fishing area on the Rio Ruidoso near the Village. This is the first reach downstream that has a healthy floodplain and is not entrenched into the landscape. The property owner, Circle E, LLC, would have to be a

willing partner in this project. There would need to be a restoration project implemented to repair the meander cut-off that was created with a bulldozer on this reach. The other portions of the project would address channel width by planting and maintaining vegetation on the banks, and managing cattle grazing.

Stream length treated: 2500 feet

Parker Road Energy Dissipator

There is a very large and expensive concrete energy dissipator at the Parker Road bridge. This is at the terminus of a long ditch which routes water from a small natural basin across the highway. This water goes past an agricultural field for 700 feet and could easily be used to irrigate approximately 17 acres of farmland. If the landowner does not want this, there is certainly room to get this water to slow down, soak into the ground, and arrive at the river cleaner and less erosively. Benefits include modulating the flood pulse to the river, reducing downstream erosion, improved water quality, increased base flow, improved aesthetics, and providing a positive example of using stormwater as a beneficial resource.

Fixing Rio Ruidoso on Stansell Ranch

This project would involve repairing two meander cut-offs on the Rio Ruidoso on Stansell Ranch. Some treatments to address the fish barriers at the two irrigation diversions would also be suggested. A grazing management program and revegetation program would also be initiated to restore the riparian bank vegetation and canopy above the river. Other treatments would be determined by a complete assessment and survey of this reach. This project would address the worst portion of the Rio Ruidoso, and would have a beneficial effect on downstream owners and water users.

Stream length treated: 5,500 feet

Fixing Rio Ruidoso on the Lazy H Ranch

The Rio Ruidoso on the Lazy H ranch has both healthy and unhealthy reaches. However, there is a good potential for a healthy river in this reach. One treatment would involve fixing the irrigation diversion so that it is not a fish barrier. There would be a large willow and cottonwood planting component and fencing of the riparian area so that grazing can be managed. In addition, the Williams Ranch reach, where the Rio Ruidoso is 100 feet wide with excess sediment, would have to be completely restored and a new channel dug into the sediment overburden.

Stream Length: 3500 feet

Projects Involving Legislation or Management/Policy Decisions

Retain Funds for the next Post-Flood evaluation

It is apparent that the post-flood work was not done by a trained river restorationist. It was done hastily as an emergency response, yet the emergency was over when the water subsided and everyone was rescued. Note: this is when the true emergency for the community and the river ecosystem began. This river is in much poorer condition now because of this work, most of which was not only expensive, unnecessary, and

catastrophically ugly, but actively harmful to both the proper function of the river and overall flood protection for the community.

This proposed project is to retain funds to hire Stream Dynamics, Inc., or another equally qualified firm, to evaluate the river and tributaries after the next big flood and advise the municipalities on how to best respond. Once the floodwaters have receeded and everyone has been rescued, the mayor should put a halt on all heavy equipment use until a proper emergency assessment has been made by helicopter and on foot.
This is why: Natural rivers have a central tendency to self heal. Large floods do important work of sorting sediment and shaping floodways, sculpting beautiful and effective energy dissipating fish pools and meander bends, building groundwater replenishing and energy dissipating floodplains and installing flood protection in the form of river terraces. This work has been done by the river free of charge for millennia.

This is what created the beautiful streams and valleys where Ruidoso was founded. For many people, this aesthetic value has been destroyed, especially in the Upper Canyon. Properly evaluating the changes wrought by a large flood can sort out the beneficial changes from the true problem areas, and greatly reduce the extent and cost of repairs. Sometimes the most cost effective approach is to not rebuild infrastructure in harm's way. A team who understands both river processes and human values needs to be empowered to make difficult decisions and provide balanced recommendations to the authorities.

River Protection Ordinance

Preventing future damage to the streams is a good way to leverage precious restoration dollars. This is much more cost effective than allowing untrained operators to do ill advised things to the river that will exacerbate the stated problem, then fail and have to be redone at great expense. Therefore, generous credit should be given to each municipality that writes, passes and vigorously enforces a river and stream protection ordinance. Provisions should include prohibition against filling the floodplain, straightening the watercourse, placing manmade materials in a stream, and manipulation of the stream channel without a U.S. Army Corps of Engineers 404 permit and a State of New Mexico 401 permit. All of these actions are illegal under federal law and are very common in Ruidoso on private lands. Discharging stormwater runoff directly to a watercourse without a natural buffer strip should also be prohibited.

Designing and constructing stream channel manipulations without proper training in river restoration (Rosgen level IV training) should be prohibited. Several states now require this training. Any projects designed by engineers should be reviewed by a river restorationist. Only contractors specifically trained in river restoration should be allowed to do work within the flood prone area of a stream.

Stormwater / Water Harvesting Ordinance

A progressive ordinance that both allows and encourages landowners to do projects on their property, selected from a list of best management practices including cisterns, proper driveway drainage, proper culvert installation, water harvesting earth basins, and so on, should be written and passed into law by both municipalities. Stream Dynamics, Inc. asserts that this would be an extremely valuable in-kind contribution. It

would address an important cause of degradation, and should receive a large credit if properly implemented.

Drainage Management

The Village of Ruidoso Downs has a draft drainage management plan. This plan does not sufficiently consider water quality, and it does not value stormwater as a water source. Instead, it treats stormwater as a nuisance. Substantial modifications to this plan that take into account the latest advances in stormwater management would be worth substantial credit. If stormwater is converted from a nuisance to a water resource, this will substantially alleviate the municipality's needs to develop additional well fields or other water infrastructure, saving lots of money while protecting the groundwater resources. It is proposed that the Draft Drainage Management plan include small water harvesting earth basins that will each detain 100% of the two year storm, causing the water to soak into the ground within 48 hours.

Water supply and Demand Projects

There are four basic sources of water available to the city: well water, water from the reservoirs, greywater, and stormwater. The first two have been developed extensively and expensively to the detriment of the natural stream system. Developing greywater and stormwater as water sources will relieve the pressure to drill more and deeper wells, and prove to be a very cost effective solution because it will simultaneously address multiple issues of water resource needs and stream channel degradation.

Stormwater

Residential and commercial water harvesting demonstration project

Dan Dee Cabins could be used as a stormwater demonstration site. During a recent rainstorm, most of the access roads to the cabins lost their surfacing material. This has since been relaced, but the roads have not been properly drained. This project would demonstrate the proper drainage of driveways, confine the driving surfaces to the minimal area needed, build small stormwater harvesting basins, and restore a healthy ground cover to prevent runoff from escaping to Main Street, which drains directly to the river.

Winfield Park

This new park was created by draining the wetland ecosytem. This type of land conversion is an important reason why the Rio Ruidoso has flooding, poor water quality and poor fishing relative to the potential of this beautiful mountain river. The proposed project is to remove most of the drainage tiles and create a beautiful wetland with a few ponds to lower the water table. The overflow from the ponds would enter the last remaining tiles and flow to the river via culverts. This area would be much more beautiful and productive than this site was prior to the recent wetlands draining work. Footpaths, benches, and other amenities can be incorporated into this site on the perimeter of the wetlands.

Analyze Emergency As-Built Gabion Basket and Stream Revetment

20,000 linear feet of gabion baskets and other expensive, ugly, poorly designed treatments were hastily built on the river after the flood. These projects addressed only the immediate issue of bank erosion without looking at the effects on river function. The proposed project is to hire an engineer who has training and experience doing natural channel design river restoration to model the anticipated response during the next large flood.

It is our belief that these treatments were never modeled as an "as-built" project to assess their affect on 100 year flood elevations in the future. Ruidoso has an excellent model created to design the gabions, it could easily and at a moderate price model the flood elevations in the next large flood.

Drop Structures / Clogging / Fish Barriers

All culverts on all streams were checked for this issue. The assessment has a very complete list of all culverts and their affects on the river and creek ecosystems. A project could be implemented to install culvert inlet structures and outlet splash pads on many culverts and address the fish barrier problem. These all need to be fixed by a qualified stream restoration professional.

Public Awareness of River Issues Projects

River Keepers River Cleanup

Fund river cleanup to the tune of $10,000 per year for ten years. This is an important way to keep citizens involved in the health of their river while cleaning up hazardous items and other pollution.

River Keepers Water Stewardship Training

River Keepers could organize a water stewardship training for interested residents. This would train people in the neighborhoods to design and build water harvesting earthworks for themselves and their neighbors. There is a good model in Tucson, Arizona to follow. Residents in an increasing number of Tucson neighborhoods are transforming runoff into a beneficial resource for the community. This could be happening in Ruidoso as well.

River Coordinator

Create a river coordinator position in the planning and permitting section of the municipal government. This individual would help promulgate proper Best Management Practices for stormwater treatment, water harvesting, stream bank protection, proper culvert installation, etc., and encourage public awareness of river ecosystem health issues, such as the new stormwater / water harvesting ordinance..

Water Harvesting Conference

The two municipalities can host a water harvesting conference featuring notable water harvesting experts from the Southwest such as Brad Lancaster, the author of *Rainwater Harvesting for Drylands*. This is an excellent way to stimulate interested people to do projects on their own. Brad was the keynote speaker at the 2007 Gila River Festival, and inspired people in Silver City to complete several projects.

Project Ranking Criteria

Evaluating the merits of a wide variety of proposed projects by a diverse committee can be a difficult task. An important criterion is creating ample opportunity for stream based recreation, including fishing. This is closely related to aesthetic value and appreciation of natural beauty, which benefits everyone, whether they fish or not. There are also concerns about bank erosion, riparian shade trees, water pollution, wildlife habitat, nature trails, stormwater management, saving society money over the long term, preventing future damage to infrastructure and natural systems, to name several of the most important criteria.

Fortunately, there are established State of New Mexico standards for temperature and impurities for this watershed. As will be explained below, these encapsulate many of the other criteria. Temperature and impurities are easy to observe and explain to everyone, and are quickly and inexpensively measured. Another easy to determine metric for general watershed health in this mountain stream network is the quality of the fish habitat. This is also a very important value for this community. It is for these reasons that Stream Dynamics proposes three criteria for ranking the various projects: turbidity, water temperature, and the quality of the fish habitat.

Stream Dynamics proposes that trying to rank these criteria on a scale is fraught with difficulty, and that this evaluation should be a yes or no vote. Either a project does or it does not substantially help to address a particular issue.

Turbidity

Turbidity is caused by small particles suspended in the water, making it appear less than crystal clear. Natural healthy streams have a small amount of turbidity. Impaired streams can sometimes have so much that it is disruptive to stream ecology. This is the case for the Rio Ruidoso and tributaries. As has been described in the assessment section of this report, the main source of excess turbidity in the Rio Ruidoso and tributaries comes from sediment caused by runoff from streets, improper stormwater management from urbanized surfaces, poorly designed culverts and bridges, poor bank stability due to lack of riparian vegetation, bank modifications and floodplain encroachment, conversion of wetlands to other uses, etc.

As the state document quoted below describes, this has deleterious effects on the local fishery. The sediment load is so great that it also affects the stability of the creek, including the natural formation and maintenance of pools and riffles. These are important both for fish habitat, and for habitat for fish food species. Since so many stream health effects can be encapsulated by turbidity, and turbidity is easy to understand, readily observable, and inexpensive to measure, we propose that this be used as one of the primary evaluation criteria for determining which projects will best serve the watershed, the community at large, and the stipulations of the consent judgement.

For the convenience of the committee, the following quotes have been copied and pasted directly from a document prepared by the State of New Mexico Surface Water Quality Bureau entitled *Final Approved Total Maximum Daily Load (TMDL) for the Rio Hondo Watershed (Lincoln County) Pecos River to Headwaters:*

According to the New Mexico Water Quality Standards (20.6.4 NMAC), the general narrative standard for turbidity reads:

Turbidity: Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function, or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water.

The total suspended solids (TSS) analytical method is a commonly used measurement of suspended material in surface water. This method was originally developed for use on wastewater samples, but has widely been used as a measure of suspended materials in stream samples because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. This analytic method does not discern between solids produced from erosional activities versus biosolids when instream samples are collected and analyzed. Since there are no WWTPs discharging into this reach of the Rio Ruidoso, it is assumed that TSS measurements in these ambient stream samples are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from WWTP effluent. Turbidity levels can be inferred from studies that monitor suspended sediment concentrations. Extrapolation from these studies is possible when a site-specific relationship between concentrations of suspended sediments and turbidity is confirmed. Activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (USEPA 1991). The impacts of suspended sediment and turbidity are well documented in the literature. An increased sediment load is often the most important adverse effect of activities on streams, according to a monitoring guidelines report (USEPA 1991). This impact is largely a mechanical action that severely reduces the available habitat for macroinvertebrates and fish species that utilize the streambed in various life stages. An increase in suspended sediment concentration will reduce the penetration of light, decreases the ability of fish or fingerlings to capture prey, and reduce primary production (USEPA 1991). As stated in Relyea et al (2000) "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrouphs to substrate surfaces."

Temperature

The Rio Ruidoso and its mountain tributaries that flow through town are historic high quality cold water fishery. Many environmental, vegetation and stream geomorphology factors are neatly encapsulated in the stream temperature criteria. Consider the existence of substantial wetlands in the watershed. Wetlands provide energy dissipating floodplains and alluvial storage in the stream system, decrease erosive peak flows, store the water in the ground where it is not exposed to the sun, and slowly release it, providing for higher base flows than if the wetland did not exist. Higher base flows coming from cold underground storage make for lower summer water temperatures and better fish habitat.

Consider healthy stream geomorphology maintained by mature stands of native vegetation: Overarching riparian trees shade the water surface in the summer and keep the water cool. The roots and many stems of willows protect stream banks, maintaining a narrow and deep channel with undercut banks. The action of occasional very large floods under the modulating influence of native riparian streamside vegetation creates and maintains deep scour pools and a narrow meandering channel with an energy dissipating floodplain that also serves as alluvial storage under the trees. All of this combines to keep the base flow higher and the water temperature lower, especially in the summer when it is the most critical.

Since so many stream health effects can be encapsulated by the temperature, and temperature is easy to understand, readily observable, and inexpensive to measure, we propose that this be used as one of the primary evaluation criteria for determining which

projects will best serve the watershed, the community at large, and the stipulations of the consent judgement.

For the convenience of the committee, the following quotes have been copied and pasted directly from a document prepared by the State of New Mexico Surface Water Quality Bureau entitled *Final Approved Total Maximum Daily Load (TMDL) for the Rio Hondo Watershed (Lincoln County) Pecos River to Headwaters:*

Monitoring for temperature was conducted by SWQB in 2003. Based on available data, several exceedences of the New Mexico WQS for temperature were noted throughout the watershed (Figure 6.1). Thermographs were set to record once every hour for several months during the warmest time of the year (generally May through September). Thermograph data are assessed using Appendix C of the State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report (NMED/SWQB 2004b). Based on 2003 data, the temperature listing on the 2002-2004 CW §303(d) for Rio Ruidoso (US Highway 70 to Mescalero Apache boundary) was confirmed. Temperature data from 2003 were used to develop TMDLs.

*The State of New Mexico has developed and adopted numeric water quality criteria for temperature to protect the designated use of high quality coldwater fishery (HQCWF)(20.6.4.900.C NMAC). These WQS have been set at a level to protect cold-water aquatic life such as trout. The HQCWF use designation requires that a stream reach must have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain a propagating coldwater fishery (i.e., a population of reproducing salmonids). The primary standard leading to an assessment of use impairment is the numeric criterion for temperature of 20 °C (68°F). Table 6.1 and Figure 6.1 highlight the 2003 thermograph deployments. The following TMDL addresses a reach where temperatures exceeded the criterion (**Appendix G** of this document provides a graphical representation of thermograph data): Rio Ruidoso (US Highway 70 to Mescalero Apache boundary): Three thermographs were deployed on this reach in 2003. One thermograph was deployed at Rio Ruidoso at Hollywood USGS gage (site 8), recorded temperatures from May 20 (17:00) through September 15 (14:00) exceeded the HQCWF criterion 185 of 2,830 times (6.5%) with a maximum temperature of 23.71°C on July 8. A second thermograph was deployed at Rio Ruidoso at Hwy 70 above the WWTP (site 9), recorded temperatures from May 20 (17:00) through September 16 (12:00) exceeded the HQCWF criterion 362 of 2,852 times (13%) with a maximum temperature of 23.74°C on August 10. The third thermograph was deployed at Rio Ruidoso at Mescalero boundary (site 10), recorded temperatures from May 20 (17:00) through September 16 (14:00) exceeded the HQCWF criterion 289 of 2,854 times (10%) with a maximum temperature of 25.07°C on July 9.*

Fish Habitat

High quality cold water fish habitat is a water quality designation made by the State of New Mexico Environment Department, Surface Water Quality Bureau. There are also various habitat suitability index models, and computer programs such as Fish-X that model barriers to fish migration. To get a practical sense of the important factors that determine good fish habitat in Ruidoso, we spoke with Shawn Denny of New Mexico Department Game and Fish.

<u>Pools</u>

According to Mr. Denny, limiting factors in Ruidoso are lack of sufficient pool habitat, particularly during summer low flows. Brown Trout do best with a 50-70% pool to riffle-run length. Projects such as the Boulder lined pools at Two Rivers Park, and those that improve streamside vegetation (which tends to create and maintain pools) would help the fish habitat; also beneficial are projects that would prevent silt (that could clog these pools) from arriving to the stream system from contributing sources.

Width to depth Ratio

Another limiting factor is the width to depth ratio of the riffles. If the stream is too wide, it will be too shallow to be good fish habitat. Channel manipulations such as bank protection gabions that increase the width to depth ratio are bad for the fish.

Sediment

Runoff that is high in sediment can fill in pools and clog gravels which are spawning habitat and habitat for macroinvertebrate prey species. Relatively silt-free inputs are best. Filtering stormwater before it reaches the river would address this issue.

Canopy

For most Brown Trout streams, canopy cover will ideally provide 50-75% mid day shade. Too little shade, and the temperature may get too high from sun striking the water, too much shade, and the riparian forest (which requires sun to grow) will become decadent. Projects that help the stream banks achieve the optimal level of riparian canopy cover are beneficial.

Fish Migration Barriers

Fish migration barriers for the Rainbow Trout put/take fishery is not an issue. This is a significant issue for wild Brown Trout, however. Brown Trout run upstream to spawn in the fall and fry tend to move downstream. Fish barriers can cause isolated upstream reaches to become depopulated over time. Migration barriers at the top of a stream are less important than ones lower in the stream system.

For a drop-off to be an effective barrier, it must be high in relation to the jump pool below it. If there is no significant jump pool, a 6" dropoff is too high. Culverts have velocity and length limitations due to fish exhaustion. In Ruidoso at this time, Carrizo Creek is the only tributary that contributes significantly to the fishery. This may be because, although it has drop-offs, most of these have deep jump pools below them, where Cedar Creek and Gavilan Canyon Creek do not. Projects that eliminate fish barriers are likely to greatly improve the fish population in the Rio Ruidoso and its tributaries.

Flow Regime

Mitigating summer low flows is very important for fish habitat. Projects that can store floodwaters in the alluvial aquifer and re-release this water slowly during periods of low flow are beneficial for the flow regime.

END

Addendum 1; Riverside Park

This newly built park is in the City of Ruidoso Downs. Two modifications are suggested to the design and construction of the park that would positively affect river function and health. On the east side of the park, a large gully brings stormwater past the park directly into the river. This gully could be treated with a rock-lined channel and the water harvested and spread across the park with small basins and water spreading structures. The second modification would harvest the water on the west side of the park and direct this water into the pond, as shown in the picture.

East side of Riverside Park