RATTLESNAKE CANYON SEDIMENT AND DRAINAGE MITIGATION STUDY

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THANK YOU TO PARTICIPANTS:

Jefferson County Soil and Water Conservation District
Confederated Tribes of Warm Springs
Study Area Landowners
North Unit Irrigation District
Natural Resources Conservation Service
Oregon Water Resources Department
Oregon Department of Transportation
Oregon Department of Agriculture
Oregon Department of Environmental Quality

I. EXECUTIVE SUMMARY

In 2007 an issue was highlighted by the Confederated Tribes of Warm Springs and brought to the attention of the Jefferson County Soil and Water Conservation District. It involved the observed discharge of sediment-laden water during certain periods of the year into the Deschutes River at Rattlesnake Canyon above the CTWS drinking water extraction point from the River. This concern was evaluated by the CTWS, JCSWCD and NUID in 2007 with mixed data results. Following these initial efforts, farming interests located on Agency Plains above the Rattlesnake Canyon implemented mitigating measures including the excavation and construction of tail-water capture ponds at the canyon rim on the Boyle property. Unfortunately, the varying tail-water flows above Rattlesnake Canyon and background flows within the canyon continued to pass sediment-laden water intermittently to the Deschutes River.

In 2012 another concerted effort by the JCSWCD, NUID and other agencies was performed to gather more field data to try to better understand the characteristics of the sediment discharge issue. From March to October of 2012, turbidity and flow rate data was gathered at several key points within the drainage area. After completion of this series of measurements and solicitation of more input from landowners, the JCSWCD and the NRCS felt it important to obtain the services of a professional engineer to evaluate the situation and data further.

In 2013, Black Rock Consulting was employed under a Technical Assistance grant to evaluate the issue and to:

1) Involve Landowners and Stakeholders in the Process
2) Gather Additional Field Data and Develop and Understanding of the Issues at a Reconnaissance-Level
3) Develop a Recommended Solution or List of Solutions for Further Consideration in Higher-Level Evaluations and/or Designs Specific to the Solution or Solutions
4) Develop a Map Indentifying the Location of Proposed Solutions Relative to the Study Area

After meeting with landowners, reviewing the data, and collaborating with agencies and stakeholders, I summarized the cause of the issue as follows:

1) Background flows in Rattlesnake Canyon are 2CFS-7CFS (non-irrigation season)
2) Higher flows are generally passed to Rattlesnake Canyon in the early irrigation season (April-June). Thunderstorms and precipitation concident with this period likey exacerbate the flow rate spiking issue.
3) Rattlesnake Canyon discharge later in the irrigation season indicated little presence of sediments.

4) Farming practices tend to disturb the fine-grained Loess soils and such disturbance is greater and wider-spread early in the irrigation season conicident with the periods of higher and "spikier" flows.
5) Sediment-laden ponds and lack of additional storage exacerbates the sediment transport issue.
6) The ODOT quarry segment of Rattlesnake Canyon appears to add some sediment to the flows passing the site. Some additional flow is added through the ODOT site as well.
7) During these early irrigation season periods, as flows increase, sediment entrainment in the drainage water increases and is noticeable at the Rattlesnake Canyon drainage confluence with the Deschutes River when NTUs climb above 20 NTUs.

The recommended solutions that were a subset of proposed solutions already provided by landowners are:

1) Implement small on-farm ponds
2) Clean existing ponds
3) If necessary after lack of implementation or only partial implementation of 1) and 2), develop a series of small ponds in Rattlesnake Canyon
4) Encourage and try to fund the implementation of additional on-farm practices: Sprinkler conversion from flood irrigation, no-till farming, and long-chain polymer soil binder use
5) Apply excess water to currently non-irrigated but eligible farm land
6) Maintain existing drains
7) Coordinate with NUID for the implementation of Lateral 63 head-end telemetry to better regulate flows to the study area

II. BACKGROUND

In 2007 the Confederated Tribes of Warm Springs (CTWS) water quality management team contacted the Jefferson County Soil and Water Conservation District (JCSWCD) to collaborate on a sampling regime to try to better understand the sediment and nutrient introduction at the Rattlesnake Canyon drainage confluence with the Deschutes River. The CTWS was concerned with the sediment (and associated nutrients) being discharged as the water supply to the Warm Springs Reservation is located downstream of Rattlesnake Canyon on the Deschutes River.

A map of the study area is attached after Section X. of this study. The study area location is Township 9 South, Range 13 East, sections 29, 30, 31 & 32. The Rattlesnake Canyon is approximately 8,400-feet in length and the gradient is steep until it reaches the Oregon Department of Transportation (ODOT) rock quarry. There is a rock boulder berm along the Rattlesnake Canyon drainage in this canyon that is limited to the Oregon Department of Transportation (ODOT) Source OR-16-015-4 described as NE 1/4 NE ¼ of section 31, Township 9 South, Range 13 East, W.M. Jefferson County. ODOT refers to the quarry as Geeder Canyon Quarry, DOGAMI # 16-0018 and further locates it at M.P. 105.9 of Warm Springs Highway or State Highway 26 M.P. 105.9. The Deschutes River serves as a boundary marker between the Warm Springs Reservation and Jefferson County Agency Plains.

Attachment A describes a series of studies that were performed by the Jefferson County Soil and Water Conservation District and the North Unit Irrigation District as well as the Confederated Tribes of Warm Springs (CTWS).

Starting in 2007, the JCSWCD and the North Unit Irrigation District collaborated with the CTWS to try to sample the Rattlesnake Canyon drainage water with mixed results. Once the concern was raised and landowner became aware of the gravity of the issue, tail-water ponds were constructed near the canyon rim to capture the excess water. Additionally, the JCSWCD, the NRCS, OWEB and NUID worked cooperatively since 2007 to provide incentives for irrigation efficiency projects that would reduce tail-water.

But this collaboration turned into a more concerted effort to evaluate the matter and collect additional data. In 2012 the JCSWCD and NUID collaborated further with the CTWS, ODOT, DEQ and ODA. Flow rate and turbidity monitoring and analysis by the JCSWCD resulted in a helpful data set that refined the understanding of the intermittent sediment transport from the Agency Plains study area through the Rattlesnake Canyon to the Deschutes River. In 2012, area landowners were invited to a meeting to discuss the data gathered in 2007, frame the issue, and to solicit input. Following this meeting, the JCSWCD believed it vital to employ the input of a professional engineer to evaluate the issue further and to provide more detailed input and recommendations for remediation of the issue. JCSWCD took the lead on applying for a Technical Assistance grant and were awarded the grant in December, 2013.

Following the Technical Assistance Grant award in December, 2013, in conjunction with the North Unit Irrigation District, the Jefferson County Soil and Water Conservation District and other collaborators, Black Rock Consulting has pursued evaluation and understanding of the issues with results documented in this study report.

III. DATA GATHERED AND ANALYSIS

In 2007 the Confederated Tribes of Warm Springs (CTWS) water quality management team contacted the Jefferson County Soil and Water Conservation District (JCSWCD) to collaborate on a sampling regime to try to better understand the sediment and nutrient introduction at the Rattlesnake Canyon drainage confluence with the Deschutes River. The data from the initial study performed by the respective teams was inconclusive (see Attachment A).

The CTWS and JCSWCD continued to pursue better information related to the issue and in 2012 collaborated with the North Unit Irrigation District, the Oregon Department of Agriculture, the Oregon Department of Transportation, and the Department of Environmental Quality. Flow rates, and turbidity levels were measured at a variety of locations and dates within the Rattlesnake Canyon drainage area including the Boyle pond discharge (weir), the Rattlesnake Canyon drain at the ODOT easterly property boundary, and at the Highway 97 crossing culvert (see Attachment A).

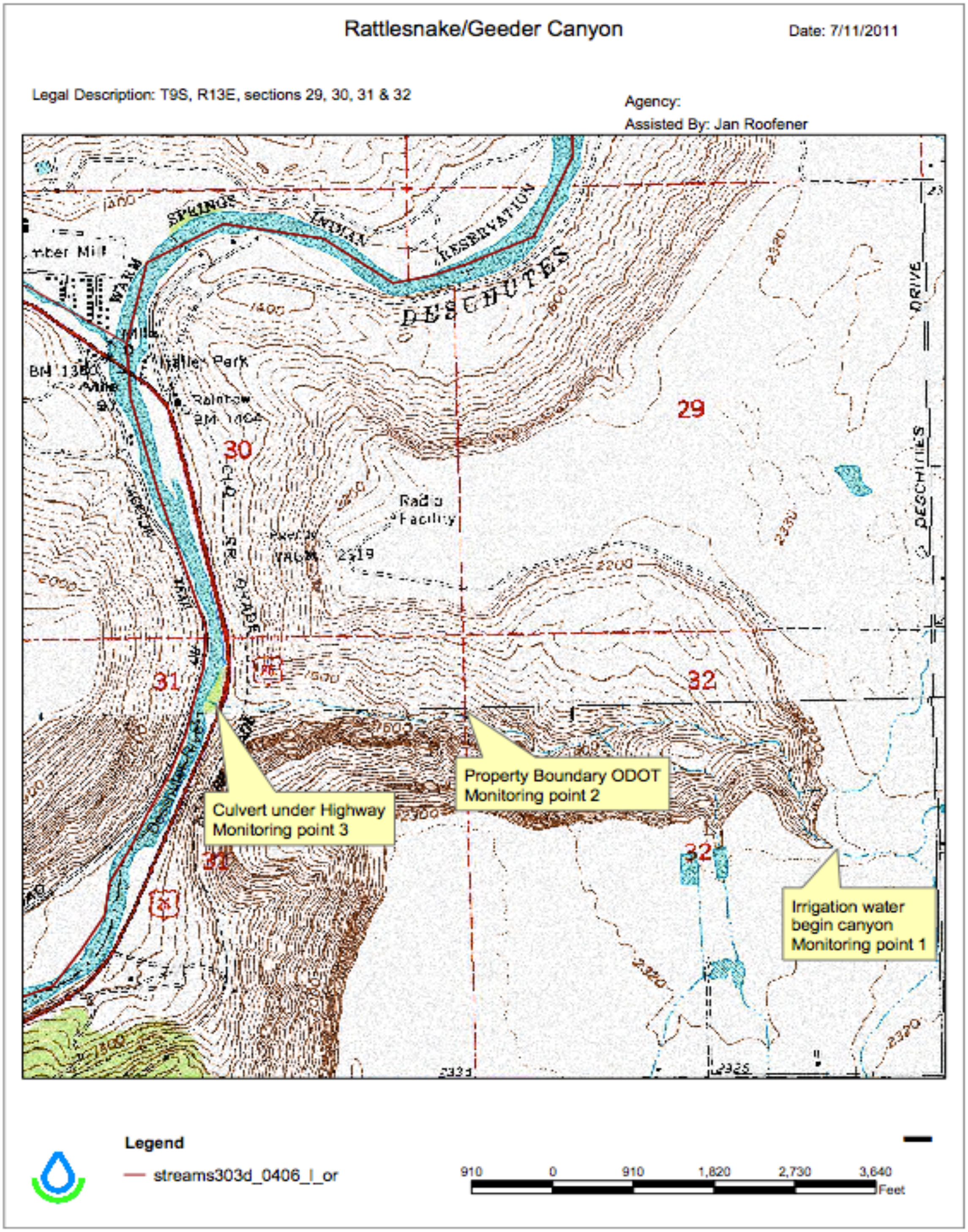


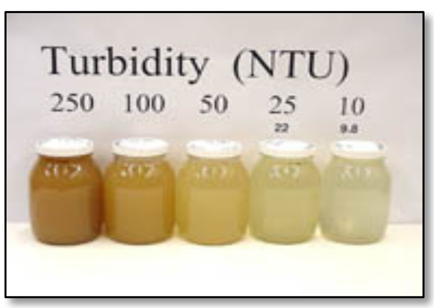
Figure 1 – Monitoring Locations

Black Rock Consulting and the JCSWCD, with the assistance of the North Unit Irrigation District, collected additional flow rate and turbidity data in 2014. Flow rates were measured using a wading rod and Marsh McBirney doppler flow meter with digital readout and turbidity was measured using the JCSWCD NTU meter after calibration. Black Rock Consulting found that in the non-irrigation season (measurements in February and April, 2014) the natural flow rate in the Rattlesnake Canyon was in the range of 2-7 CFS. During the irrigation season, several series of measurements were taken and included an additional measurement point at the Boyle South Pond location as it was found to be an additional irrigation tail water to the Rattlesnake Canyon drainage. This data was added to the data gathered in 2012 and was tabulated (see Table 1 Below).

Reading Date	Boyle Pond Discharge (CFS)	Turbidity (NTU)	Boyle Sl'y Pond Disch. (CFS)	Turbidity (NTU)	Canyon at ODOT Bdry (CFS)	Turbidity (NTU)	West Side Hwy 97 (CFS)	Turbidity (NTU)	Precipitation
3/14/12	2.0	2.5					2.3	1.9	0.08"/10 days
3/30/12	0.0				4.0	4.4	5.2	3.8	0.45"/10 days
4/11/12	0.0				4.9	3.5	6.4	5.5	0.5"/10 days
4/27/12	2.0	58.4			8.6	40.0	10.6	40.6	0.5"/10 days
5/3/12	12.0	81.0			15.0	153.0	17.0	161.0	0.22"/10 days
5/24/12	9.0	48.0			17.0	53.0	20.0	55.0	5.99"/10 days
6/6/12	8.0	53.0			12.0	50.0	14.0	49.0	7.3"
6/20/12	6.9	24.9			9.0	34.0	12.0	29.8	7.8"
7/9/12	3.3	15.7			6.0	22.4	10.0	19.9	No
7/13/12	4.5	23.2			10.2	14.9	10.0	18.7	No
8/13/12	1.5	13.6					4.8	12.3	No
9/28/12	2.0	9.0					8.0	11.0	No
10/19/12	2.0	16.8			8.0	10.3	10.0	9.3	No
4/15/14	0.0		0.0				7.0		No
7/29/14	0.0	15.4	1.5	20.7	3.1	4.9	2.6	4.2	No
8/15/14	4.0	10.6	2.5	13.1	8.9	8.8	10.1	10.6	No

Table 1 – Field Flow Rate and Turbidity Data

For reference, the level of opacity caused by sediment in water, measured in nephelometric turbidity units (NTUs) is demonstrated by a visual representation as provided below.



Based upon our assessment of the data provided in Table 1 above:

1) Flow rates in the Rattlesnake Canyon drainage tend to increase from winter to Spring, peaking in late May and then trail off into September.
2) Peaking flow rates, also coincident with the earlier irrigation season period from April to the end of June carry the highest and most concerning sediment load as evidenced by the turbidity units measured (40NTU – 161NTU).
3) On May 3, 2012, the highest turbidity values were recorded. The turbidity doubled between the Boyle Pond discharge and the ODOT boundary. Unfortunately, there was no recording for the runoff from the Boyle south Pond therefore there is not definitive explanation as to the source of the turbidity between the canyon rim outfalls and the ODOT property boundary. 21 days later, the measurement of turbidity from Boyle's Pond discharge and the ODOT boundary was similar during some of the highest flows recorded.
4) The data supports the premise that some sediment is added through the ODOT quarry property but not to a substantial degree. For example, on May 24, 2012 the flow rate at the ODOT boundary was 17 CFS at 53 NTU and at the Highway culvert was 20 CFS at 55 NTU. The volume of water increased by 3 CFS and the NUT also increased indicating the addition of sediments through the ODOT property.
5) Interestingly, similar flow rates measured in the latter part of irrigation season (8/15/14) to those measured in the early part of irrigation season (4/27/12) measured significantly different NTUs. The supposition would be that disturbed agricultural soils may more easily migrate then when crops are less mature and ground is freshly tilled.

IV. IRRIGATION PRACTICES AND SOILS WITHIN STUDY AREA

It is estimated that 30%-40% of the lands within the project area are irrigated through flood irrigation. Many farmers have continued flood irrigating which avoids pumping and pumping power costs. Flood irrigation, however, is a less efficient application method. It is estimated that furrow irrigation results in efficiencies ranging from 35%-65% and flood irrigation efficiencies ranging from 15%-35%. These efficiencies contrast significantly with sprinkler irrigation efficiencies ranging from 60%-80% and micro-drip systems achieving 90%-95% efficiency. The JCSWCD developed an irrigation map of the study area and is included as Attachment B.

Lower irrigation application efficiency equates to the need for additional irrigation water to perform the fully required crop irrigation. For irrigators in the project area, additional incremental water ordered from NUID comes at a cost. Additionally, flood irrigation generally requires additional water to "push" water across the fields, therefore there is generally more tail-water wastage associated with this irrigation practice. This additional water also creates a surface drainage situation that tends to pull loose topsoil with it, thus contributing to surface sediment transport in the project area.

The top-soils found in the study area are fine grained and readily migrate when subjected to moving surface water.

- Study Area Soils

  - Brief description (Soil Survey) – both soils general information list loam for the top layers (soil depth 24-18 inches)
  - Parent Material for both soils is Loess over residuum weathered from volcaniclastic sediments of the Deschutes formation.
  - Loess is a fine grained material dominated by silt sized particles deposited by wind.
  - Summary emphasizing limited soil depths and associated water holding capacities

Study Area Soils

Soil symbol	Soil Name	Available Water Capacity (in/in)	Soil Depth (for design) (in)	Total Available Water capacity (in)	Readily Available Water 40% depletion (in)	Readily Available Water 50% depletion (in)
2A	Agency	0.16	24	4.7	2.82	2.35
87A	Madras	0.16	18	3.6	2.2	1.8

V. EXISTING IRRIGATION DISTRICT CONVEYANCE SYSTEM (SEE ATTACHED STUDY AREA MAP)

The North Unit Irrigation District delivers water from its canal system that is predominantly open-channel (i.e. open uncovered earthen canal). The source of its water is from the Deschutes River in Bend, Oregon and is supplemented by water from the Crooked River when needed. Diverted water from these sources is conveyed through a network of earthen canals. The study area is served from Lateral 63, that branches off of the NUID Main Canal at mile 63 (i.e. 63 miles from the NUID diversion in Bend, Oregon). The approximate 65,000 LF lateral (including sub-laterals) conveys approximately 100 CFS to the area at peak irrigation season.

Once delivered to the farm users at their turnouts the farmers apply the water to crops. Generally, any excess water is captured in a series of surface drainage channels, typically called “drains”. The drains are not part of the NUID system, rather a feature of tail-water conveyance for the farmers within the study area. The series of drains convey water to tail-water ponds located near the Rattlesnake Canyon rim. Two ponds at the east edge of the rim, termed “Boyle’s Ponds”, and two ponds located at the south edge of the rim, termed “Boyle’s South Pond”. If filled to capacity, these tail-water ponds spill through concrete structures to a small earthen ditch that conveys water to the canyon rim where it spills over and joins any naturally occurring water in the valley of the canyon.

VI. KEVIN L. CREW, P.E. - ENGINEER ASSESSMENT OF ISSUE(S) CAUSING RUNOFF AND SEDIMENTATION

I visited the study area on several occasions, driven the roads that transect the area, walked portions of canal, visited with landowners/farmers, visited with District personnel, observed the NUID delivery system, the lateral network, on-farm irrigation systems and cropping, and the drains and tail-water ponds that the system terminates into. I have also performed field flow measurements, accompanied a portion of the turbidity measurements and visited the Rattlesnake Canyon from its rim to the Boyle/ODOT property boundary and to its connection to the Deschutes River. I have seen sediment-laden water entering the Deschutes River and also have seen water entering the Deschutes River that was clear in appearance.

Based upon these personal observations, input from the landowners, input from the NUID, and review of the available data, it is my opinion that:

1) The farmed Agency Plains plateau is comprised of fine-grained surface soils that will migrate when disturbed and exposed to moving water. The finer the grain size, the slower that the water needs to move to cause the sediment to move.
2) Seasonal farming activities including the plowing and tilling and other disturbance of the farmed soils tends to de-segregate the soil particles and make them susceptible to migration in the presence of moving water.
3) Precipitation and irrigation that results in surface water movement across the newly disturbed fine-grained farm soils in the study area causes migration of sediment-sized soil particles.
4) The conditions described in 2) and 3) above generally occur in the early farming and irrigation season from April through May and into early June.
5) Sediment entrained in the moving water stays entrained in the moving water unless it slows down enough to allow gravity to pull the sediment out of the moving water.
6) The study area does not have a propensity of catchment ponds for irrigation run-off and many that do exist have filled up with sediment. Ponds that are largely filled with sediment no longer have the wetted cross sectional area to slow down influent water therefore the fine-grained sediments continue to migrate in these instances.
7) During these limited periods when sediments are moving and higher flows are generated from precipitation events and rotational irrigation activities, the sediment entrained water passes through the final tail-water ponds located on the Boyle property and spills to the Rattlesnake Canyon valley. This spilled water joins naturally occurring water in the Canyon valley. As the water travels in the valley, especially across the

confined channel stretch through the ODOT property, some additional sediment is added from side-bank cutting. This water finally crosses Highway 97 and enters the Deschutes River.

8) When turbidity is high (likely in excess of 20NTU) in the Rattlesnake Canyon drainage discharge to the Deschutes River, the issue becomes visual as the water enters the Deschutes River. The data gathered in 2012 indicates that this may occur from mid April (at the start of irrigation season) through June.
9) Excess flows cause tail-water in the system because there are excess irrigation flow events, precipitation events, and because there is not enough storage in the study area to capture these high-flow events. Irrigation water delivered to the study area travels 63 miles from the City of Bend diversion and can not therefore be immediately regulated. This situation causes fluctuation in delivery volumes, especially when demands in the study area are affected by variables such as precipitation.
10) Excess flows generally occur between April and June during the irrigation season startup and precipitation period although precipitation from thunderstorms can occur at any time during the irrigation season.
11) Flows added to irrigation runoff in Rattlesnake canyon are generated from springs in the canyon and from precipitation events. Measured natural flows from the canyon ranged from approximately 2CFS-7CFS.

VII. LANDOWNER MEETING AND SOLICITATION OF INPUT PROCESS WITH RESULTS

Solutions to the Rattlesnake Canyon drainage issue could not be developed in the absence of landowner input and participation since the solutions rely on the participation of the landowners. The Jefferson County Soil and Water Conservation District, the Natural Resources Conservation Service and the North Unit Irrigation District recognized this early in the study area evaluation process. While multiple agencies collaborated and participated together during the course of the evaluation, the input of landowners was the most experienced and fundamental to the solutions ultimately discussed.

Starting in 2007, the JCSWCD and the North Unit Irrigation District collaborated with the CTWS to try to sample the Rattlesnake Canyon drainage water with mixed results. Once the concern was raised and landowner became aware of the gravity of the issue, tail-water ponds were constructed near the canyon rim to capture the excess water. Additionally, the JCSWCD, the NRCS, OWEB and NUID worked cooperatively since 2007 to provide incentives for irrigation efficiency projects that would reduce tail-water.

But this collaboration turned into a more concerted effort to evaluate the matter and collect additional data. In 2012 the JCSWCD and NUID collaborated further with the CTWS, ODOT, DEQ and ODA. Flow rate and turbidity monitoring and analysis by the JCSWCD resulted in a helpful data set that refined the understanding of the intermittent sediment transport from the Agency Plains study area through the Rattlesnake Canyon to the Deschutes River.

In 2012 a study area broadcast was made by the JCSWCD to invite landowners to a meeting to discuss the data gathered in 2007, frame the issue, and to solicit input. The meeting was held on June 21, 2012 (See Attachment C) at the Madras Fire Hall and was well attended. As can be seen in Attachment C, the landowners and Oregon Water Resources Department in particular provided significant input on the issue.

Following this meeting, the JCSWCD believed it vital to employ the input of a professional engineer to evaluate the issue further and to provide more detailed input and recommendations for remediation of the issue. JCSWCD took the lead on applying for a Technical Services grant and were awarded the grant in December, 2013.

On December 18, 2013, the JCSWCD held a landowner update meeting on the project that was attended by Kevin L. Crew, P.E. of Black Rock Consulting. Black Rock Consulting had summarized the data and input from landowners to date and presented that summary at the December 18, 2013 meeting.

During the course of the study, Black Rock Consulting collaborated with the JCSWCD, the NUID, the OWRD, and landowners. Of significant benefit were personal conversations with landowners Scott Samsell, Ryan Boyle and Greg Williams. Mr. Samsell provided me a tour of the study area and during the tour he gave me multiple suggestions for improvements that may be incorporated into the area that may result in reduced flows and/or sediment transport (see meeting notes, Attachment D).

During the study, Kyle Gorman, Regional Manager, OWRD, was contacted on several occasions to discuss potential solutions. Kyle's knowledge and input were invaluable in understanding use of the District's water conservation authorization and potential for expansion of the District's boundary into Rattlesnake Canyon.

The Oregon Department of Transportation was also contacted to discuss the status of the quarry near the bottom of Rattlesnake Canyon and potential participation by ODOT in the solution. Notes from my initial telephone conversation with Mr. Frost are contained in Attachment E. ODOT continued to participate and cooperate through the study process and attended the final meeting held at the Madras Fire Hall.

Once the landowner input and field data had been assessed and considered, a final landowner meeting was held at the Madras Fire Hall on December 12, 2014. At this meeting, the landowners and other attendees were provided the findings of the study to date and were asked again for input on the potential solutions, many of which were conceived by them originally. Each solution was presented separately, and the landowners had the opportunity to discuss the solution and then write down whether they felt that it was a good or poor solution and whether they would participate in its implementation. Additional ideas and comments were also solicited and many landowners provided these in writing. A copy of the presentation made is included in Attachment F and the landowner input is tabulated in this study report below.

This final landowner input helped to guide the recommendations and solutions prioritized by Black Rock Consulting hereinbelow.

VIII. DISCUSSION OF SOLUTIONS

a) Clean-Out Existing Ponds –

Many of the existing ponds in the project area are laden with silty sediments. These sediment deposits reduce the capacity of the ponds and therefore their ability to capture surface runoff and to settle out additional sediments. Silt is a constant issue due to the fine-grained nature of the plains soils and their propensity to migrate when disturbed by farming operations and surface water velocity. Aggressive mitigation of sediment build-up is highly recommended.

Sediment removed from ponds may be used to further build up pond banks and in some cases the pond freeboard and/or capacity. Alternatively, the material may be incorporated into amended soil mixtures and re-used in farming operations. These solutions would tend to maintain use of the on-farm soils back on farm versus losing them from the project area.

b) Additional Ponds/Re-Use –

Ponds are an effective method of mitigation for the sediment-laden runoff issue in Rattlesnake Canyon. Ponds collect excess water that may be re-used for farming operations. Ponds also slow down surface water velocity and therefore allow for water-born sediments to fall out.

Given the range of flows measured from the Boyle Pond weir discharge to Rattlesnake Canyon (1.5-12 CFS, 2012), and given a 24 hour peak flow period, we estimate that about 1,100,000 CF of water or 24 Acre-Feet of storage would be required to impound that volume of water. Given a 4,000 Acre project area, **only 0.24 Acre-Feet of free storage per 40 acres of farmed area** would be required to impound the 24-Acre-Feet of peak flow run-off.

This solution seems reasonable and attainable, but would require the active participation of farmers in the project area and a system of silt management for each of these ponds in the system. The benefit to the individual farmers would be the ability to recapture top-soils from their land and to potentially re-use captured water for farming use.

c) **Irrigation Efficiency and Application Method –**

It is estimated that 30%-40% of the lands within the project area are irrigated through flood irrigation (see Attachment B). Many farmers have continued flood irrigating which avoids pumping and pumping power costs. Flood irrigation, however, is a less efficient application method. It is estimated that furrow irrigation results in efficiencies ranging from 35%-65% and flood irrigation efficiencies ranging from 15%-35%. These efficiencies contrast significantly with sprinkler irrigation efficiencies ranging from 60%-80% and micro-drip systems achieving 90%-95% efficiency.

Lower irrigation application efficiency equates to the need for additional irrigation water to perform the fully required crop irrigation. For irrigators in the project area, additional incremental water ordered from NUID comes at a cost. Additionally, flood irrigation generally requires additional water to "push" water across the fields, therefore there is generally more tail-water wastage associated with this irrigation practice. This additional water also creates a surface drainage situation that tends to pull loose topsoil with it, thus contributing to surface sediment transport in the project area.

Some irrigators are converting lands to sprinkler irrigation systems. For example, the Boyle Farm was currently assessing and moving forward with the addition of a pivot system for lands that had previously been flood irrigated. Higher labor rates to operate flood systems may be a contributing factor for irrigators to move to sprinkler systems.

Reduction of flood irrigation will result in the reduction of sediment transport in the project area. Programs such as the NRCS EQUIP program are effective methods for conversion to sprinkler irrigation.

d) **Long Chain Polymer** -

Long-chain polymers such as polyacrylamide (PAM) are used to bind soil and reduce its propensity to migrate. Generally, such polymers are introduced to irrigation water prior to application. One irrigator estimated that he used about 70 pounds of polymer per 100 acres irrigated at about $15/pound of polymer. He believed that the application of polymer was an effective way to retain top-soil.

e) No-Till Education and Practice of No-Till Farming -

No-till farming involves the planting of certain crops such as soy beans, corn or dryland wheat and avoids repetitive and cyclical plowing. Reduction of top-soil disturbance reduces the potential for soil migration. Implementation of no-till practices is subject to individual farmer participation.

f) Re-Lift Pumping –

It was suggested that runoff from the project area may be captured in the upper extremities of Rattlesnake Canyon and then re-pumped from the canyon to the rim for farming use. Ram pumping or screw pumping were suggested.

Ram pumps return a small volume of water for a larger volume of pressurized water. In this application, returning a small volume of runoff would not contribute significant benefit.

Pumping run-off water back into the project area is possible. If a reservoir were constructed at the upper limits of Rattlesnake Canyon, a pumping system could be utilized to pump the water back up to the rim. If a piping distribution system were in place, this system could be used to move the water back to the various farm operations. If no piping system were in place, the returned water could be piped to the NUID canal upstream of the project area and returned to the various farm deliveries. This may require coordination with NUID and the Oregon Water Resources Department to account for the re-use of water versus the use of purchased irrigation water.

Capturing water in local ponds across the study area would keep the water closer to the application points, and would require far less energy to return to the lands versus pumping from the canyon.

g) Wetland Treatment –

Wetland vegetation treatment is an effective method of water quality polishing. Wetlands can extract undesirable nutrients such as nitrates, phosphates, and sediments from water.

Unfortunately, wetlands are best suited to treat consistent flow rates and require a significant area to treat a small amount of water. For these reasons, wetland treatment was not considered further in this study.

h) Water Spreading –

Water spreading is the practice of utilizing excess water (i.e. tail-water) to irrigate land that has no water right. This practice is not allowed in Oregon and was not considered further in the solution set for the subject study area.

i) Use of Excess Water on Un-Irrigated Lands Within District –

There are some lands that exist within the project area that are currently un-irrigated but are within NUID District boundaries and could have a water right associated with them. These lands could be used as a location for application of excess runoff from the project area. It is our understanding that approximately 300 acres exist that may qualify (see Map). Given this quantity of land, it is estimated that as much as 4 CFS may be applied. Although this would not mitigate a peak flow of 12 CFS, it could contribute to mitigation of excess runoff and may totally mitigate excess through much of the irrigation season.

j) Expansion of the NUID Boundary –

Rattlesnake Canyon is outside of the NUID boundary, therefore is not eligible for a surface irrigation water right. According to the Oregon Water Resources Department, the NUID boundary could be expanded, although the process could be difficult and lengthy. If the boundary were expanded into the canyon, an irrigation water right could be added to the Boyle property in the upper extremities of the canyon. An approximate 60 Acre area exists that could be irrigated with a gun system and may utilize as much as 1 CFS of excess water.

k) Series of Ponds or Reservoir in Rattlesnake Canyon –

A series of percolation ponds located in the Rattlesnake Canyon were suggested as a potential method for settling out water-born sediments and potentially causing percolation of some or all of the excess irrigation run-off water. The efficacy of such percolation ponds is unknown and would be subject to geotechnical investigations to ascertain the ability of the ponds to retain or percolate water. Certainly, such ponds would be effective at mitigating sediments, however access to the potential pond locations is currently difficult for construction and routine sediment mitigation. The canyon does lend itself to the introduction of small retention structures and could be further evaluated.

Similarly, the canyon appears from a topographic review to be an acceptable site for a reservoir. This concept was not pursued further given State Dam Safety requirements, and the proximity of Highway 97 and the ODOT quarry located downstream.

l) Piping of the NUID System –

Piping the NUID canal delivery system to the project area would require about 65,000-LF of pipe ranging in size from 48-inches to 8-inches. Based upon current piping costs for the 58-11 Lateral, it is estimated that the cost of piping the project area could be in the range of $7MM to $9MM.

Piping the project area would not eliminate runoff in the area as it is estimated that 8% of the irrigation water runoff to Rattlesnake Canyon is attributable to canal tail-water that could be mitigated through piping and the balance from crop irrigation run-off and runoff caused by precipitation runoff. The District estimated that approximately 1.5CFS may be conserved with piping the area.

m) Water Conservation Statute Use –

Implementation of water conservation practices such as piping in the North Unit Irrigation District can now result in the use of Oregon Water Conservation Statutes to return a portion of conserved water to in-stream (Deschutes River) and a portion available for use by the District.

n) Drain Maintenance –

Uncaptured runoff within the project area currently discharges to a system of drains that, in turn, discharge into the Boyle tail-water ponds. These drains are currently under-maintained and impacted by vegetation and sediments. Sediments within these drains could be cleaned out and utilized as discussed in a) above. Some drains have sediment deposits adjacent to the drain ditches. This material could also be utilized as discussed in a) above and this practice would also return land area back to farming adjacent to the drains.

o) District System Operation Improvements –

In conjunction with other system improvements such as the addition of a system of on-farm storage ponds, partial system piping, etc., pond and canal level monitoring systems could be implemented to provide NUID real-time feedback regarding excess water. This feedback system may allow the District to more responsively manage canal flows and system pond levels.

IX. PRIORITIZATION OF SOLUTIONS TO SEDIMENT AND FLOW IN RATTLESNAKE CANYON

The issues were discussed at length with the stakeholders at the various meetings and also considered by Black Rock Consulting. The goals of this study were to:

1) Involve Landowners and Stakeholders in the Process
2) Gather Additional Field Data and Develop and Understanding of the Issues at a Reconnaissance-Level
3) Develop a Recommended Solution or List of Solutions for Further Consideration in Higher-Level Evaluations and/or Designs Specific to the Solution or Solutions
4) Develop a Map Indentifying the Location of Proposed Solutions Relative to the Study Area

We believe that within the available scope and budget the above goals were achieved on this study. The first and second goal were covered as indicated above. The third goal is addressed in this section, and the fourth goal (Mapping) is attached to this study.

As indicated in VI. and VII. above, potential mitigation measures to reduce the introduction of sediment and higher flow rate volumes were presented to the study area stakeholders at the December 18, 2014 Madras Fire Hall meeting. A summary of the proposed practices and the associated value placed on each of these by the respondents is included in the Table 2 below.

SEDIMENT AND FLOW MITIGATION PRACTICES PROPOSED MADRAS FIRE HALL MEETING - 12/12/14 STAKEHOLDER AND LANDOWNER INPUT												
PROPOSED PRACTICE	Stakeholder/Landowner Responding											
	Practice Value			*Respondent #*								
	Low	Med	High	1	2	3	4	5	6	7	8	9
Clean Exist. Ponds	1	1	7	Y	Y	Y	Y	Y	Y	Y	Y	Y
Add Ponds/Re-use		3	6	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sprinkler v. Flood	1	4	3	Y	Y	Y	Y	Y	Y	Y	Y	Y
Long Chain Polymer	1	2	5	Y	Y	Y	Y	Y	N	Y	Y	Y
No-Till Farming	2	3	3	Y	Y	Y	Y		Y	Y	Y	Y
Wetland Tmt.	2	2	1	Y	Y	N	N	Y	Y	N	N	Y
Irr. Un-Irr. Lands	3	3	1	Y	Y	Y	Y	N	Y	Y	N	Y
Canyon Pond Series	5	2	2	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pipe NUID 63 Lat.	3		1	Y	N	Y	N	N	Y	N	N	Y
Use WC Statute	1	1		Y	N	Y	N	N	N	Y	N	Y
Drain Maintenance	3	2	2	Y		Y	Y	Y	N	Y	Y	Y
Farmer				Y	Y		Y	Y		Y	Y	
Agency Rep.						Y			Y			Y
Would Add Storage						Y						
Add Lateral Telemetry									*			
Use AF as Std. Measurement										*		

Table 2 – Tabulation of Landowner Meeting Input

As indicated in the table above, the stakeholders attending and providing a reponse indicated that:

1) Cleaning Ponds is the Highest Priority/Value Measure
2) Adding Ponds was the Second Highest Priority/Value Measure
3) Long Chain Polymer Soil Binder and Conversion from Flood To Sprinkler were the Third and Fourth Highest Priority/Value Meaures
4) The Other Practices Followed With the Exception of Piping the Lateral and Use of the Water Conservation Statutes

ENGINEER'S DISCUSSION AND RECOMMENDED ACTIONS:

Based upon my review of the issue, consideration of landowner and other stakeholder input, and evaluation of the available data, I would summarize the issue as follows:

1) There exists a background flow rate in Rattlesnake Canyon that is supplied by springs and intermittent precipitation. This background flow rate appears to vary between 2CFS and 7CFS (based upon a very limited data set).
2) Based upon the data and observations by NUID District representatives and landowners in the area, higher flows are generally passed to Rattlesnake Canyon in the early irrigation season (April-June). Thunderstorms and precipitation concident with this period likey exacerbates the flow rate spiking issue.
3) Our observation of Rattlesnake Canyon discharge later in the irrigation season indicated little presence of sediments.
4) Farming practices tend to disturb the fine-grained Loess soils and such disturbance is greater and wider-spread early in the irrigation season conicident with the periods of higher and "spikier" flows.
5) Due to the sedimentation and reduced capacity in existing study area ponds and due to the lack of enough total storage volume within the study area, tail-water leaves the system and during times of higher flows and more disturbed soils (earlier in the irrigation season), sediments tend to transport with the run-off (irrigation and precipitation).
6) As the water passes through the Rattlesnake Canyon, especially at higher flows and in proximity of the confined section along the ODOT quarry property, some additioinal sediments are added to the Rattlesnake Canyon drainage flows.
7) During these early irrigation season periods, as flows increase, sediment entrainment in the drainage water increases and is noticeable at the Rattlesnake Canyon drainage confluence with the Deschutes River when NTUs climb above 20 NTUs.

Based upon these factors, my observations, and input from the landowners and stakeholders, I recommend the following actions:

1) I believe that the single most beneficial measure to mitigate the runoff and reduce sediment is to implement small on-farm ponds. Storage should be designed on each farm to capture run-off, be sized to slow down the water and drop out sediments, and be sized to capture peak flow events. Clearly, routine maintenance of these ponds and sediment removal is critical but would allow each landowner to preserve and re-use the valuable top-soil rather than losing it from the land forever.

   Given the range of flows measured from the Boyle Pond weir discharge to Rattlesnake Canyon (1.5-12 CFS, 2012), and given a 24 hour peak flow period, I estimate that about 1,100,000 CF of water or 24 Acre-Feet of storage would be required to impound that volume of water. Given a 4,000 Acre project area, **only 0.24 Acre-Feet of free storage per 40 acres of farmed area** would be required to impound the 24-Acre-Feet of peak flow run-off.

Some landowners in the stakeholder meetings said that they would implement ponds. This practice was unanimously supported by the meeting attendees.

I suggest that the JCSWCD, NRCS, ODA and others follow-up with landowners to continue to encourage an on-farm storage implementation program and try to find ways to support such practices with funding as available.

2) Cleaning of the existing ponds in the area is almost universally necessary and recommended. This measure will add the benefits indicated in 1) above.

   Cleaning of the ponds may be encouraged by continued landowner contact. The landowners indicated that the drawback is the cost of fuel for the excavation equipment needed to remove sediments from the ponds. Sediments from the ponds may be used for bank enhancement and pond capacity increase as well as re-use in farming activities.

   Another option would be to market the pond sediments to commercial businesses that will re-use the sediment in the making of enhanced and fertilized soils for reapplication to lands.

3) I believe that if implemented effectively, 1) and 2) above would solve the runoff issue and therefore would solve the sediment transport issue or mitigate it to a very intermittent issue that occurred only in extreme run-off precipitation scenarios. I also appreciate the difficulty that a broadspread private storage implementation program may face, so I offer the following additional recommendations as measures that will work in unison with an overall study area approach to flow and sediment mitigation.

   Development of a series of small ponds in the Rattlesnake Canyon designed to slow the rate of water flow and to drop out sediments could be implemented. Due to the fine size of the particulates, we recommend trying to reduce velocities to 0.5 FT/S or less in each pond. If possible the ponds could include a sinuous entrance condition to extend the distance that the particles have to drop out and to encourage vegetative growth on the banks to further capture sediments as the water passes by. I suggest that one or two ponds should be located above the ODOT property on the current Boyle property, one should be located in the ODOT property and one should be located upstream of the Highway 97 culvert crossing. Another project on the Campbell drainage to the south of Rattlesnake Canyon is being implemented and the results of that pond-series project should be monitored for effectiveness. If effective, similar design may be implemented in Rattlesnake Canyon.

4) Farming practice adjustments will provide significant benefits to the issue if implemented. Again, causing the adjustment of on-farm practices can take long periods of time and educational programs. We have seen a significant trend with farmers to move to practices that make environmental sense and remain beneficial or at least neutral to farming operations. We strongly recommend the continued encouragement of farmers to implement practices that are supported by the NRCS, the JCSWCD and NUID such as:

    a) Conversion from flood irrigation to direct, metered (i.e. appropriate nozzle size) applications such as sprinkler or drip systems.
    b) Implementation of no-till practices.
    c) Use of long chain polymer to hold soils on-farm, especially in areas such as the study area that has very fine-grained (Loess) soils.

5) Application to farm lands within the study area that are within the district boundary and are eligible for application of water but are currently un-irrigated is a measure that I would recommend if the development of private on-farm ponds was not occuring or not occuring at a fast enough rate. A landowner with fallow land indicated his willingness to entertain the idea of the application of excess tail-water to his land. Intermittent application of water may sustain beneficial grasses but may also develop a weed issue that would have to be addressed if water were applied.

    To implement this measure, an agreement would have to be made with the landowner regarding the terms of the intermittent water availability and the drain system in the study area would have to be modifed or pumping system installed to deliver water to the currently fallow land.

6) Implementation of a wetland is not recommended for this application. It is my experience that wetlands may be designed for a more regular flow of water and a large area is required to treat a small volume of water.

7) Drain maintenance is recommended but is currently subject to landowner action so should be a common discussion topic at educational presentations and when landowner contacts are made.

8) Piping the lateral would only address a fraction of the tail-water issue. The NUID estimated that approximately 1.5 CFS of tail-water would be mitigated by piping Lateral 63. Although piping of the NUID system is highly recommended as is the use of the Water Conservation Statute and Federal authorization bill for water conservation, implementation of piping for the sole purpose of tail-water and sediment migration mitigation into Rattlenake Canyon is not suggested nor does the cost of such implementation appear feasible in the near term.

On-farm piping implementation may prove very valuable as piping prevents the entry of sediments into the piped water and could help to mitigate the introduction of sediments from farm to off-farm conveyance drains.

9) Evaluation of telemetry and tight regulation of Lateral 63 from the main canal may provide some benefit as its location is much closer to the farms and may be adjusted more effectively than NUID canal adjustments higher in the system. This may also simply result in moving a peaking flow issue in the NUID main canal further downstream so this idea should be further considered with the input of the NUID.

X. PROPOSED STUDY AREA RECONNAISSANCE-LEVEL SOLUTIONS MAP

See attached study insert.

ATTACHMENT A

ATTACHMENT B

ATTACHMENT C

ATTACHMENT D

ATTACHMENT E

ATTACHMENT F