CHAPTER 4
SKYLINERS ROAD PENSTOCK

Prepared for
City of Bend, Oregon
October 23, 2009
Revised November 19, 2009

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CHAPTER 4

SKYLINERS ROAD PENSTOCK

4.0 Introduction

This chapter describes a conceptual level study to define the cost to provide a new penstock from the Bridge Creek Intake to the Outback Treatment and Storage Facility to supply a hydropower unit at the Outback Facility.

The two existing pipelines (a.k.a., intakes, conduits, or mains) that convey water from the Bridge Creek Intake to the Outback Facility have neither the required size or sufficient strength to supply a hydropower unit as described in the existing condition summary presented below.

4.1 Existing Pipelines

The existing welded steel pipelines convey water approximately 10 miles from the Bridge Creek Intake to the discharge at the Outback Facility. The pipelines were completed in 1926 and 1957 and have been repaired several times since their original installation. Both pipelines were designed with a small cross sectional area to develop high flow velocities to burn the excessive potential energy associated with the drop from the 4,992-foot elevation at Bridge Creek Intake to the 4,010-foot elevation at the Outback Facility overflow structure.

Most of the alignment lies within heavily forested areas on U.S. Forest Service (USFS) land. The pipelines also cross several private properties on City of Bend (City) easements. In several easements, structures encroach on the pipeline alignments. Tree roots have contributed to decrease the hydraulic capacity of the pipelines. This chapter provides a review of the existing condition as it relates to the hydraulic capacity of the pipeline.

The original capacity of the pipelines is not known, but it is estimated to be 13.5 million gallons per day (mgd) or 9,380 gallons per minute. Due to the condition of the pipes, the safe operational capacity is less than the original design capacity.

4.1.1 1926 Pipeline Alignment

According to the City's website, when Bend was founded in the early 1900s, the Deschutes River provided the City with its primary source of drinking water. However, when the Deschutes River developed water quality problems, the City decided to investigate other alternative sources for their drinking water supply. One alternative was found in the 1920s when a tributary in the upper Tumalo Creek watershed, Bridge Creek, was determined to be a reliable source for Bend's drinking water supply needs.

In 1926, an intake structure and the first pipeline from Bridge Creek to what is currently the Outback Facility were constructed. The intake structure and pipeline have undergone few improvements or updates since their original construction. The alignment was constructed originally with approximately 28,000 feet of 14-inch-diameter pipe and 21,000 feet of 12-inch-diameter welded steel pipe. The transition between diameter sizes occurs at approximately 28,000 feet from the intake. This is also the location of a high point which limits the hydraulics of the system. The 14-inch-diameter pipe has since had 8 percent of its total alignment replaced with 20-inch-diameter ductile iron pipe in the years of 1982, 1985, and 1986.

On original blueprints, the pipeline is shown to be located between 5 and 10 feet below the existing grade. Following the existing grade resulted in many relative high and low points along the alignment. To prevent air accumulation within the pipeline at the high points and to provide drainage for maintenance at the low

points, the pipeline was constructed with approximately 21 air valves and 25 blow-offs along its alignment. The alignment also included five gate valves used for flow control. As-built drawings and a description of the alignment are provided in Appendix 4-A.

4.1.2 1957 Pipeline Alignment

To increase the capacity of the water supply system, a second pipeline was constructed in two stages from 1954 through 1957. The second pipeline alignment was constructed with approximately 22,000 feet of 14-inch and 21,000 of 12-inch-diameter welded steel pipe. The transition in pipe diameter is at the same location as the 1926 alignment. Although the second pipeline has a similar hydraulic profile as the first pipeline alignment, it does not consistently follow the first alignment. This alignment follows existing roads where possible.

On the original blueprints, the pipeline is shown to be located approximately 5 feet below the existing grade. However, there are many places where the pipes are not buried 5 feet deep but are exposed to the surface. Similar to the first alignment, closely following the existing grade at a relatively constant 5-foot depth resulted in many local high and low points along the alignment. To prevent air accumulation within the pipeline at the high points and to provide drainage for maintenance at the low points, the pipeline was constructed with approximately 28 air valves and 25 blow-offs along its alignment. The second alignment also included four crossties into the first pipeline as well as several gate valves to assist in flow control and allow the system to be operational during required maintenance to either of the pipelines. As-built drawings and a description of the alignment are provided in Appendix 4-A.

To maintain the integrity of the intake structure, the diversion dam and intake structure were not modified greatly during the installation of the second pipeline, with exception to the tapered outlet structure. This structure was replaced with a 24-inch pipe which bifurcated into the first and second 14-inch pipelines. Two 14-inch gate valves were installed on each of the pipelines to assist with flow control. The original blueprints and a description of the alignment are provided in Appendix 4-A.

4.2 Proposed Penstock Design Issues

The existing pipelines were designed to carry the water from Bridge Creek to the Outback Facility, intentionally consuming much of the energy available because at the time there was no need for that energy at the Outback Facility and small pipes are cheaper than big pipes. To provide water to a cost-effective hydroelectric plant, the energy available in the water must be transferred to the turbine. This requires larger diameter and thicker pipes. These large diameter pipes that convey water to turbines are called penstocks. In this case, one 36-inch penstock will replace the 12- and 14-inch existing pipelines. The use of the 36-inch penstock will allow more the energy of the water to be converted into electrical energy.

This section presents a description and discussion of penstock design and route alignment issues related to the proposed penstock that will replace the two existing pipelines. This section also includes a discussion of financial considerations focused on sizing of the Skyliners Road penstock, a conceptual review of the proposed penstock corridor issues and a brief investigation of possible geotechnical, right-of-way (ROW), and permit-related issues that would potentially impact the cost and schedule for the installation of the penstock.

The design of a penstock is influenced by issues that can be divided into several categories. These categories can include design parameters or requirements, regulatory requirements, environmental issues, geotechnical issues, site conditions and constructability issues as well as time constraints.

For this particular project, a number of factors have contributed to the establishment of design issues and requirements for this penstock project. These factors include the following:

- The need to maximize all of the City's potential water rights.
- The existing pipelines were not designed as a penstock and do not provide enough hydraulic capacity to support a hydropower unit.
- The U.S. Environmental Protection Agency (USEPA) has established a set of water quality standards for surface water sources that need to be addressed by October 2012 which influences the project schedule.
- USFS and the U.S. Federal Highway Association (USFHWA) are planning on alignment revisions of the existing road which could affect the existing pipelines.
- Locating the penstock out of the forest land and into existing roadways is preferred by USFS and also makes future maintenance access easier.
- Clean power sources are in high demand and funding assistance is available.
- Revenue from a power generation facility can help fund the required water treatment improvements.
- Incentive funding opportunities from the overall hydroelectric project can help pay for the penstock.

With this as a background, it was concluded that a new single penstock is required to generate hydropower. Design issues are described in the following subsections.

4.2.1 Penstock Materials

For a 10-mile-long penstock with a vertical drop of almost 1,000 feet, the static pressure at its lower end will be almost 433 pounds per square inch. For this static pressure, and allowing for surge, there are only a limited number of penstock materials available. One viable material is steel penstock available from Northwest Pipe, which has a manufacturing plant located in Portland. Not only can the penstock be designed and manufactured to meet the pressure requirements, the joints can be welded to provide a fully restrained system.

Steel can be furnished in varying grades dependent upon project needs. In general, the higher the grade of steel, the higher the cost. While the higher grade of steel is more expensive, it does affect the way the penstock is manufactured. For example, if the steel used to manufacturer the penstock is 1/2-inch or less in thickness, the penstock can be manufactured using a spiral welding process. However, if the penstock is more than one-half in thickness, the penstock must be rolled and welded along a longitudinal seam which is significantly more expensive. For this project, after talking with Northwest Pipe, it was concluded that it would be more cost-effective to select a higher grade of steel to allow the penstock to be welded spirally.

4.2.2 Penstock Length and Joints

Steel penstock can be manufactured in various lengths with 20-foot, 40-foot and 60-foot lengths being common. For this project, an optimum length appears to be 60-foot penstock lengths given the diameter of the penstock, the size of the work area and a contractor's desire to reduce the number of welds.

Welding of penstock joints is an important task during its installation. Given the diameter of the penstock, welding from the outside would be preferred since it is easier to perform and inspect the work.

Steel penstock lengths can be joined together in the field using different jointing methods. However, given the high pressures that can occur for this project and the need to provide restrained joints, it is anticipated that the penstock lengths will be joined using a Single-V butt weld which will develop full strength of the steel.

4.2.3 Penstock Lining and Coating

The proper use of a protective lining and coating is important in protecting steel penstock from interior and exterior corrosion. The importance of using a proper coating and lining system for a potable water application, which is another intended use of the penstock, cannot be overemphasized. The selection of the coating and lining system needs to consider shop/field application and repair attributes, surface preparation requirements, physical performance requirements, and handling and safety requirements.

While there are several lining and coating systems available for steel penstock in potable water applications, two of the more common systems include cement mortar and polyurethane. However, based on the Grade 52 steel selected for this project and on recommendations from Northwest Pipe, it is proposed that polyurethane be selected as the coating and lining material per American Water Works Association C222 *Polyurethane Coatings for the Interior and Exterior of Steel Pipelines and Fittings*.

4.2.4 Cathodic Protection

Soil conditions and backfill can affect the performance of a penstock coating and need to be considered during the design of penstock projects. Soil conditions can be rated by considering several factors such as resistivity, pH, moisture content, existence of stray current, and chemical contamination. In addition to soil conditions, penstock installation can impact the performance of its coating. For example, if rocks fall on the penstock or if it the coated penstock strikes a rock projection during installation, the coating may be damaged which could lead to future corrosion problems.

For a long steel penstock with welded joints, it is very desirable to have cathodic protection to supplement the penstock coating system. The two protective systems work concurrently with the coating, greatly reducing the costs of the cathodic protection system, substantially extending the coating's useful life. Installing the cathodic protection system during penstock installation is a minor cost compared to the cost of penstock itself.

The cathodic protection system proposed for this project is an impressed current system with sacrificial anodes. Monitoring stations would be installed at regular intervals of up to 5,000 feet to monitor the operation of the cathodic protection system.

4.2.5 Penstock Appurtenances

The profile of the 10-mile length of the penstock, while dropping a total vertical height of almost 1,000 feet, will have numerous high and low points along the alignment. At the high points in the profile, it will be necessary to install combination air vacuum/air relief valves. These valves are important for protecting the penstock from surge and water hammer by letting air out during the filling operation and letting air in should a vacuum condition occur during an emergency situation. Normally these valves would be located on top of the penstock in a concrete vault with a vent pipe to the surface to let air into the vault. A reliable valve that would be suitable for this type of facility is the Vent-O-Mat Series RBX Air Release and Vacuum Break Valve. Special considerations that will need to be addressed include maintaining the valve operation during the winter under freezing conditions when snow covers the ground. These conditions include maintaining air to the vent pipe and keeping any small diameter pipe from freezing.

In addition to the air/vacuum valves at the high points in the alignment, a means to drain the low points will be provided. At each low point in the profile, a drain vault will be installed around the penstock. Inside the vault, a small diameter pipe elbow will be welded to the invert of the penstock with a normally closed ball valve attached to this drain pipe. The configuration of the drain piping downstream of the ball valve could be a quick coupling connection for a fire hose or piping could be extended to a fire hydrant located near the vault or a gravity drain line to daylight.

For a 10-mile-long penstock, there is an advantage of installing isolation valves at intervals along the alignment so that a segment of the penstock could be shut down without having to drain the entire system. These valves could be installed at 1-mile intervals to provide the ability to isolate a segment of the penstock. Valves that could be installed to provide this isolation feature include butterfly valves or gate valves. Operation of these valves will have to be controlled carefully to prevent damage to the penstock.

4.2.6 Stream Crossings

One special issue that will need to be addressed during design of the penstock is the crossing of two creeks. The first creek crossing is near the diversion dam where the creek bed is approximately 30 feet wide, and the second creek crossing is near the middle of the penstock alignment where the creek bed is approximately 100 feet wide. Photographs of each creek crossing are shown in Figures 4-1 and 4-2.

Figure 4-1. First Creek Crossing near Tumalo Creek Road

Figure 4-2. Second Creek Crossing near Skyliners Road

There are options available for crossing each creek. In all cases it would be prudent to install a casing pipe first and then install the penstock. Three options available include the following:

- An above-ground crossing with the casing pipe resting on concrete columns or piers outside the creek channel.
- A casing pipe installed using the open-trench construction method across the creek.
- A casing pipe installed using a pipe-ramming trenchless construction method.

After the casing pipe is installed across the creek, the next item would be to install the penstock.

It is preferable to install the casing pipe under the creek, out of sight, and protected from vandalism. However, there are constructability and permitting issues associated with installing a casing pipe under the creek, which would need to be addressed. Likewise, if the casing pipe is installed above ground, there are a series of issues that will need to be addressed, including visual impact, permitting requirements, thermal expansion, and combination air vacuum/air release valve requirements.

Although installing a steel casing under the two creek crossings utilizing the pipe ramming technique would minimize impacts to the creeks, existing geotechnical conditions represent a very difficult construction condition including the presence of boulders, rocks, and groundwater. While the length of each crossing is well within the capability of the pipe ramming technique, the findings of the geotechnical reconnaissance states that there are too many significant risks for this method to remain feasible. Given the uncertain permitting approvals with a penstock bridge crossing, a cost estimate was not prepared at this time. However it should be evaluated further during the permitting of the predesign of the penstock. Therefore, stream diversion and open trench construction techniques will be used for both of the stream crossings for the proposed penstock in this conceptual design.

To limit the environmental impacts during open trench stream crossings, a modified open-cut crossing would be used. This would include methods of construction that incorporated cofferdams or isolated work areas and flumes to eliminate or minimize the discharge of silt into the downstream waters. Fluming would include diverting the water through a culvert or pipe during construction around the active construction area. If piping the stream is not feasible, a cofferdam-type isolating system could be used. This would allow the stream to be crossed in two phases.

4.3 Proposed Penstock Sizing

The diameter of the penstock was chosen to maximize possible revenue generated through hydropower per dollar spent on construction and to allow future flexibility in operation of the water system. Various standard internal diameters were considered in this process which used historical Bridge Creek flow data to calculate the amount of friction over the length of the penstock. The larger the diameter of the penstock, the smaller the frictional losses per linear foot of penstock. Therefore, to maximize the power generated, the frictional losses should be kept to a minimum. However, as the penstock size increases, its price also increases, resulting in a lower overall revenue-per-dollar spent on construction. The annual revenue produced from the sale of energy from the project was compared to the cost of the project. The penstock size with the highest annual revenue-per-dollar spent on debt service was determined to be the optimum penstock size.

For a more realistic predicted revenue estimation, the cost of construction and revenue generated was adjusted to consider the time value of money, the impact of inflation, the increase in the value of energy sold over time, the cost of borrowing money to build the penstock and hydropower facilities, and incentives such as tax credits. A summary of penstock size, turbine head produced, predicted generator size, and accompanied average annual revenue from power sales, total capital costs, actual capital costs, average annual debt service, and average annual profits is presented Table 4-1. Total capital including incentives represents the total capital cost with the appropriate tax credits considered and is the estimated actual capital cost of the project. Annual revenue, debt service, and profit are averaged over the 25 years after construction.

Table 4-1. Determination of Penstock Diameter

Diameter, inches	Turbine head, feet	Predicted generator size, megawatts	Annual revenue from power sales, million dollars	Total capital costs, million dollars	Sum after incentives, million dollars[1]	Annual debt service, million dollars	Annual profit, dollars
30	780.7	2.50	1.39	34.00	14.40	1.07	317,000
32	866.5	3.00	1.54	36.84	16.10	1.20	343,000
34	926.3	3.00	1.65	38.38	17.03	1.27	381,000
36	968.4	3.00	1.73	39.92	17.95	1.34	387,000
38	999.1	3.25	1.78	42.10	19.26	1.44	344,000
40	1,021.5	3.25	1.82	43.64	20.18	1.50	315,000
42	1,038.1	3.25	1.85	45.18	21.11	1.57	276,000

[1] Oregon and Federal tax credit.

Assumptions: *Bonds at 5.5 percent over 30 years*
Labor and present worth analysis inflation at 4 percent
Power, green tags, federal hydropower credit inflation rate at 5.7 percent
Sale is to Pacific Power & Light at its Schedule 37 until 2024, then it inflates at 5.7 percent
Federal hydropower credits are at $0.02 per kilowatt hour (kWh) inflated at 5.7 percent over 10 years
Green tags of $0.022 kWh are inflated at 5.7 percent
Oregon Business Energy Tax Credit is 50 percent of the cost of construction, up to $10 million
Federal investment tax credits at 30 percent of project cost

As listed in Table 4-1, generally smaller penstock diameter will cost less to construct, but will produce significantly less annual revenue from the sale of power it can generate. Conversely, the larger penstock diameters will produce more energy from the sale of power than smaller penstock diameters but will not produce enough annual revenue from the sale of power to pay for the increase in penstock costs. The optimum penstock diameter from the above analysis was found to be 36 inches. At this diameter, the amount of revenue from the sale of power is maximized.

4.4 Penstock Alignment

Similar to the existing alignments, the penstock will be located approximately 4 feet below the existing grade and require the addition of approximately 18 blow-off valves and 16 air release valves at the respective low and high points along the alignment. A plan and profile of the proposed alignment is presented in Appendix 4-B and a summary of the penstock alignment is presented in Table 4-2.

Table 4-2. Approximate Penstock Alignment

Stationing	Location	Description
00+00	Intake	Start of 36-inch steel penstock alignment.
00+00 – 12+50	Forested land	Penstock to be installed in existing corridor in national forest service land and removal of the existing 12-inch 1926 steel pipeline.
12+50 – 13+20	Creek crossing	Penstock to be installed beneath North Fork of Tumalo Creek using open trench construction method. Existing pipeline could be abandoned in place or removed.
13+20 – 20+00	Forested land	Penstock to be installed in existing corridor in national forest service land. Existing pipelines are to be abandoned in place.
20+00 – 138+50	National Forest Development (NFD) road 4603	Penstock to be installed along the centerline of NFD road 4603. Existing pipelines are to be abandoned in place.
138+50 – 139+75	Creek crossing	Penstock to be installed beneath Tumalo Creek by open trench construction method. Existing pipelines are to be abandoned in place.
139+75 – 520+00	Skyliners Road	Penstock to be installed along shoulder of Skyliners Road. Existing pipelines are to be abandoned in place.
520+00	Outback	Penstock enters Outback Facility.

The construction phase of the penstock should not interfere with the operation of the two existing pipelines along most of the alignment or until it was necessary to connect the new penstock to the diversion dam. This would allow for normal operation during construction of the penstock corridor. However, there are selected locations where the 1957 pipeline will cross the new penstock or run parallel and any potential conflict will need to be addressed. Funds have been included in the project estimate to avoid having the existing pipeline and the new penstock interfere with each other. In several cases the new penstock will go below the existing penstock and in other cases, the existing pipeline may need to be moved a short distance to avoid the new penstock.. To minimize impact to the National Forest Land, the alignment of the penstock would be primarily within the right of way of NFD road 4603 and Skyliners Road, with the exception of the alignment from the intake to the first creek crossing and the two creek crossings themselves.

The section of alignment from the diversion dam to the first creek crossing would parallel the first pipeline alignment east toward the North Fork of Tumalo Creek through National Forest Land and through an existing corridor of cleared tress. The removal of the first pipeline and the installation of the new penstock would occur during periods of low demand and water supply would only be available through the second pipeline and from the City's wells.

4.5 Anticipated Geotechnical Issues

A geological reconnaissance was conducted by Siemens and Associates along the proposed penstock alignment. They provided a general understanding of the soil, rock, and groundwater conditions which would be encountered along the penstock corridor. Their primary objective was to provide geotechnical information which would be useful in developing a sense of feasibility of various construction methods as well as input early into cost estimates regarding earthwork practices. The detailed geotechnical report can be found in Appendix 4-C.

4.5.1 Geotechnical Findings

Based on the results of the geotechnical reconnaissance, it was concluded that open trench techniques facilitated by powerful track hoe type equipment would be very feasible to the anticipated 7-foot depth to the bottom of the trench along the majority of the penstock installation. There were notable exceptions where seismic testing and surface observation revealed shallow rock, shallow groundwater, and other earthwork-related difficulties. In addition, the proposed alignment would cross two possible fault lines near the Outback Facility.

It was estimated that difficult conditions requiring specialized techniques to handle rock excavation, shallow groundwater, slope instabilities, or a combination of these factors would be necessary through about 1.7 miles of the 10 mile project–roughly 18 percent of the proposed alignment. The remainder of the alignment is anticipated to be through soils which excavate in an easy fashion or with moderate difficulty in dry conditions which would offer reasonably good trench stability. In addition, it was estimated that the majority of the spoils would be suitable for trench backfill with pipe bedding and trench backfill readily processed onsite.

4.5.2 Creek Crossings

This section describes the two creek crossings.

4.5.3 First Crossing—North Fork of Tumalo Creek

At the upstream crossing, the geotechnical data indicated drilling and blasting methods for excavation deeper than approximately 8 feet is likely and shallow groundwater dominates within 300 to 400 feet of the creek bed where many springs are apparent. In addition, a nearby road cut provided evidence of numerous large boulders in this area of the canyon. On the left bank of the North Fork of Tumalo Creek, the pipe jamming staging area possibly could encroach on the existing roadway embankment. The embankment was found to be composed of cobbles and boulders and excavation into these soils may have adverse stability effects on the existing, higher elevation roadbed. Slightly better conditions may exist a short distance downstream from the area of the existing pipe crossing where access along the left bank appears to improve due to more favorable terrain and greater setback of the road.

4.5.3.1 Second Crossing—Tumalo Creek

In this area, the existing pipe crosses just downstream the bridge for good reason. An upstream alignment would be complicated by a wide, braided channel and abrupt topographic rise at the right bank. Shallow groundwater would be likely coincident with the stream elevation and the shallow soils appear to be composed of loose, highly permeable sand and gravel requiring ambitious dewatering efforts along with poor open-trench stability. Complications associated with tight confines, the existing pipe, boulders, loose soil in the shallow environment, and rock at depths as shallow as approximately seven feet indicate a tough environment for a pipeline jamming operation. As such, solutions such as stream diversion and open trench techniques or supporting the pipe on the existing bridge may be preferable options.

4.5.4 Conclusions

The geotechnical report found the proposed alignment which follows the right of way to be feasible in terms of excavation and geotechnical principles; however, the existing alignment diverges from the ROW in some areas primarily to avoid some of the geotechnical obstacles found along the alignment. An example is the bypass between Station 192+00 to 225+00 where the existing pipe takes a route that is relatively free of shallow rock and the terrain is fairly flat. The Skyliners Road ROW, however, traverses a steep hillside with rock outcrop indicating very difficult construction. Opportunities to take advantage of the area geology such as this one may be available and should be balanced with the extra effort and cost of other important considerations such as easement and project schedule.

4.6 Anticipated ROW Issues

ROW issues associated with the Skyliners Road penstock project can be divided into two general categories. The first category is for those areas where the new penstock will be located on property under the jurisdiction of the USFS. For these areas, the City will submit a permit to install the new penstock on federally-regulated property. The second category is for those areas where the new penstock will be installed on dedicated county street right-of-way. For these areas, the City will submit a street occupancy permit to the county. The alignment of the new penstock will be set to avoid private property if possible. However, if private property cannot be avoided, the City will obtain a temporary construction easement and a permanent easement.

4.7 Permit-Related Issues

As part of the environmental and regulatory permit assessment for this project, effort was spent identifying the permits that potentially could be required to perform work on the selected alternative. This effort is described in detail in Chapter 10. Listed below is a summary of major permit issues that could be required for the installation of the penstock along NFD road 4603 and Skyliners Road.

As part of the assessment process, the following agencies were contacted or researched for potential regulatory and permit requirements:

- Federal
  - USFS
  - USFHWA
  - U.S. Army Corps of Engineers (USACE)
  - U.S. Fish and Wildlife Service (USFWS)
- State
  - Oregon Department of Fish and Wildlife (ODFW)
  - Oregon Department of State Lands (ODSL)
  - State Historical Preservation Organization (SHPO)
  - Oregon Department of Environmental Quality (DEQ)
- Local
  - Deschutes County
  - City of Bend

4.8 Summary of Key Permit Requirements

Listed below is a summary of key permit requirements for the penstock segment of the Bridge Creek Water System Project.

4.8.1 USFS

According to USFS, any major alternations to the existing pipeline will require an Environmental Assessment (EA). An EA is a requirement of the National Environmental Policy Act of 1969 (NEPA) which requires environmental reviews for potential impacts of proposed construction on the social, economic and physical environment. The EA evaluates the impacts and assess measures to prevent, minimize, mitigate or compensate for adverse environmental effects. The NEPA process requires scoping, special studies such as wildlife and plant surveys, and mitigation measures.

The City also holds a Special Use Permit with USFS that allows for the existing water system facilities on USFS land. Any changes to the existing uses on USFS land will require amendments to the Special Use Permit. Before Special Use Permits are issued, USFS must determine that the proposed use complies with all management plans and laws, that there is a demonstrated need for the activity, and that the use is appropriate on national forest system lands.

4.8.2 USFHWA

The Forest Highways Program provides funding to resurface, restore, rehabilitate or reconstruct designated public roads that provide access to area within a National Forest. The program is administered by USFHWA's Federal Lands Highway Office in partnership with USFS and Oregon Department of Transportation. The paved portion of Skyliners Road, west of the City's western urban boundary has recently been designated as a Forest Highway. In the event that the penstock construction corresponds to the reconstruction of Skyliners Road, the required NEPA compliance would be similar to that for the USFS. However, USFHWA would be the lead agency rather than USFS.

4.8.3 USACE

USACE issues permits for the discharge of dredged or fill material into waters of the U.S. under authority of the Clean Water Act. Both Tumalo and Bridge Creeks, and any associated wetland areas would be under the jurisdiction of USACE. Activities that require permits would include the construction of a penstock where materials are removed and replaced after its installation. The basic form of authorization used by USACE for these activities is the Individual Permit. Processing Individual Permits involves evaluation of project specific application in the following three steps:

1. Pre-application consultation
2. Formal project review
3. Decision making

4.8.4 USFWS

USFWS issues permits under various wildlife laws including Endangered Species Act. According to published USFWS lists, there are no threatened or endangered species expected within the study area of the project.

4.8.5 ODFW

ODFW regulates in-water work periods in fish-bearing streams through guidelines based on ODFW district fish biologists' recommendations. While there are no anadromous (migratory) fish in Tumalo or Bridge Creeks, redband, brown and brook trout are known to occur in Tumalo Creek below Tumalo Falls. ODFW's guidelines for in-water work restrictions in Tumalo Creek are from July 1 to October 15.

In addition to regulating in-water work periods, ODFW also provides review and comment on land use, regulatory permitting and environmental compliance.

4.8.6 ODSL

Oregon's Removal-fill Law requires a permit from ODSL for the removal or fill of 50 cubic yards or more of material into waters of the state. Both Tumalo and Bridge Creeks are considered to be waters of the state. It is common that this permit will be submitted in conjunction with the federal permit from USACE. ODSL and USACE use a joint permit application.

4.8.7 SHPO

SHPO was established to administer programs for the protection of the state's historical and cultural resources. According to SHPO records, the existing pipelines have not been registered as historical.

4.8.8 DEQ

DEQ is responsible for protecting and enhancing Oregon's water, air and land quality and enforcing Oregon's environmental laws. There are three permitting processes that DEQ administers:

- Water Quality Certification
- National Pollutant Discharge Elimination System (NPDES) for Wastewater
- NPDES for General Stormwater Construction Permit (1200-C)

For the penstock project, the General Stormwater Construction Permit (1200-C) that covers construction activities such as clearing, grading, excavation, and stockpiling would have to be applied for as part of the permitting process. Often, this permit is included in the work of the construction contractor.

4.8.9 Deschutes County

Most of the land involved in the proposed project is within Deschutes County's jurisdiction and is subject to a Conditional Use Permit. At the Bridge Creek Water intake site and along NFD road 4603, the zoning is Forest Use (F-1). Water facilities are permitted conditionally.

If the penstock is relocated to the Skyliners Road alignment, this area has a Landscape Management Overlay zone on 1/4 mile either side of centerline. A Landscape Management permit could be required dependent upon structure built and trees removed.

The land along the paved section of Skyliners Road to the City's Urban Growth Boundary is zoned a mix of Forest Use F-1 and F-2 where water facilities are conditionally allowed.

4.9 Association for the Advancement of Cost Engineering (AACE) Class 4 Opinion of Probable Cost

This section presents ACCE International Class 4 cost estimate for the penstock. AACE Class 4 opinions of probable cost are considered to be order-of-magnitude costs and have an accuracy range of -30 percent to +50 percent.

The estimate was prepared using quantity take-offs, vendor quotes, and equipment pricing provided by local vendors and by Brown and Caldwell estimators. The estimate includes direct labor costs, including a shift differential if applicable, and anticipated productivity adjustments to labor, and equipment. A detailed cost estimate report is provided in Appendix 4-D. A summary of the estimated cost is provided in Table 4-4.

Table 4-4. Penstock Cost Estimation

Item	Cost estimation, million dollars
Site work, structures, roads, etc.	9.7
Penstock material	14
Engineering, Legal, Administration	4.3
Total	28

The total estimated cost of installation and materials of the penstock is approximately $28 million. Site work included trenching and rock blasting required for penstock installation and creek crossings. It was assumed rock blasting and/or trenching would be required along entire penstock alignment and creek crossings would require the use of cofferdams. Penstock material estimation was quoted by a local vendor at current steel prices and adjusted by inflating costs by 25 percent to reflect estimated steel prices at the time construction begins.

4.10 Outback Site Storage and Infrastructure Review

The City's Outback Facility has been under development since the early 1900s. From the 1950s to the present, the facility has seen many changes and expansions. The site currently includes a hydraulic control structure with an overflow to Tumalo Creek, four steel storage tanks, gas chlorination facilities, several wells, storage buildings, and vaults containing water meters and regulating valves. All these facilities have been built and modified over the last several decades. Not all of the modifications are well documented. The structures and the piping system that interconnect them are shown on the site layout maps in the Appendices of Chapter 6.

Brown and Caldwell developed a computer model of the Outback Facility system as part of a general water system model created in early 2008. However, it could model only the general operation of the Outback Facility system and not the specific piping system because data were not available for all the piping system installed at the site. With the probable addition of a new treatment system and new raw water penstock , a task was added to the Bridge Creek Alternatives Study to improve the knowledge of how the Outback Facility system operated and to identify future changes that may be necessary. This section provides the results of that brief review and recommendations on future improvements to the site.

4.10.1 Existing Operations

In simple terms, water from the Bridge Creek Intake comes to the Outback Facility in two pipes that flow to a standpipe which has an overflow elevation that controls the height of water in the storage tanks at the site. If the tanks are not full, all the water coming from Bridge Creek enters the tanks. When the tanks are full, water in excess of what is being used is diverted via the overflow back to Tumalo Creek.

Chlorine is added to the water before it enters the storage tanks. Because the system is currently without ultraviolet (UV) treatment and not filtered, USEPA drinking water regulations require an extended chlorine contact time. To obtain sufficient contact time, three of the storage reservoirs (total volume of 6.5 million gallons [MG]) are connected in series and held full by a regulating valve. The valve controls the amount of water released to the water system such that the tanks remain full. This slows down the speed the water moves through the three tanks and thereby increases the chlorine contact time. The result is that the system cannot benefit from the ability to use the volume of all three tanks at the Outback Facility to meet peak system or fire flow demands.

The wells at the Outback Facility do not require an extended chlorine contact time. They normally pump to the new 3.6-MG Reservoir 3, which is controlled by a regulating valve set to allow the tank volume to be used to meet peak system demands.

To allow a detailed computer hydraulic model to be constructed for the Outback Facility site, interviews were conducted with City field staff to gather available existing as-built drawings and supplement them with oral records of onsite pipes and valves, noting which were still active. The results of the review are contained in Appendix 4-E. The schematics were used to update the earlier hydraulic model for the Outback Facility, which were then provided to Murray, Smith and Associates for use in developing a new, optimizing hydraulic model for the full water system.

4.10.2 Recommended Improvements

The installation of a new treatment system for Bridge Creek will allow the required chlorination contact time to be reduced to only 49 minutes with membrane filtration and to 12 minutes with a UV treatment system. This will free the water system from the need to dedicate storage tanks solely to providing chlorine contact time.

If the new treatment system is coupled with a hydropower facility as is expected for permitting purposes, it will need to be located on City property. This may require that one of the four existing water tanks be removed to make room for the new facilities. Two of the existing steel storage tanks are old, bolted tanks that are leaking and in need of significant repair. They would be logical candidates to be removed.

From the brief review of the Outback Facility, the following recommendations were developed:

- Once a new treatment system is place, remove the restrictions on the tank system that now provides the chlorine contact time and allow the water system to use all the storage in the tanks to meet peak and fire flow demands.
- If in-town hydropower units are placed in the system, such as at Aubrey Butte and Overturf, allow the system to be pressurized directly from the water elevation of the Outback Facility tanks so that maximum pressure can be developed at the hydropower units.
- Maximize the storage at the Outback Facility. To operate a 13- to 26-mgd water treatment system reasonably, the system should have 10 MG of storage at the Outback Facility to provide an operating cushion so that the water treatment plant does not need to be staffed continuously.

- Storage above 10 MG at the Outback Facility and other storage in the system can be used to surge water through the hydropower facilities during peak power usage periods. Power produced during peak periods is approximately 20 percent more valuable than non-peak power. Adding the flexibility to sell peak power may pay for most, if not all, of the cost of the added storage over the life of the project.
- Construct one of the planned storage tanks on the property governed by the special use permit from USFS in the near future. The added storage will add the flexibility necessary to replace or repair the two existing bolted steel tanks.
- Construct a dedicated overflow pipeline sized to take the full flow of the capacity of the Outback Facility systems across into the proposed discharge pipeline to Tumalo Creek.
- Install seismically-activated shut-off valves on existing Reservoir 3 and any new tanks placed at the Outback Facility. The new intake, penstock, and treatment system will be designed to remain operable after a major earthquake. However, it may take some time to secure the transmission and distribution system. By installing seismically-activated valves, the water in storage will remain in storage until the distribution system is ready for it.

APPENDIX 4-A

Existing Pipeline Drawings

APPENDIX A

EXISTING PIPELINE ALIGNMENT

1926 Pipeline Alignment

The intake located on Bridge Creek consists of a diversion dam and accompanied screening structure. Water exits the screening chamber through a square 24-inch outlet structure which tapers to a 14-inch diameter pipe which is the beginning of the pipeline alignment. The remaining capacity of Bridge Creek continues downstream by cresting over the diversion dam.

From the outlet structure the pipeline travels due east toward the North Fork of Tumalo Creek and to the first creek crossing. The creek crossing is located 75 feet downstream from the existing bridge and crosses beneath the creek through a 14-inch wrapped concrete encased pipe.

After the creek crossing the pipeline alignment travels east, paralleling the existing Forest Service Development Road 4603 (Tumalo Falls Road), varying between approximately 100 feet to 10 feet south of the existing road. The alignment then veers to the southeast, toward Skyliners Road. At this point, pipeline alignment crosses the existing road and begins to parallel the road approximately 100 feet to the north of the road.

The second significant creek crossing occurs just before the pipeline alignment enters onto Skyliners Road. The creek crossing is significantly wider at this location than at the first creek crossing. At the crossing, the pipeline travels beneath Tumalo Creek through a 14-inch wrapped concrete encased pipe approximately 40 feet downstream from the existing bridge.

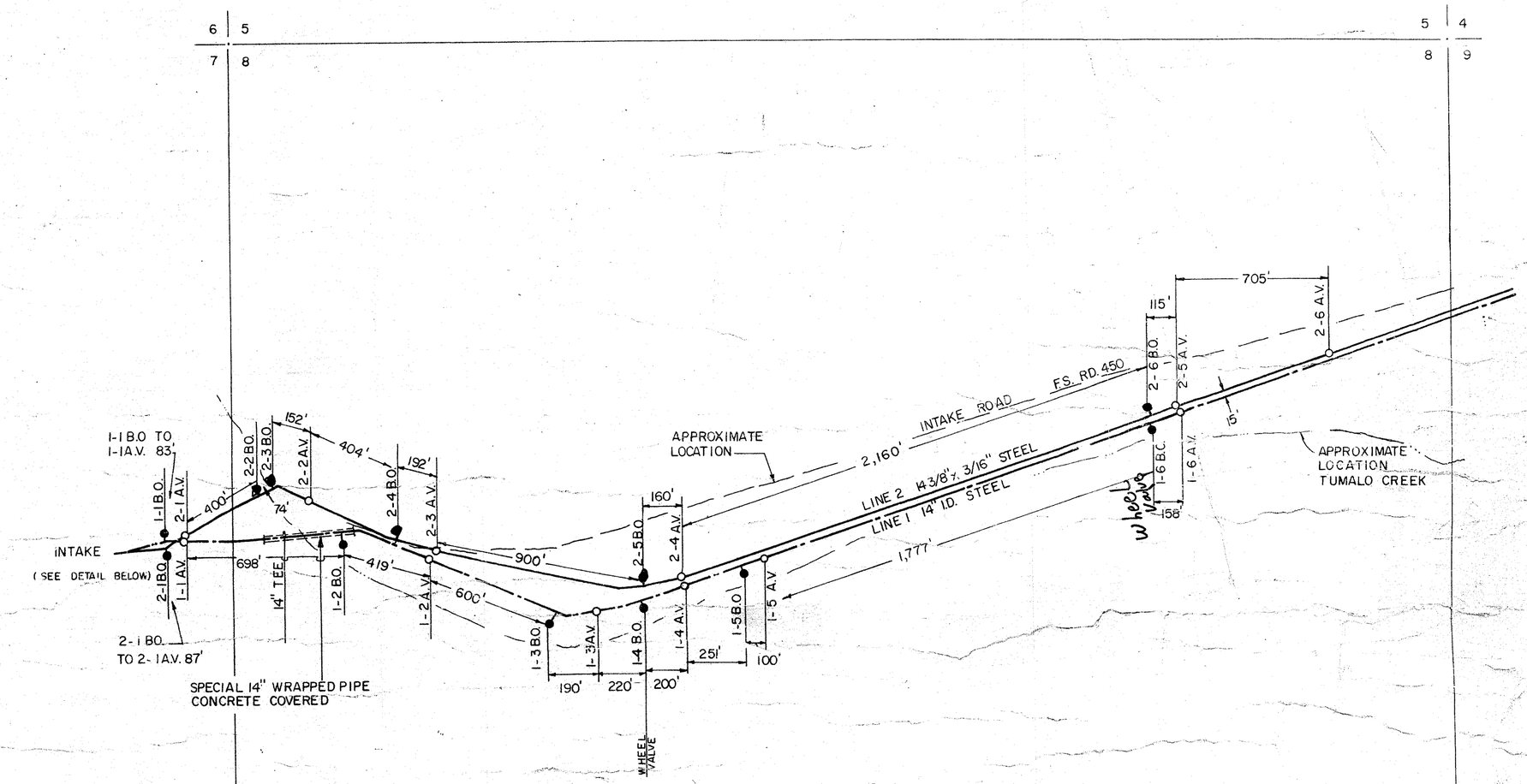
After the creek crossing, the pipeline alignment travels northeast and parallels Skyliners Road on the north side of the road. While following Skyliners Road, the pipeline alignment travels through several city easements on private property within the Skyline Subdivision. East of the Skyline Subdivision, the pipeline alignment travels exits Skyliners Road to head due east and begins to parallel Forest Service Road 090. At the point the Forest Service Road 090 crosses over Skyliner Road, the pipeline transitions into the 12-inch diameter pipe and continues to parallel Forest Service Road 090 until the pipeline discharges into the Outback Treatment Facility.

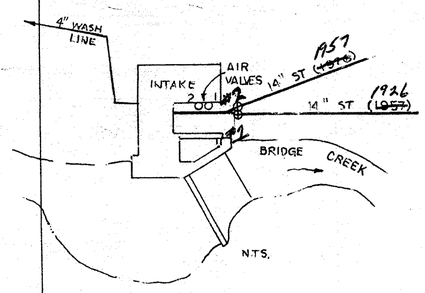
1957 Pipeline Alignment

From the bifurcation, the second alignment diverges to the north and away from the first pipeline alignment to cross the North Fork of Tumalo Creek. In contrast to the first creek crossing, the second crossing occurs on 20 foot concrete piers slightly upstream from the existing bridge.

After the first creek crossing, the alignment diverges to the southeast to follow the first pipeline alignment. The second alignment then travels parallel and on the north side of the first alignment, separated by 15 feet on centerline. The alignment crosses beneath Tumalo Creek downstream and parallel from the first pipeline alignment. When the two alignments enter onto Skyliners Road, the second alignment crosses the first alignment and then continues to parallel the first alignment on the south side. Once the alignments past the Skyline Subdivision, the second pipeline again crosses the first pipeline, diverges from the first alignment and continues to parallel Skyliners Road on the north side of the road.

At the intersection of Skyliners Road and Forest Service Road 090, the second alignment again crosses the first alignment and the two alignments are parallel to each other, Skyliners Road and Forest Service Road 090. The second pipeline alignment then diverges back onto Skyliners Road and continues north on Forest Service Road 380. At the intersection of Forest Service Roads 380 and 090, the second alignment again parallels the first alignment on the north, separated by 15 feet on centerline. The second pipeline continues to parallel the first alignment in this configuration to the Outback Treatment Facility.

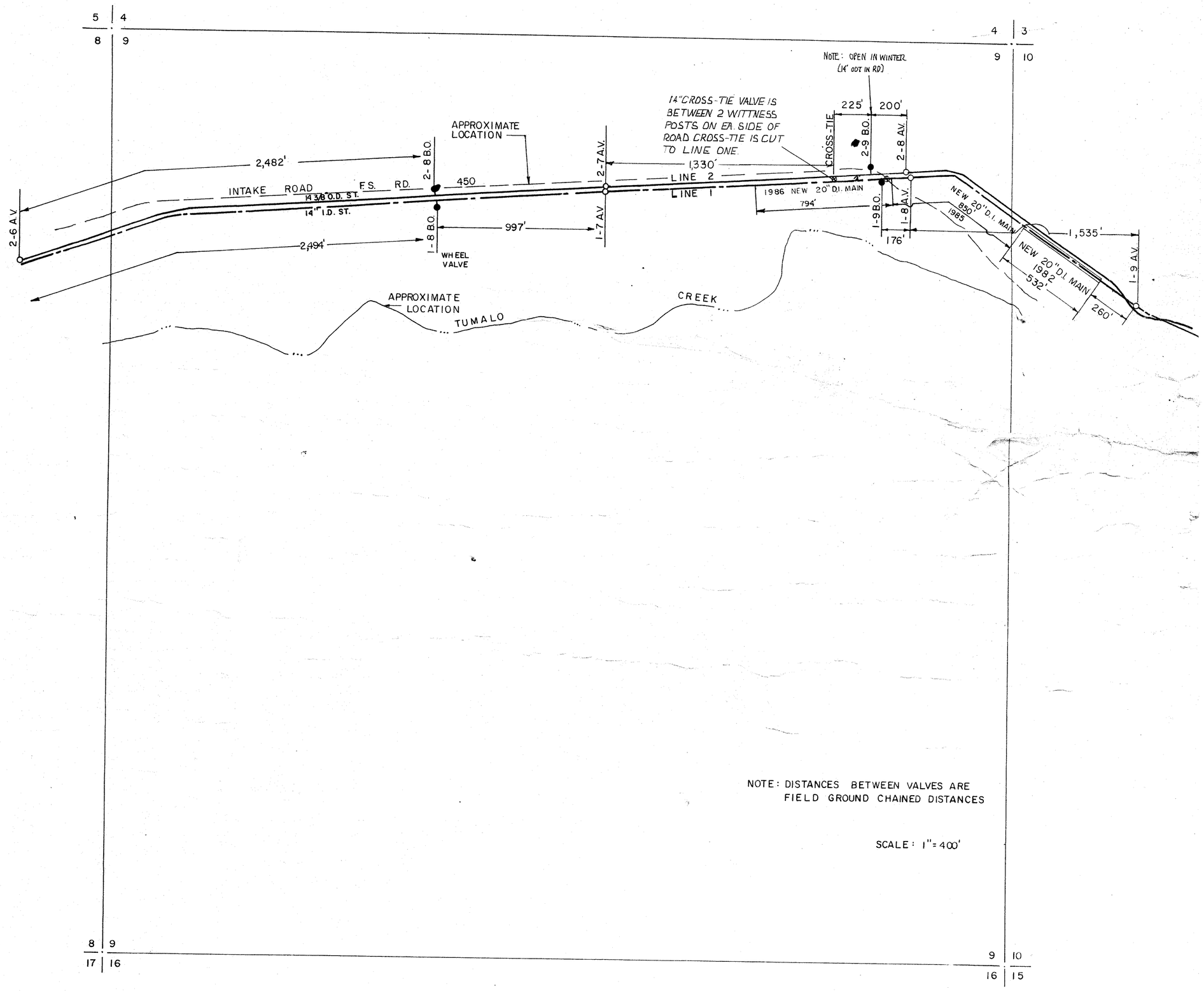




NOTE: DISTANCES BETWEEN VALVES ARE
FIELD GROUND CHAINED DISTANCES
SUMMER OF 1982

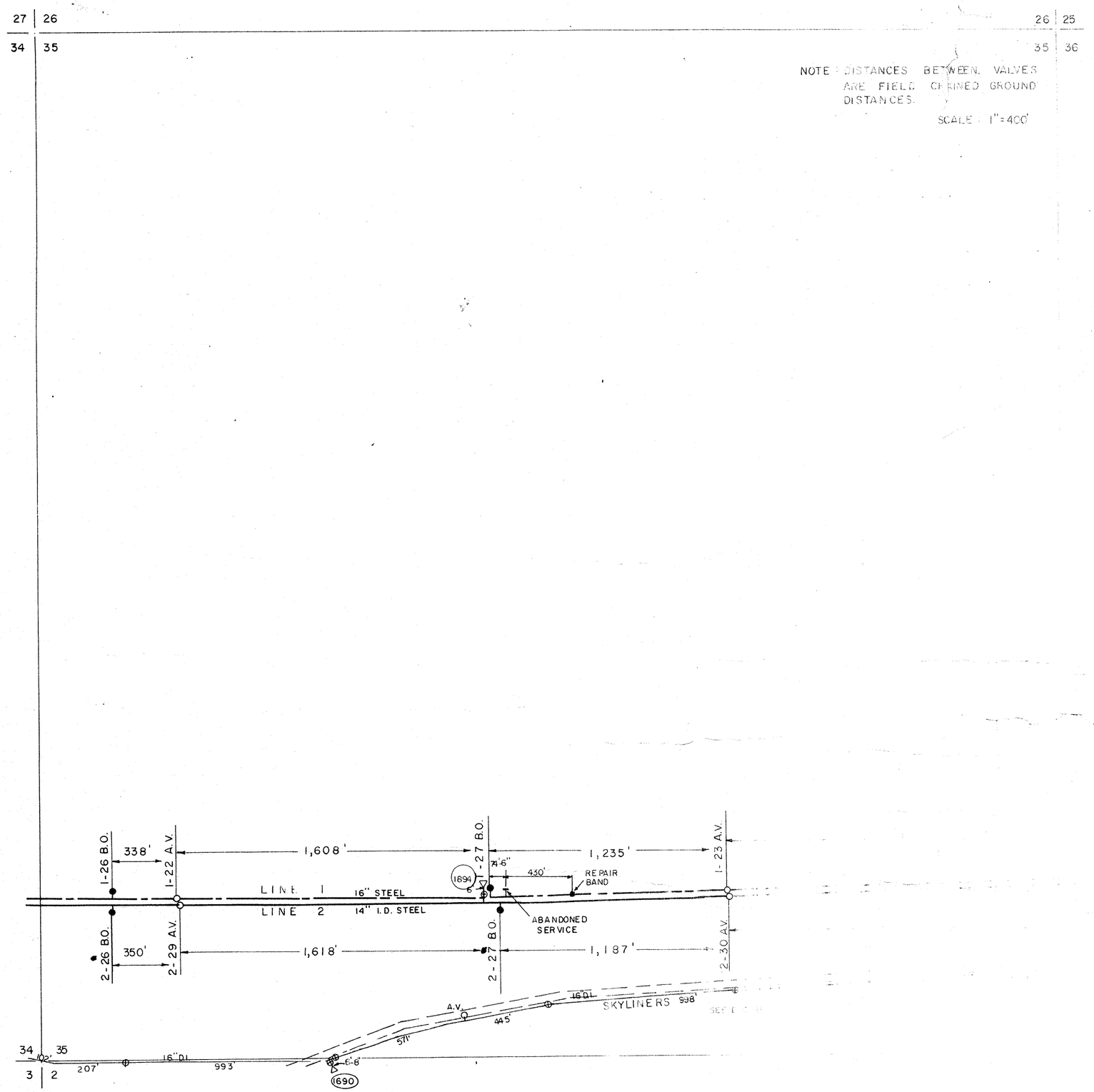
SCALE: 1" = 400'

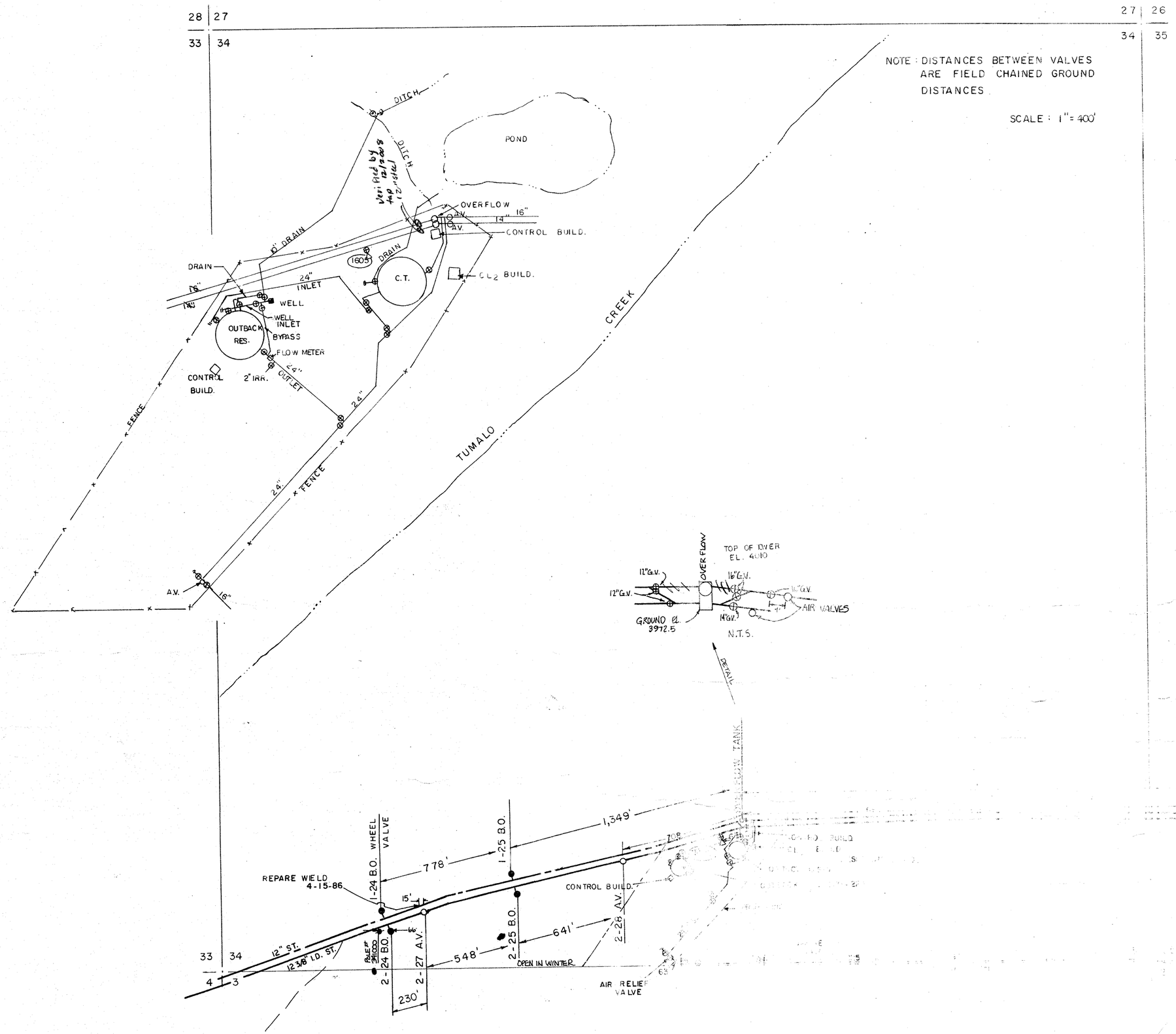
7 8
18 17
8 9
17 16

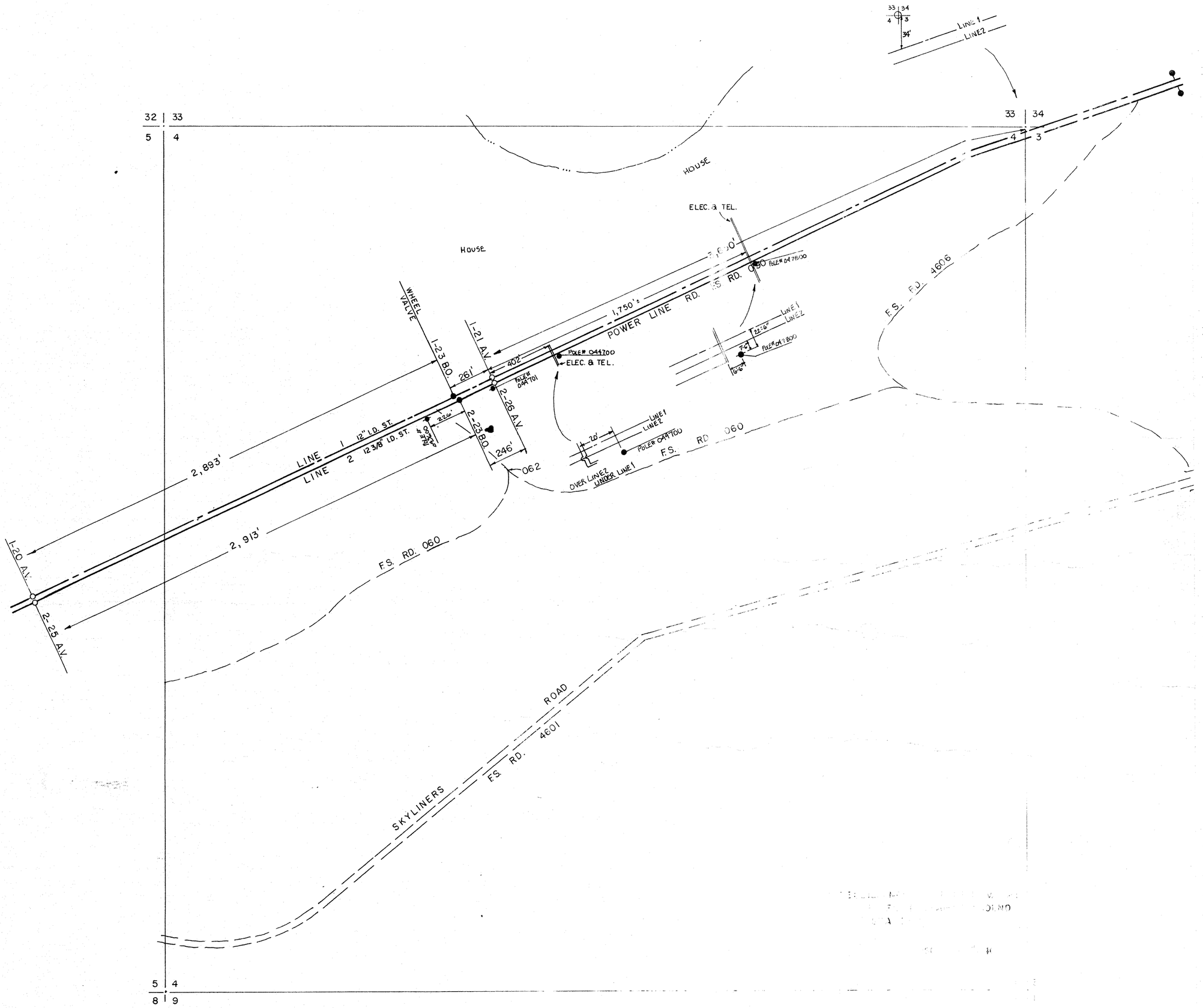

5
4
8
9
4
3
9
10
NOTE: OPEN IN WINTER
(14" ODT IN RD)
14" CROSS-TIE VALVE IS BETWEEN 2 WITTNESS POSTS ON EA. SIDE OF ROAD. CROSS-TIE IS CUT TO LINE ONE.
225'
200'
CROSS-TIE
2-9 B.O.
2-8 A.V.
APPROXIMATE LOCATION
2,482'
2-8 B.O.
450
2-7 A.V.
1,330'
LINE 2
LINE 1
INTAKE ROAD
F.S. RD.
14 3/8" O.D. ST.
14" I.D. ST.
1986 NEW 20" D.I. MAIN
794'
1-9 B.O.
1-8 A.V.
176'
NEW 20" D.I. MAIN
850'
1985
1,535'
2-6 A.V.
2,494'
1-8 B.O.
997'
1-7 A.V.
WHEEL VALVE
NEW 20" D.I. MAIN
1982
532'
260'
1-9 A.V.
APPROXIMATE LOCATION
TUMALO
CREEK
NOTE: DISTANCES BETWEEN VALVES ARE FIELD GROUND CHAINED DISTANCES
SCALE: 1" = 400'
8
9
17
16
9
10
16
15

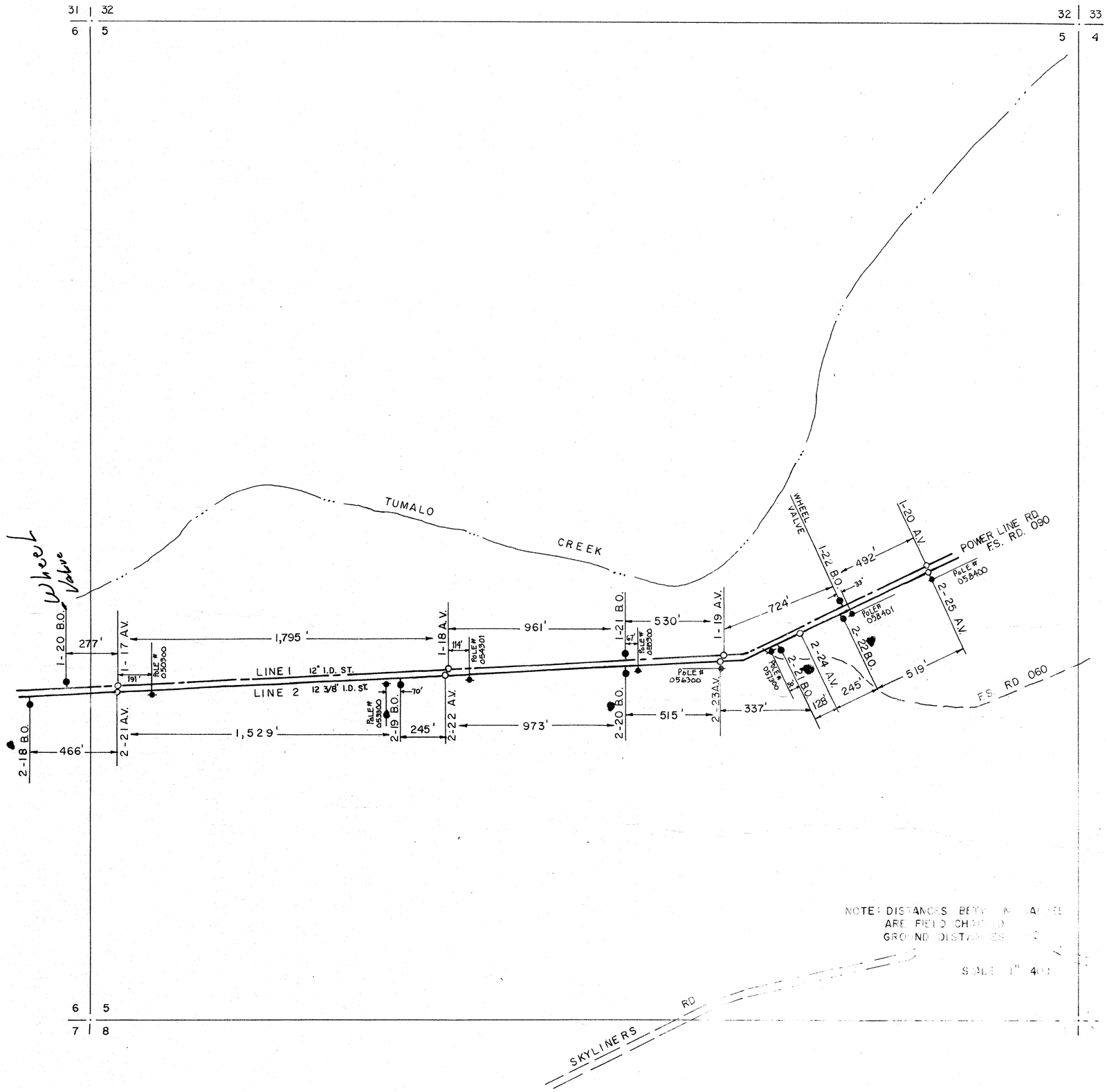
NOTE : DISTANCES BETWEEN VALVES ARE FIELD OBTAINED GROUND DISTANCES.

SCALE : 1" = 400'



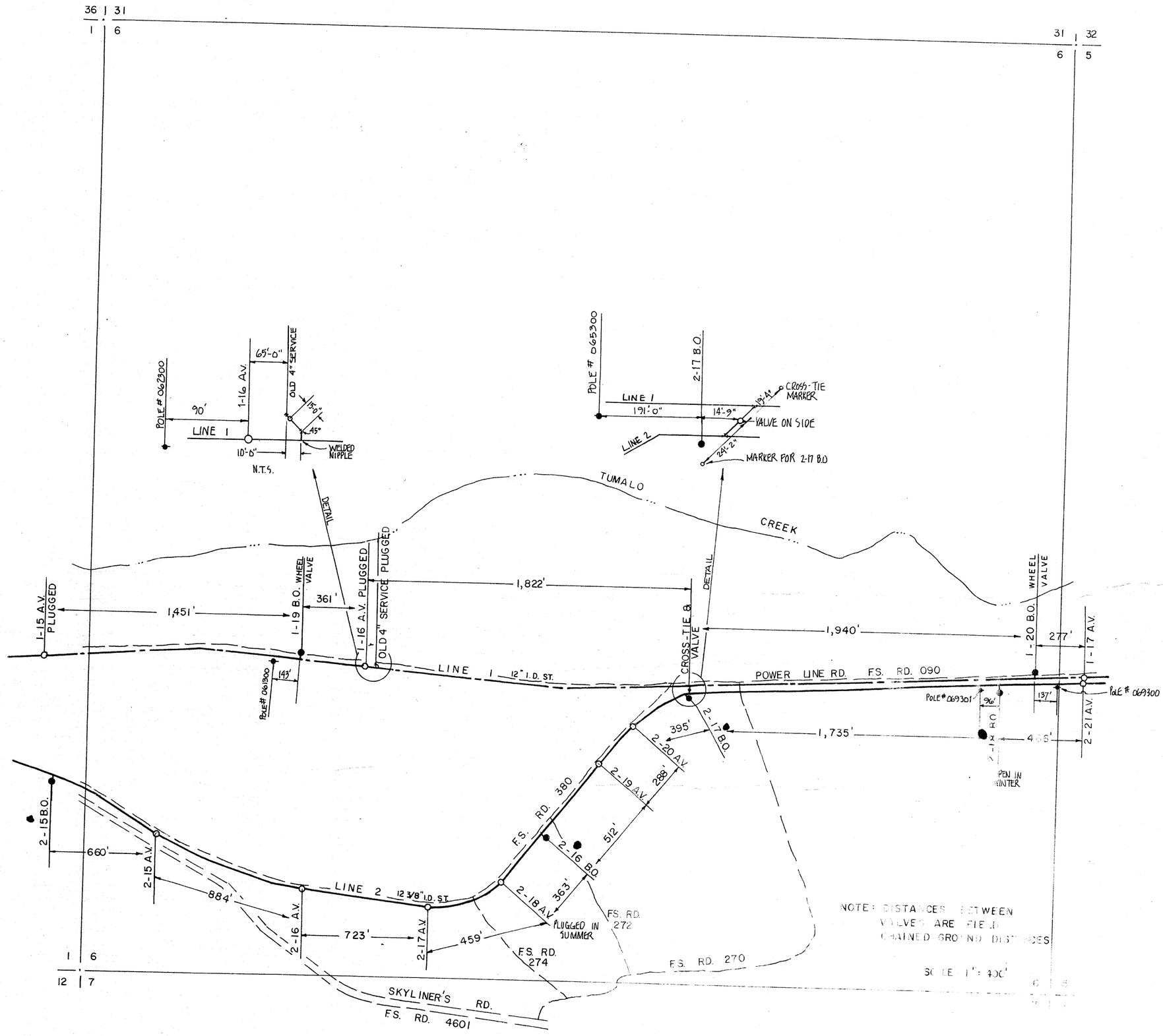

28 | 27
33 | 34
27 | 26
34 | 35
NOTE: DISTANCES BETWEEN VALVES ARE FIELD CHAINED GROUND DISTANCES.
SCALE: 1" = 400'
POND
DITCH
DITCH
Verified by TA 12/2/81 Inlet
OVERFLOW
A.V.
16"
14"
A.V.
CONTROL BUILD.
6" DRAIN
DRAIN
1605
DRAIN
C.T.
CL_2 BUILD.
16"
24" INLET
WELL
WELL INLET
OUTBACK RES.
BYPASS
FLOW METER
CONTROL BUILD.
2" IRR.
24" OUTLET
24"
FENCE
24"
FENCE
TUMALO
CREEK
A.V.
16"
OVERFLOW
TOP OF DIKE EL. 4010
12"G.V.
12"G.V.
16"G.V.
16"G.V.
AIR VALVES
GROUND EL. 3972.5
N.T.S.
DETAIL
33
34
4
3
12" ST.
12 3/8" I.D. ST.
REPARE WIELD 4-15-86
1-24 B.O. WHEEL VALVE
778'
15'
1-25 B.O.
1,349'
CONTROL BUILD.
A.V.
2-26
2-25 B.O.
641'
548'
OPEN IN WINTER
2-24 B.O.
2-27 A.V.
230'
AIR RELIEF VALVE


32 | 33
5 | 4
33 | 34
4 | 3
33 | 34
4 | 3
34'
LINE 1
LINE 2
HOUSE
HOUSE
ELEC. & TEL.
1,750'±
POWER LINE RD.
F.S. RD. 060
POLE# 047800
F.S. RD. 4606
WHEEL VALVE
1-23 B.O.
1-21 A.V.
402'
261'
POLE# 044700
ELEC. & TEL.
POLE# 044701
2-26 A.V.
2-23 B.O.
246'
062
LINE 1 12" LD. ST.
LINE 2 12 3/8" LD. ST.
POLE# 044702
22'6"
7'6"
16'6"
POLE# 047800
20'
POLE# 044700
OVER LINE 2
UNDER LINE 1
F.S. RD. 060
2,893'
2,913'
1-20 A.V.
2-25 A.V.
F.S. RD. 060
SKYLINERS ROAD
F.S. RD. 4601
5 | 4
8 | 9



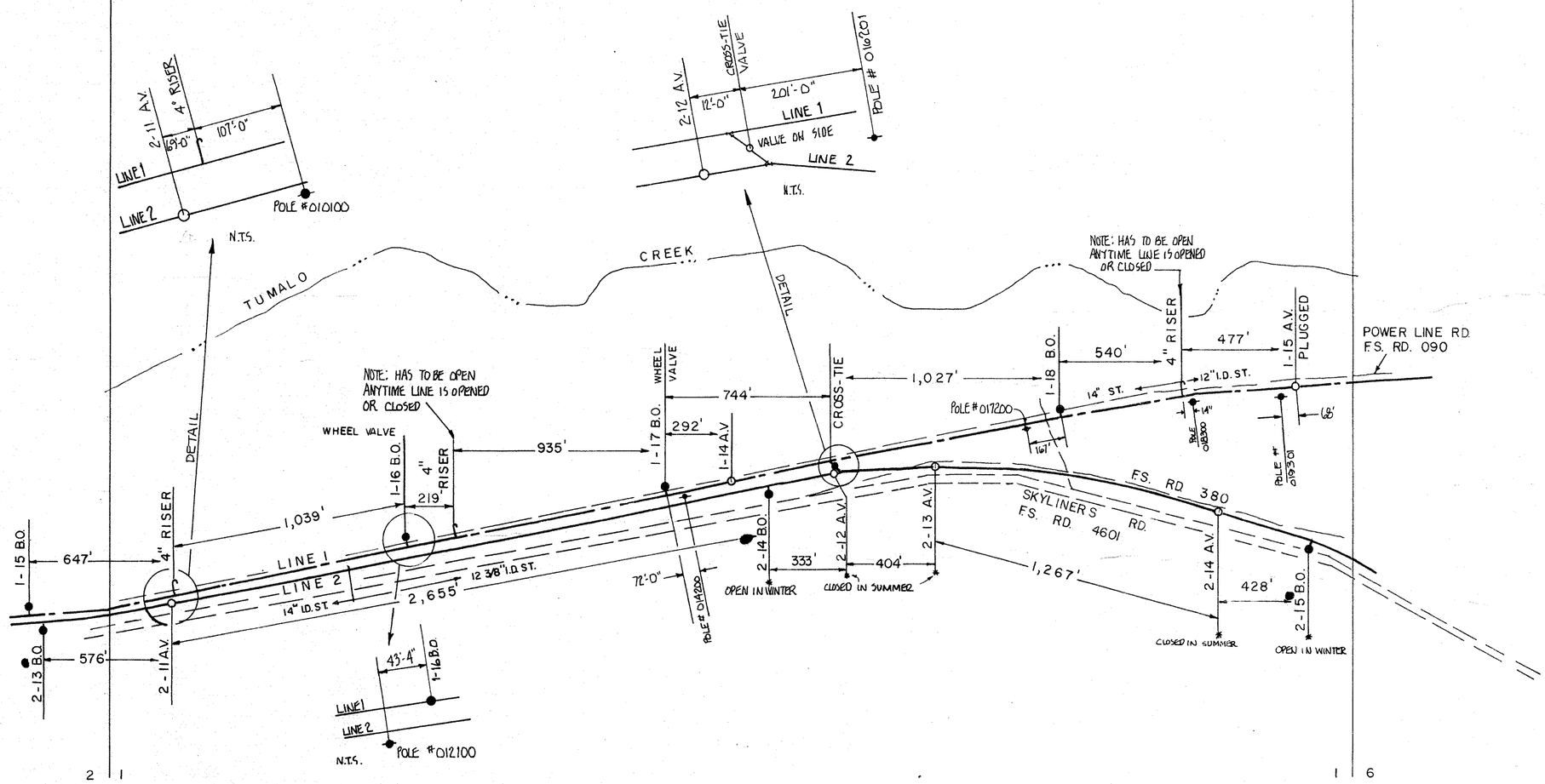
NOTE: DISTANCES BETWEEN VALVES
ARE FIELD CHAINED
GROUND DISTANCES

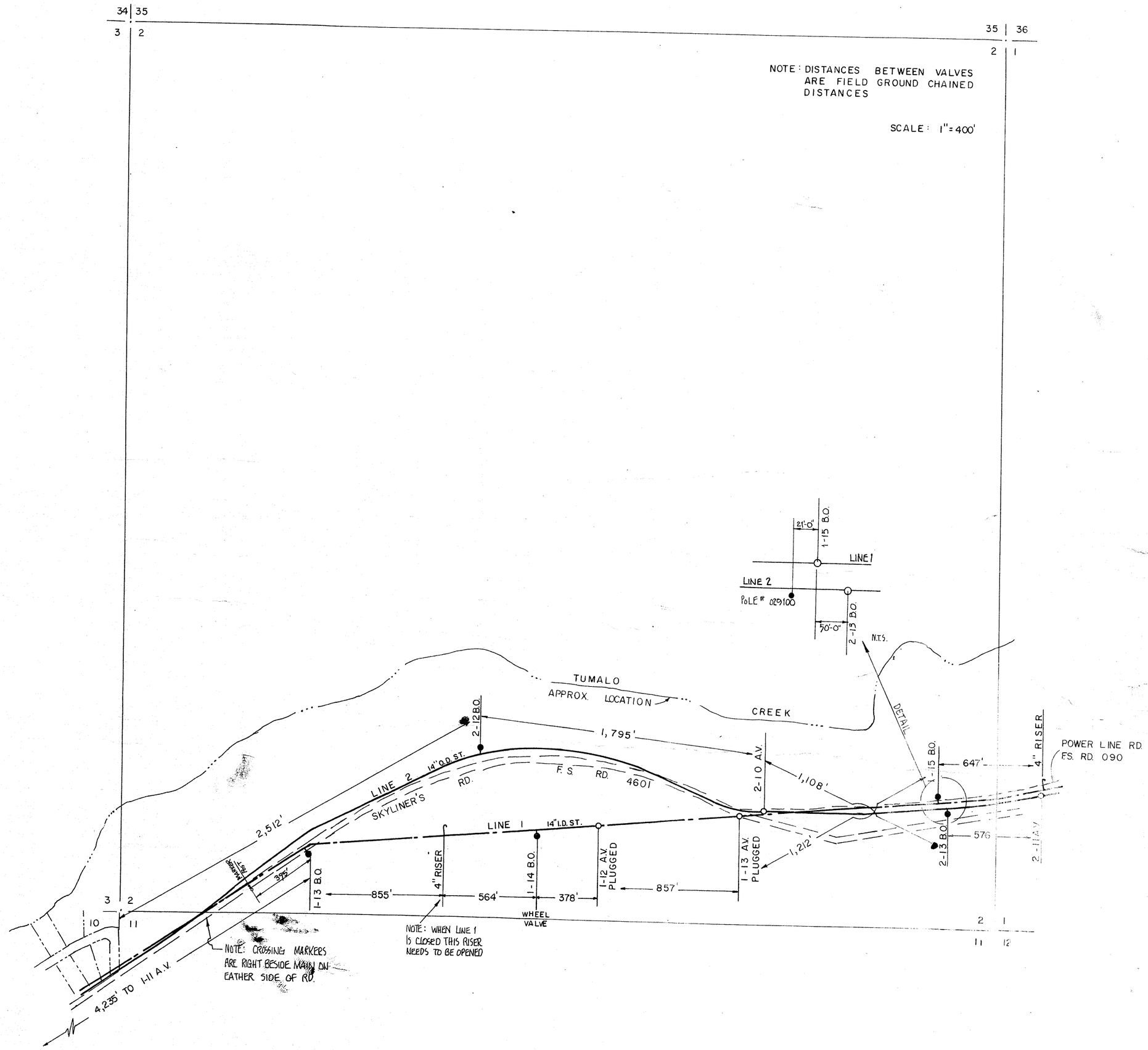
SCALE 1" 400

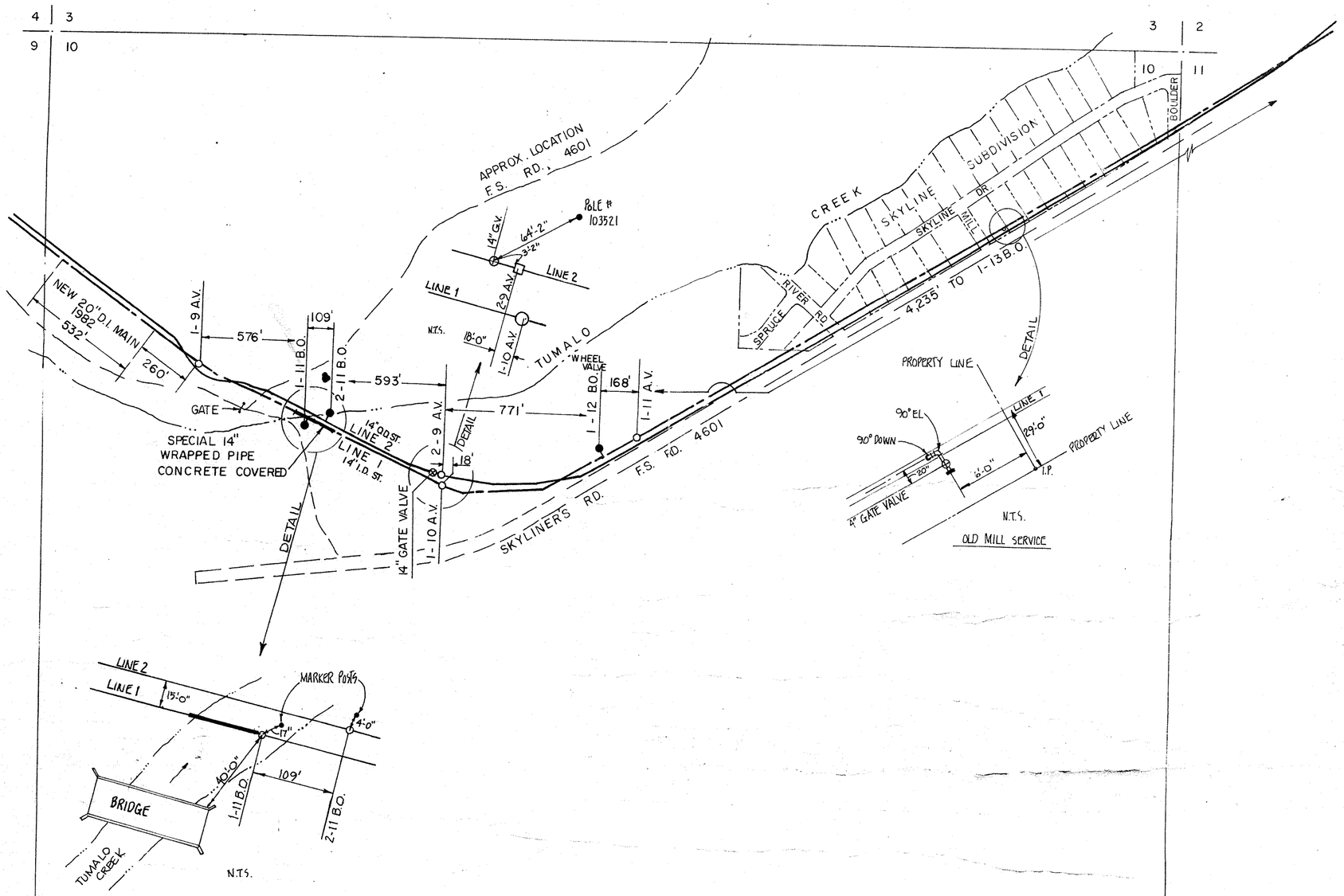

36 | 31
1 | 6
31 | 32
6 | 5
POLE # 062300
90'
1-16 A.V.
65'-0"
OLD 4" SERVICE
15'-0"
45°
LINE 1
10'-6"
WELDED NIPPLE
N.T.S.
DETAIL
POLE # 065300
2-17 B.O.
LINE 1
191'-0"
14'-9"
19'-4"
CROSS-TIE MARKER
VALVE ON SIDE
LINE 2
24'-2"
MARKER FOR 2-17 B.O.
TUMALO
CREEK
1-15 A.V. PLUGGED
1,451'
1-19 B.O. WHEEL VALVE
361'
1-16 A.V. PLUGGED
OLD 4" SERVICE PLUGGED
1,822'
DETAIL
CROSS-TIE & VALVE
1,940'
1-20 B.O. WHEEL VALVE
277'
1-17 A.V.
POLE # 061300
143'
LINE 1 12" I.D. ST.
POWER LINE RD. F.S. RD. 090
POLE # 069301
96'
137'
POLE # 069300
2-21 A.V.
2-17 B.O.
395'
1,735'
2-20 A.V.
2-19 A.V.
288'
2-1X B.O.
OPEN IN WINTER
F.S. RD. 380
512'
2-16 B.O.
2-15 B.O.
660'
2-15 A.V.
884'
LINE 2 12 3/8" I.D. ST.
2-18 A.V.
363'
PLUGGED IN SUMMER
F.S. RD. 272
2-16 A.V.
723'
2-17 A.V.
459'
F.S. RD. 274
F.S. RD. 270
1 | 6
12 | 7
SKYLINER'S RD.
F.S. RD. 4601
NOTE: DISTANCES BETWEEN VALVES ARE FIELD CHAINED GROUND DISTANCES
SCALE 1" = 400'

NOTE: DISTANCES BETWEEN VALVES ARE FIELD GROUND CHAINED DISTANCES

SCALE: 1" = 400'




34 | 35
3 | 2
35 | 36
2 | 1
NOTE: DISTANCES BETWEEN VALVES ARE FIELD GROUND CHAINED DISTANCES
SCALE: 1" = 400'
21'-0"
1-15 B.O.
LINE 1
LINE 2
POLE # 029100
50'-0"
2-13 B.O.
N.T.S.
DETAIL
TUMALO
APPROX. LOCATION
CREEK
2-12 B.O.
1,795'
14" O.D. ST.
LINE 2
SKYLINER'S
RD.
F.S. RD. 4601
2-10 A.V.
1,108'
1-15 B.O.
647'
4" RISER
POWER LINE RD.
F.S. RD. 090
2,512'
LINE 1
14" I.D. ST.
1,212'
2-13 B.O.
576
2-11 A.V.
MARKER POST
375'
1-13 B.O.
855'
4" RISER
564'
1-14 B.O.
378'
1-12 A.V. PLUGGED
857'
1-13 A.V. PLUGGED
WHEEL VALVE
3 | 2
10 | 11
2 | 1
11 | 12
NOTE: WHEN LINE 1 IS CLOSED THIS RISER NEEDS TO BE OPENED
NOTE: CROSSING MARKERS ARE RIGHT BESIDE MAIN ON EATHER SIDE OF RD.
4,235' TO 1-11 A.V.



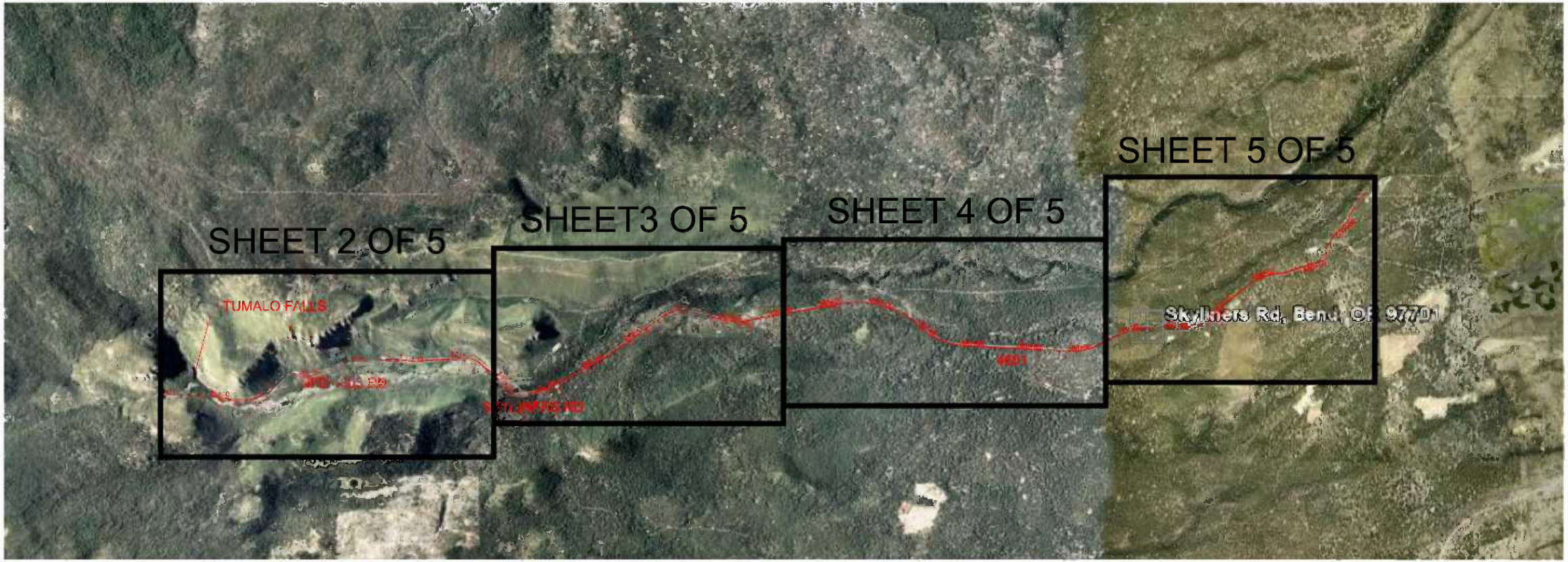
NOTE: 1. DISTANCES BETWEEN VALVES ARE FIELD GROUND CHAINED DISTANCES

2. EASEMENT RECORDED IN BOOK 45, PG. 380

SCALE: 1" = 400'

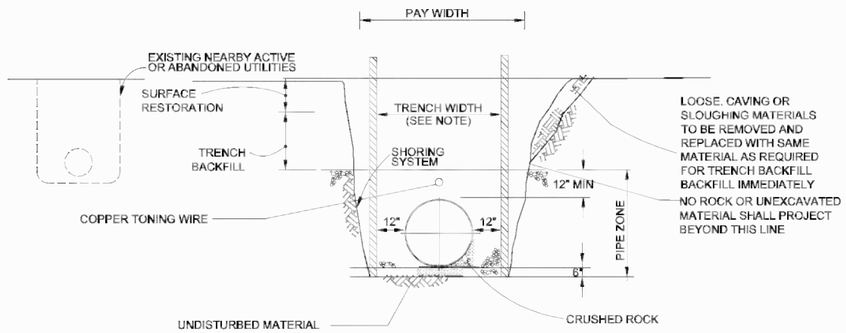
APPENDIX 4-B

Penstock Alignment and Profile Drawings

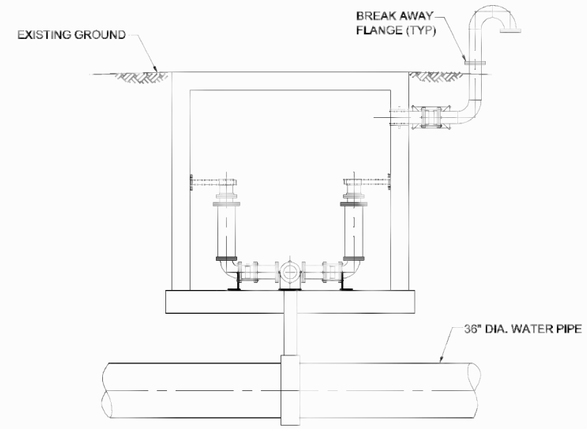


SKYLINERS ROAD PLAN - KEY MAP

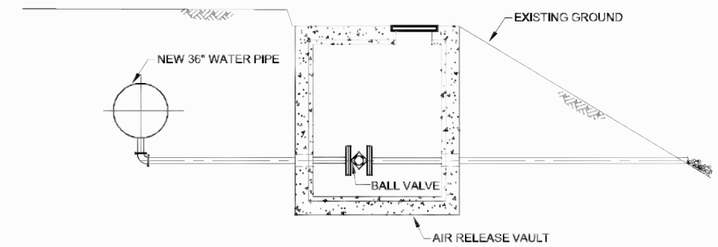
0 2000 4000
SCALE IN FEET



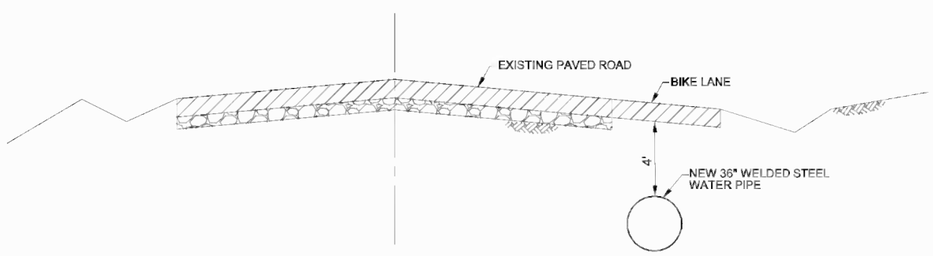
TYPICAL TRENCH DETAIL



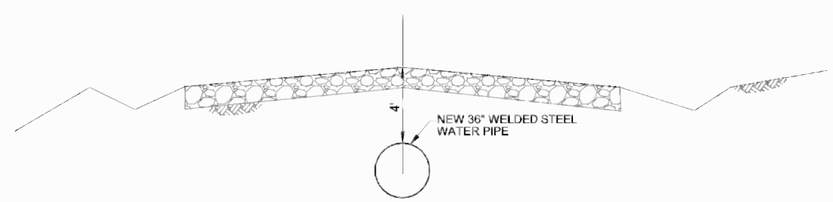
CARV - AIR RELEASE



BLOWOFF VALVE/ DRAIN



TYPICAL SECTION - PAVED ROAD

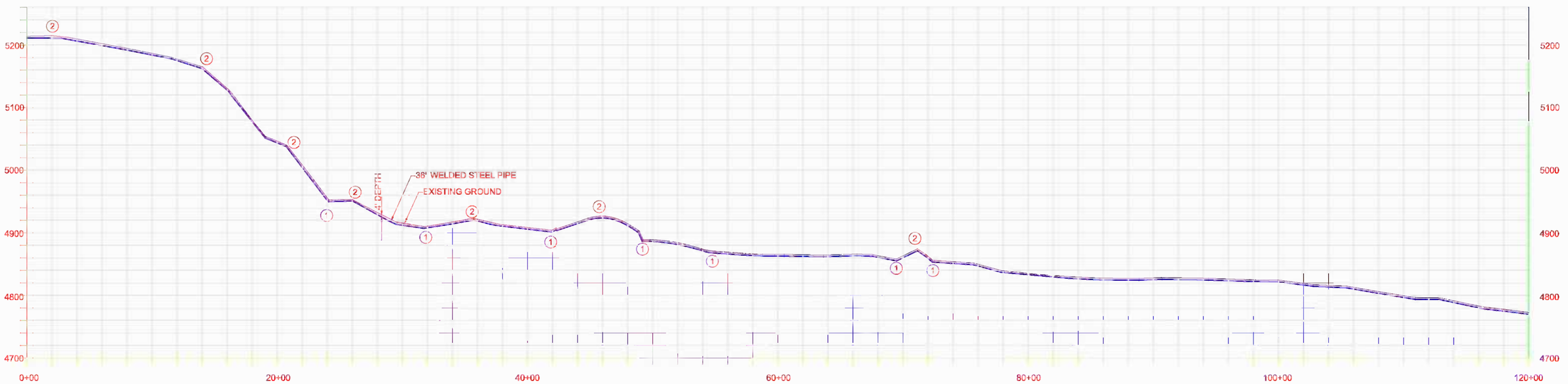


TYPICAL SECTION - DIRT/GRAVEL ROAD

DETAIL SHEET

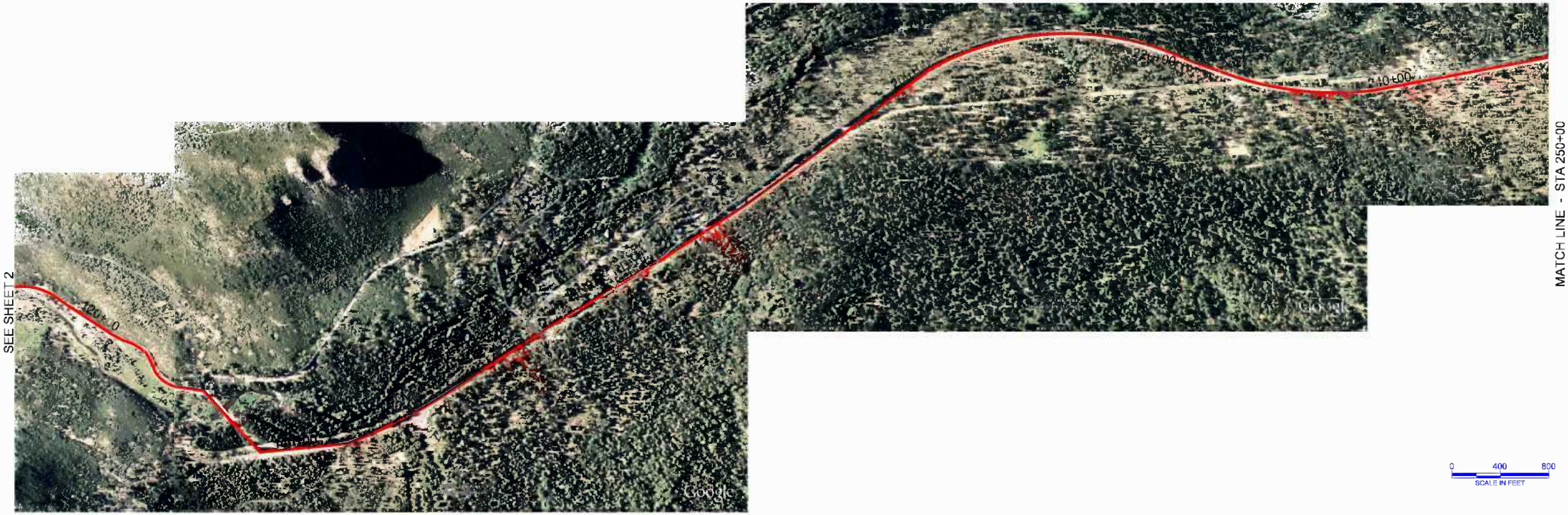
Photo Image Filename:
Path: P:\136732 City of Bend, Bend Springs Water Filename: 136732-Details Plot date: Oct 08, 2003 - 01:37:28pm CAD User: chard

SKYLINERS ROAD PLAN

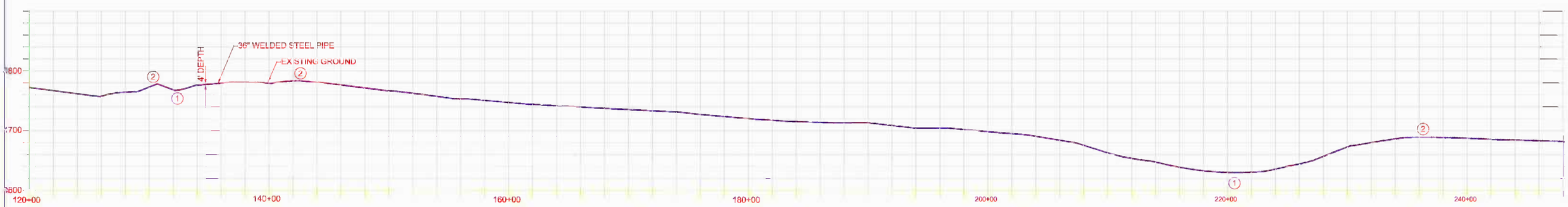


SKYLINERS ROAD PROFILE

① BLOWOFF VALVE/ DRAIN
② AIR RELEASE VALVE



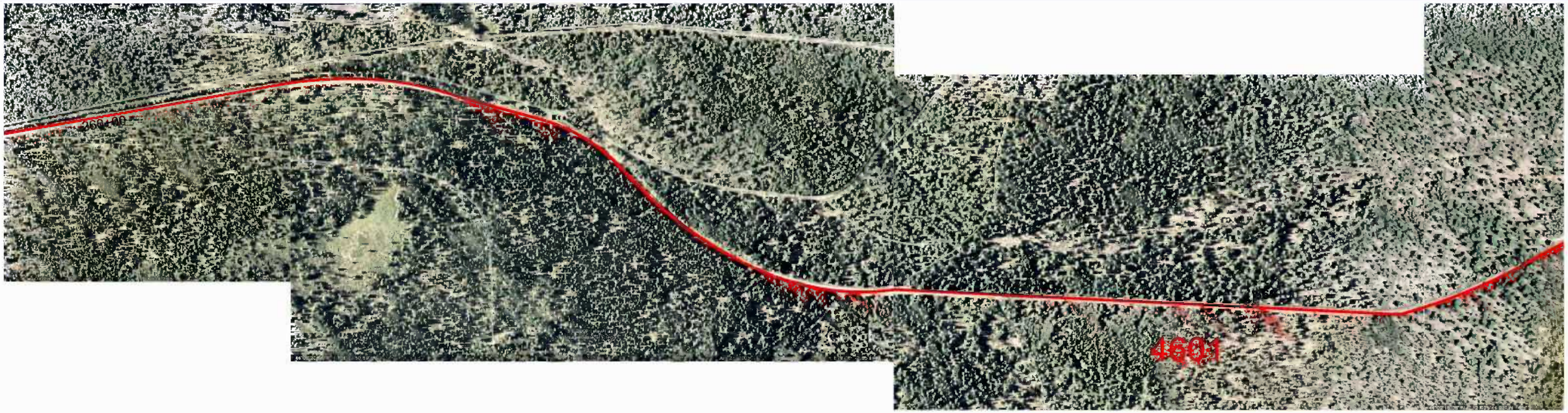
SKYLINERS ROAD PLAN



① BLOWOFF VALVE/ DRAIN
② AIR RELEASE VALVE

SKYLINERS ROAD PROFILE

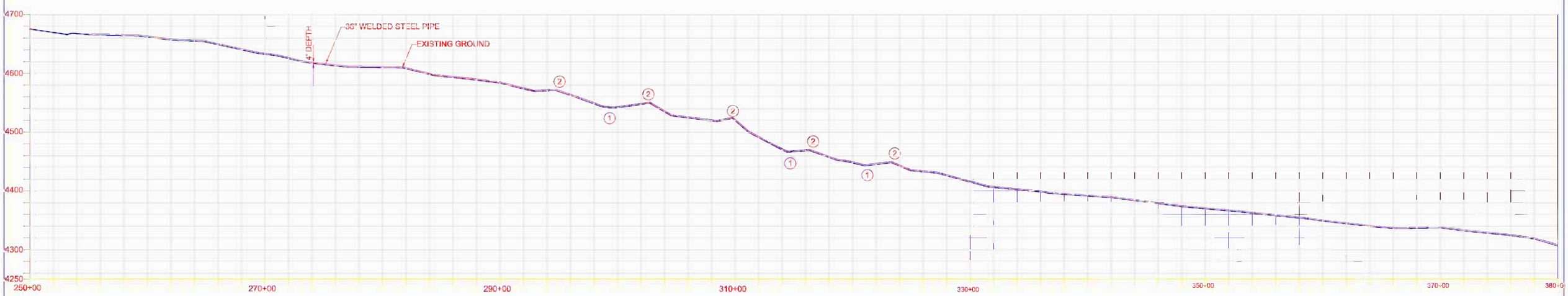
MATCH LINE - STA 250+00
SEE SHEET 3



MATCH LINE - STA 380+00
SEE SHEET 5

SKYLINERS ROAD PLAN

0 400 800
SCALE IN FEET



SKYLINERS ROAD PROFILE

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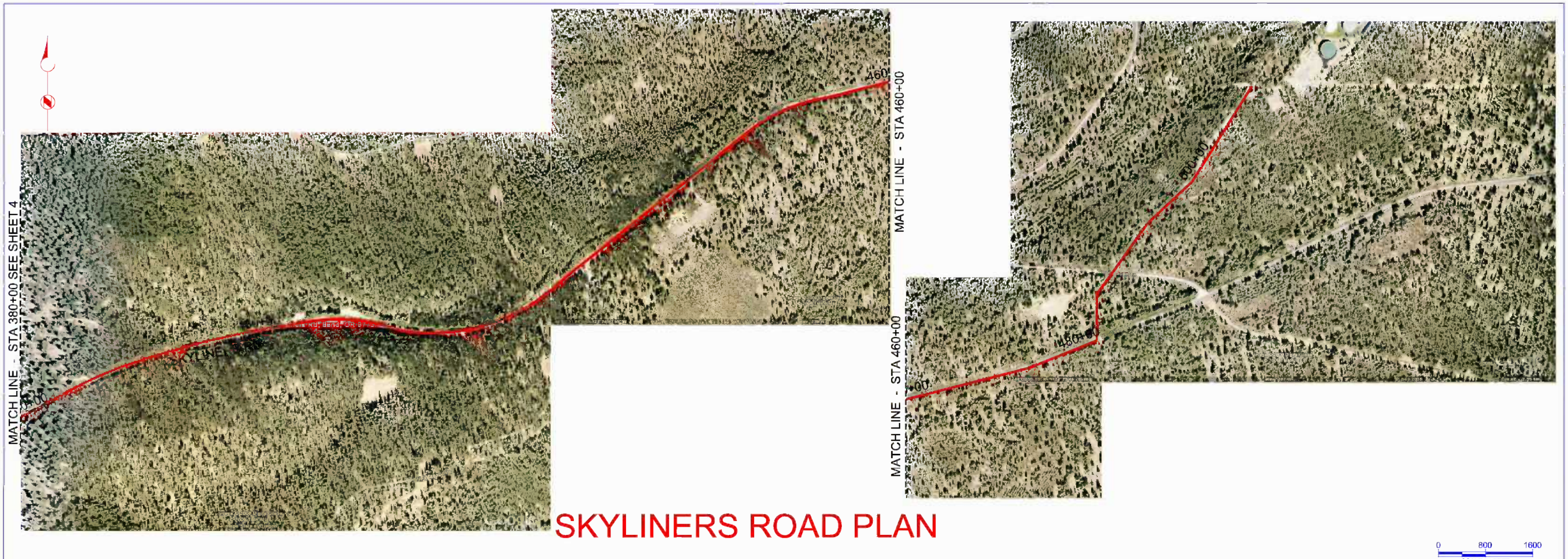
② AIR RELEASE VALVE



SKYLINERS ROAD PLAN

① BLOWOFF VALVE/ DRAIN
② AIR RELEASE VALVE

SKYLINERS ROAD PROFILE

SHEET 5 OF 5

APPENDIX 4-C

Geotechnical Reconnaissance Report

BROWN AND CALDWELL
Environmental Engineers and Consultants
6500 SW Macadam Avenue, Suite 200
Portland, OR 97239
Attention: Corianne Hart

April 24, 2009
Project No. 1091020

Project: City of Bend Water Supply Alternatives Study
Bend, Oregon

Subject: **Technical Memorandum #3**: Task 4.2: Skyliners Road Pipeline Evaluation
Results of Geotechnical Reconnaissance

Dear Corianne:

This letter presents the results of a geotechnical reconnaissance along the proposed pipeline to be aligned within the right of way along USFS route 4603 from Tumalo Falls then along Skyliners Road terminating near Outback Reservoir. The work was performed in general accordance with Exhibit A of our subcontract agreement dated April 14, 2009. Exceptions include the scale of the maps used for presentation which we have modified to include the USGS 1:24000 and 1:12000 aerial photographs to better match the broad rather than detailed nature of the reconnaissance.

Project Understanding and Scope

This reconnaissance was conducted to provide a general understanding of the soil, rock and groundwater conditions to be encountered along the proposed route. The prime objective is to provide geotechnical information useful in developing a sense of feasibility of various construction methods as well as early cost estimation regarding earthwork practices.

We understand that the new line will be a 36 inch diameter steel pipe buried to a depth approaching four feet such that excavation

depths are likely to approach 8 feet. The study alignment is about 9.66 miles in length and follows the existing right of way along the common public access roadways from Tumalo Falls to Outback Reservoir. The existing supply lines from the Bridge Creek diversion follow the same route in some areas but diverge from the study alignment in many areas. The location of the existing water lines is apparent on the aerial photographs included with this memorandum.

Exploration Methods

The evaluations were constructed through basic geotechnical reconnaissance supported at select intervals using geophysical (seismic refraction) methods. We have walked much of the alignment and driven the route numerous times. Exploration points were plotted using a Garmin rino 530HCx, hand-held GPS receiver generally capable of identifying locations with an accuracy of +or- 30 feet or better. In addition, we consulted several resources both published and unpublished for information that bears on the geology of the area. The results are presented through annotated maps and aerial photographs along with other observations which we have summarized in tabular format (Table 3). Note that since no surveying has been performed the station references are very approximate – our estimations are related to stations as illustrated on the "Skyliners Road Plan" provided by Brown and Caldwell illustrating a Google Earth Map and correlated elevation profile (not presented).

No direct subsurface exploration was done (drilling, exploratory excavations, etc.) and the data derived through this effort should be substantially verified through a more rigorous exploration to keep pace with the need for greater confidence and detail of subsurface information as the project moves from conceptual stages into design.

At nine (9) locations we set out a seismic array composed of 24 receivers on 3 foot spacing. Shot points were induced off each end of the line using a sledge hammer and steel plate. First arrival wave velocities (P-waves) were interpreted to develop the time-distance plots of these data. Subsequently, the plots were used to calculate the depth to the first refractor using slope intercept methods. Through more rigorous data collection

and analysis, much greater detail and revealing information can be developed through seismic procedures; however, such interpretation was well beyond the scope at this level of study.

We also recorded background surface wave data for the purpose of interpreting shear-wave depth profiles at each of the exploration sites. The refraction microtremor method (ReMi) is a seismic procedure that relates the character of surface waves to the shear-wave depth profile and was very successful at most of the locations with exception being S-4 at the lower bridge crossing of Tumalo Creek. At this location, the shear-wave data were weak and do not correlate with the more simplified and robust P-wave model and therefore, we have not presented the shear-wave data at S-4. The seismic reconnaissance data are presented in graphical format at the end of this memorandum and incorporated as indication of excavation difficulty in the tabulation of Interpretation of Conditions Encountered (Table 3).

Conclusions

Summary

Based on the results of our reconnaissance we conclude that along most of the proposed alignment, open trench techniques facilitated by powerful trackhoe type equipment is very feasible to the anticipated 8 foot depth. There are notable exceptions as logged on Table 3 where seismic testing and surface observation reveal shallow rock, shallow groundwater and other earthwork related difficulties. We estimate that difficult conditions requiring specialized techniques to handle rock excavation, shallow groundwater, slope instabilities or combinations of these factors will be necessary through about 1.7 miles of the approximate 9.66 mile project – roughly 18 percent of the proposed alignment. The remainder is anticipated to be readily accomplished through soils that excavate in an easy fashion or with moderate difficulty (occasional boulders and stiff layers) in dry conditions that are likely to offer reasonably good trench stability. In addition, we estimate that the majority of the spoils will be suitable for trench backfill with pipe bedding and cover soil readily manufactured onsite.

Seismic Velocity Interpretation

Seismic P-wave and S-wave velocity is a robust indicator of material strength and a common indicator of

overburden character, depth to rock, rock strength and dynamic properties such as Poisson's ratio and elastic modulus useful in estimating excavation difficulty. Based on our observation and experience using these methods throughout Central Oregon we have prepared Table 1 to help interpret the conditions that could be indicated by the velocity data presented with this reconnaissance.

TABLE 1

Seismic Velocity (feet per second)		**Estimated Trackhoe excavation difficulty**	**Soil and rock possibilities**
P-wave	**S-wave**		
< 1000	< 600	Easy	Silty sand and loose, unconsolidated cinder and volcanic ash – could include boulders
1000 to 2000	600 to 1200	Mod. Difficulty	Dense soils including assemblages of sand & gravel, cobbles and boulders. Mildly indurated volcanics including cinder and ash-flow tuff
2000 to 5000	1200 to 2500	Very Difficult	Densely welded volcanics including ash-flow tuff and heavily indurated cinder. Heavily fractured, jointed and weathered rock (basalt and andesite).
> 5000	> 2500	Drilling and Blasting	Rock (basalt and andesite) offering various degrees of fracture, jointing and weathering.

In addition to the strength of the soils and rock to be encountered, other factors have been considered and include shallow groundwater, conflict with underground and overhead utilities (including the existing pipelines), stream crossings, adjacent hillside stability and open trench stability. Of these, the greatest challenges include the two stream crossings.

First Tumalo Creek Crossing ~ Sta. 13+00
A the upstream crossing, our data indicates drilling and blasting for excavation deeper than about 8 feet is likely and shallow groundwater dominates a 300 to 400 foot approach to the creek where many springs are apparent. In addition, nearby road cut provides evidence of numerous large boulders in this area of the canyon. On the left bank of Tumalo Creek, roadway embankment encroaches and is composed of

cobbles and boulders and excavation into these soils may have adverse stability effects on the existing, higher elevation roadbed. Slightly better conditions may exist a short distance downstream from the area of the existing pipe crossing where access along the left bank appears to improve due to more favorable terrain and greater setback of the road.

Second Tumalo Creek Crossing ~ Sta. 139+00

In this area, the existing pipe crosses just downstream the bridge for good reason. The upstream alignment is complicated by a wide, braided channel and abrupt topographic rise at the right bank – probably onto private property. Shallow groundwater is likely coincident with the stream elevation and the shallow soils appear to be composed of loose, highly permeable sand and gravel requiring ambitious dewatering efforts along with poor open-trench stability. In our view, complications associated with tight confines, the existing pipe, boulders, loose soil in the shallow environment, and rock at depths as shallow as about 7 feet indicate a tough environment for a pipeline jacking operation. As such, solutions such as stream diversion and open trench techniques or supporting the pipe on the existing bridge may be preferable options.

Listed in Table 3 are the data that we gathered along with a column depicting “Excavation Difficulty.” This data column is simply our best judgment concerning the ability of a powerful trackhoe excavator to accomplish the work without the aid of a pneumatic chisel, drill and blast assistance a dewatering effort or procedures to stabilize adjacent slopes. Although the entire alignment was included in our reconnaissance, Table 3 is built to illustrate transitions in conditions based on our observation. Due to the cursory nature of this work, it is very possible that conditions differing from our opinion exist between the Station intervals that are described. For this reason, confirmation and additional geotechnical work will be required at some later stage to support more detailed design and construction planning efforts.

Not documented in Table 3 are the numerous trees, brush and other vegetation that exist along the route. In addition, residential driveways, other roads and underground utilities are numerous but not detailed as part of this work. Overhead utilities are limited but do exist in a few areas.

References to left and right consider an orientation looking downstream (forward stationing). Abbreviations: SO = surface observations, SR = seismic refraction, ReMi = refraction microtremor, E = easy, MD = moderately difficult, D = difficult, VD = very difficult, GWT = groundwater table, RK = rock, Lt = left, Rt = right,

Table 3: Interpretation of Conditions Encountered

Station	Reconnaissance Methods	Excavation Difficulty	Remarks
Begin Project: 0+00 to 9+00	SO	E to MD	No outcrop observed, soils likely to be composed of alluvial sand and gravel, numerous boulders with possible GWT at lower elevations
9+00 to 13+00	SO	VD	GWT at surface, soils anticipated to include loose alluvium with many cobbles, boulders and shallow rock likely as excavation approaches creek
13+00 to 14+00	SO SR ReMi	VD	First Tumalo Creek Crossing: GWT at surface, very hard RK < 8 feet deep, numerous cobbles, boulders see preceding paragraph in text
13+00 to 24+00	SO	VD to D	Shallow GWT, loose cobble, boulder roadway embankment, steep talus slope on uphill side with possible trench and hillside instability
24+00 to 27+00	SO SR ReMi	VD to D	Hard RK as shallow as 4.7 feet, steep hillside profile, possible hillside and trench instability and possible conflict with existing pipes
27+00 to 34+00	SO	MD to D	Slight possibility of shallow RK, strong possibility of many boulders, alignment is shared with existing pipe and pipes likely to cross – see aerial photo
34+00 to 58+00	SO	VD	Shallow groundwater from springs entering from Lt – see USGS Quad., area of many boulders, slight possibility of shallow rock

58+00 to 130+00	SO SR ReMi	MD	Area of many cobbles, boulders in coarse alluvium, GWT not apparent but possible at depth, RK not indicated < 8 feet
130+00 to 137+00	SO	MD to D	Shallow GWT indicated by spring at ~ sta. 130+00 on Rt, no indication of RK < 8 feet
137+00 to 143+00	SO SR	VD	Second crossing of Tumalo Creek – see preceding paragraph in text
143+00 to 208+00	SO SR ReMi	MD	Soft surficial soils underlain by dense gravel assemblages and/or indurated volcanics including cinder and ash-flow tuff, no indication of hard RK < 8 feet
208+00 to 228+00	SO	VD	Potential shallow GWT @ ~Sta. 208+00 indicated by wet soils and aspen grove Rt, alignment begins uphill grade traversing steep hillside with hard rock outcrop on Rt and cobble, boulder embankment on Lt. Existing pipe avoids these difficulties with diversion from Skyliners Road through southern bypass – see aerial.
228+00 to 256+00	SO SR ReMi	MD to E	No indication of RK < 8 feet or GWT, soils likely composed of alluvial sand & gravel and/or unconsolidated cinder and volcanic ash
255+00 to 258+00	SO	VD	Hard RK outcrop dominant Lt, appears to represent isolated zone of horizontally fractured andesite mound
258+00 to 291+00	SO	MD to E	No indication of RK < 8 feet or GWT, soils likely composed of alluvial sand & gravel and/or unconsolidated cinder and volcanic ash
291+00 to 415+00	SO SR ReMi	MD to VD	Skyliners enters narrowing canyon with occasional road cut through hard RK, outcrop at Sta. 305+00 and 394+00. These features are judged to represent basaltic and andesitic mounds from vents spread out over cinder and less consolidated volcanics such as ash-flow tuffs. The thickness of these outcrops is likely to be limited. Very difficult excavation expected through about 15% of this interval.
415+00 to 510+00 End Project	SO SR ReMi	MD to E	No indication of RK < 8 feet or shallow GWT, soils likely composed of loose to moderately indurated volcanics (cinder and ash-flow tuff) including sand and gravel with occasional boulders

We consider the proposed alignment which follows the right of way to be feasible in terms of excavation and geotechnical principles; however, the existing alignment diverges from the right of way in some areas primarily to avoid some of the geotechnical obstacles discusses in this Memorandum. An example is the

bypass between Sta. 192+00 to 225+00 where the existing pipe takes a route that is relatively free of shallow rock and the terrain is fairly flat. The Skyliners right-of-way however, traverses a steep hillside with rock outcrop indicating very difficult construction. Opportunities to take advantage of the area geology such as this one may be available and should be balanced with the extra effort and cost of other important considerations such as easement and project schedule.

Limitations

We present the data collection and interpretation effort to represent our endeavor to conform to the normal standard of care exercised by geoprofessionals conducting similar reconnaissance in the Bend area at this time. We offer no other warrantee express or implied.

We appreciate the opportunity to provide these services and sincerely hope that the results help your endeavor to serve the City of Bend. If you have any questions, please call.

Respectfully submitted,
Siemens & Associates

J. Andrew Siemens, P.E., G.E.

Addressee: 1 hard copy, 1 electronic

Encl. Geologic Compilation Map
Aerial Photographs 1 – 5
USGS 7.5 Minute Quadrangles 1 – 3
Seismic Refraction Time-Distance Plots S-1 through S-9
ReMi, S-wave Profiles 1 through 3 and 5 through 9

Geologic Compilation Map for Deschutes County Oregon

DOGAMI Bulletin 89

Qhb — Holocene basalt flows
Holocene basalt and basaltic andesite flows less than 11,000 years old. Most are dark-gray to black, dense basaltic lavas of aa or block flows. Age determined by radiocarbon, absence of Mazama pumice mantle (6,600 radiocarbon years), or estimated by comparison with other known Holocene surfaces.

Qhr — Silicic flows and domes
Holocene silicic lava flows, obsidian domes, pumice cones, and ash flows. Mostly rhyolite to dacite in composition. Age determined by radiocarbon and hydration-rind dating, absence of Mazama pumice, or estimated by comparison with other known Holocene surfaces.

Qal — Alluvium and surficial deposits
Unconsolidated gravels, sands, and silts laid by streams, with minor wind-deposited silt and ash. Pumiceous and cindery at many locations. Includes slope wash, playa deposits, alluvial fans, lake-bed deposits, and dune sand. Numerous patches of alluvial deposits too small to map occur on lava flows and ash flows.

Qb — Pleistocene basalt flows
Gray, diktytaxitic, olivine basalts originating on and about flanks of Newberry Volcano and associated with Brothers Fault Zone in eastern part of County. Also includes large area of medium- to dark-gray, vesicular to dense olivine basalts and basaltic-andesite lavas of High Cascades, some of which are porphyritic.

Qgm — Glacial and fluvio-glacial deposits
Gravels, sands, silts of glacial and fluvio-glacial origin. Includes lateral moraines, terminal moraines, drift, and outwash. Distinction between glacial and fluvio-glacial deposits and interfingering alluvium is mostly inferred. Bedrock is mapped in many places where only thinly mantled by glacial debris.

Qrd — Silicic lavas and domes
Domes and flows of silicic andesite, dacite, and rhyolite mostly in Newberry Volcano area and in High Cascades, particularly in Broken Top-South Sister area.

Qwt — Ash-flow deposits
A series of at least five ash-flow tuffs separated by minor erosional unconformities. Exposed mostly west of the Deschutes River; source near Broken Top volcano in High Cascades. Ash-flow units vary in color from red through gray to black and are semi-welded to highly welded. The ash-flow unit east of Newberry Caldera (Newberry Crater) is brownish, contains many rock fragments, and is believed to have been erupted from a source at Newberry Volcano.

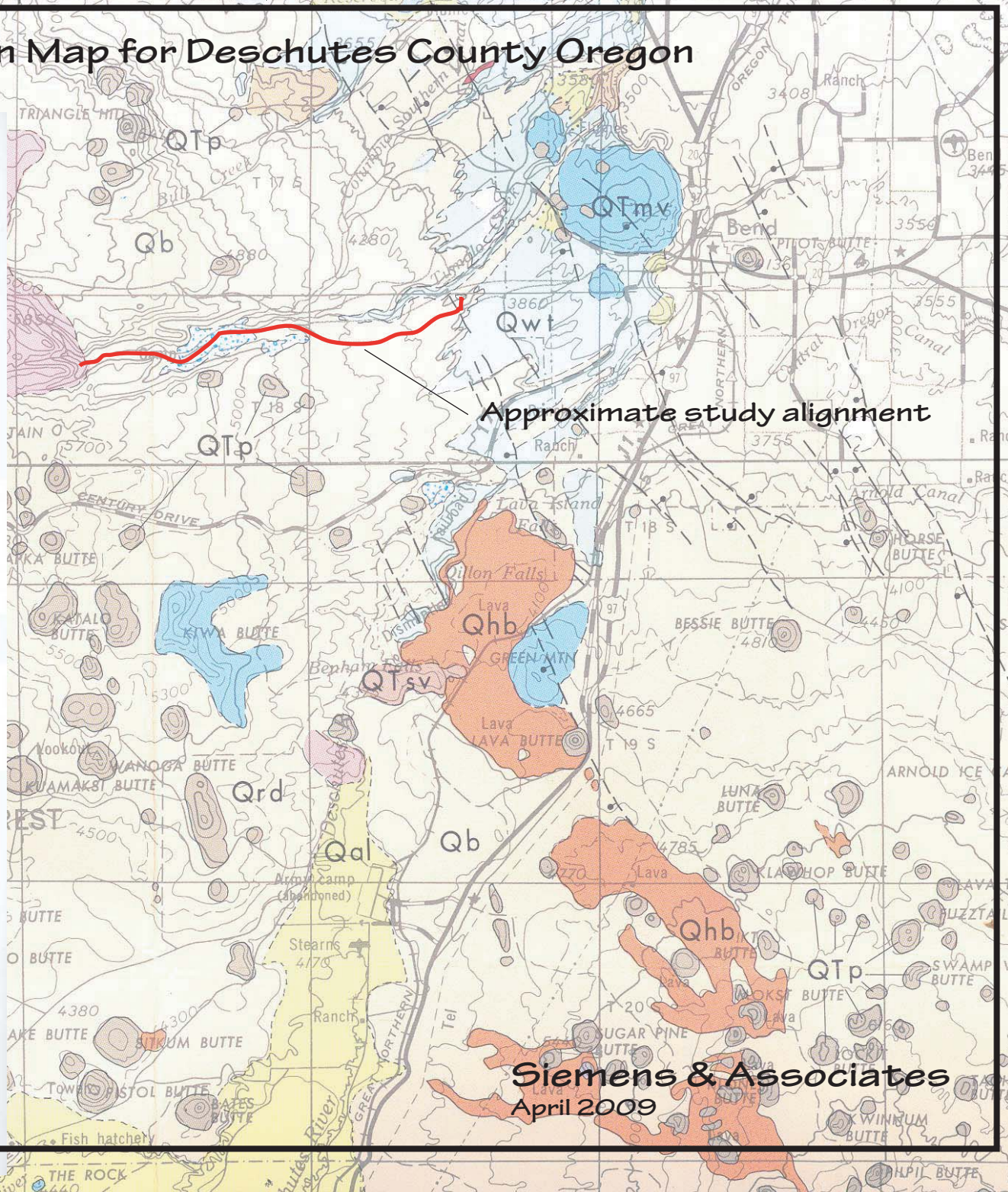
QTb — Older basalts
Thick to thin flows of vesicular to dense basalts and basaltic-andesites. Some are diktytaxitic and many dense varieties show characteristic platy jointing. Typically form rimrocks along lower Deschutes River Canyon in the northern part of County. Also a major unit in eastern part of County. Age: Pliocene and Pleistocene.

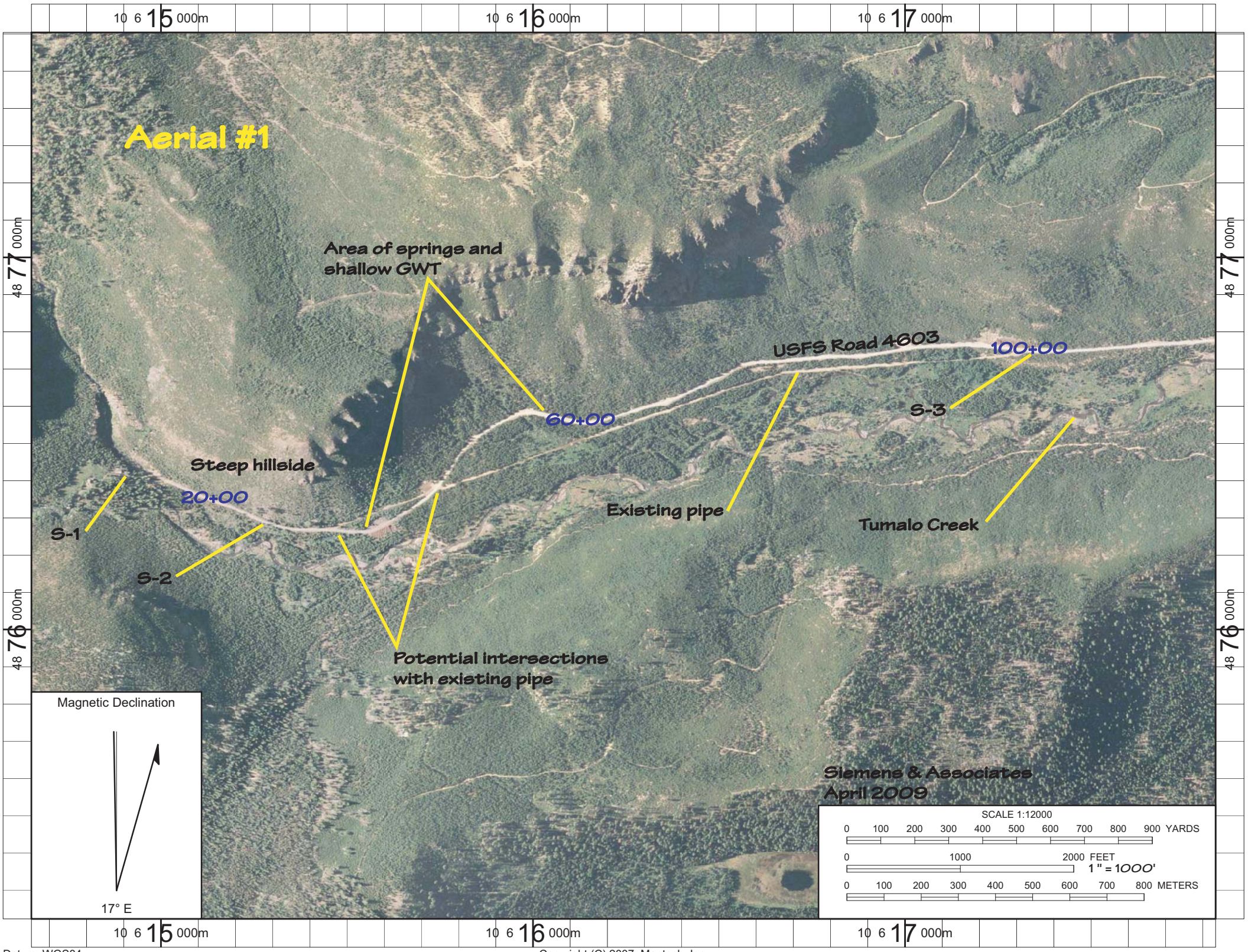
QTd — Deschutes Formation
Fluviatile and lacustrine sediments composed of gravels, sands, and silts of volcanic ejecta and reworked volcanic material; much of sediment pumiceous and cindery. Interbedded basalt flows and ash-flow tuffs occur in the section; best exposed in Deschutes River Canyon in northern part of County. Diatomite deposits in Lower Bridge area of Deschutes River Canyon are included. In northern part of County, Deschutes Formation reported to be Pliocene in age but near Bend it appears to be part of a continuous depositional sequence from Pliocene into Pleistocene.

Dike — Dikes
Narrow sinuous basalt spines associated with the cinder and lava mounds which in some cases mark fissure sources for the QTb flows.

QTp — Pyroclastic volcanic rocks
Basaltic and andesitic scoria cones (cinder cones), mounds, and spatter cones. Composed of coarse to fine fragments varying from red to black and large to small bombs and lapilli with some agglutinate zones. Includes tuff cone Sitkum Butte, maars of North and South Twin Lakes, and eroded palagonite tuff cones of Wake Butte, also three eroded palagonite tuff cones within Newberry Caldera (Newberry crater). Includes hundreds of symmetrical cinder cones on flanks of Newberry Volcano and the east flank of the High Cascades. Many pyroclastic features modified by erosion to low mounds with intrusive spine and dike-like masses. Age: Pliocene, Pleistocene, and Holocene.

QTmv — Mafic vent rocks
Constructional landforms, lava cones, and shields; some highly modified by erosion, as in High Cascades (North and Middle Sisters). Composed of basalt and basaltic-andesite flows, agglomerates, scoria, and breccia. Includes associated dikes and intrusive masses of basalt and basaltic andesite. Age: Miocene, Pliocene, and Pleistocene.





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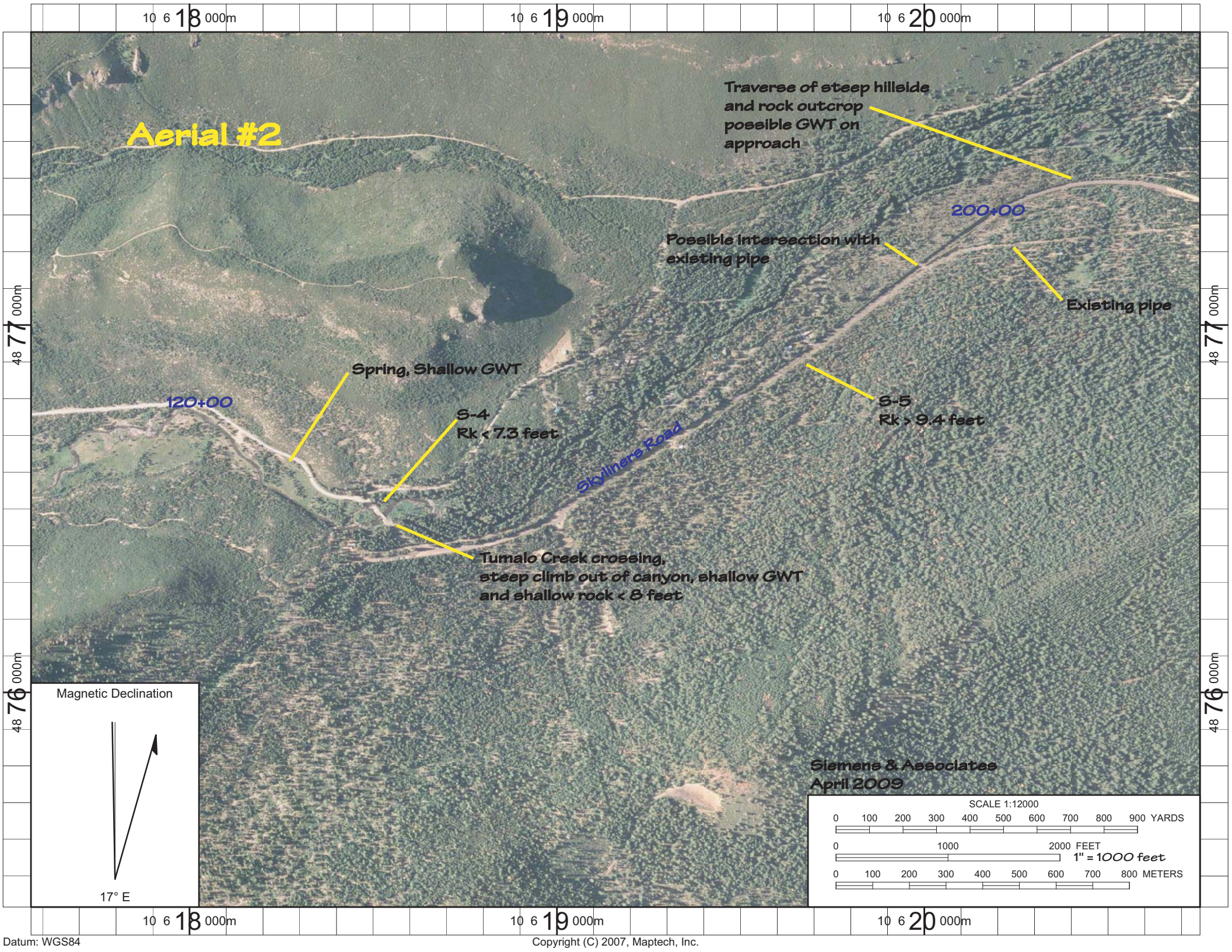

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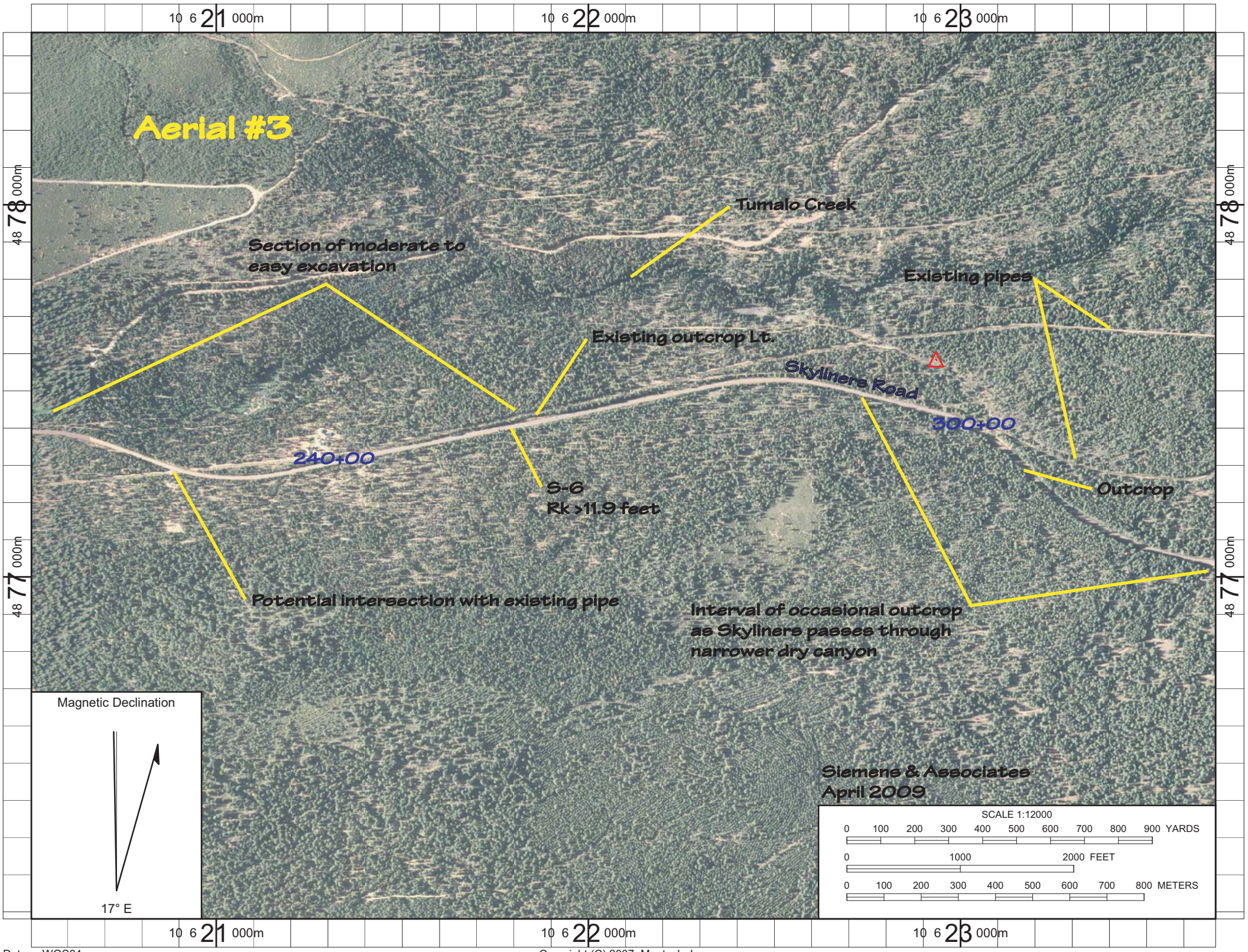

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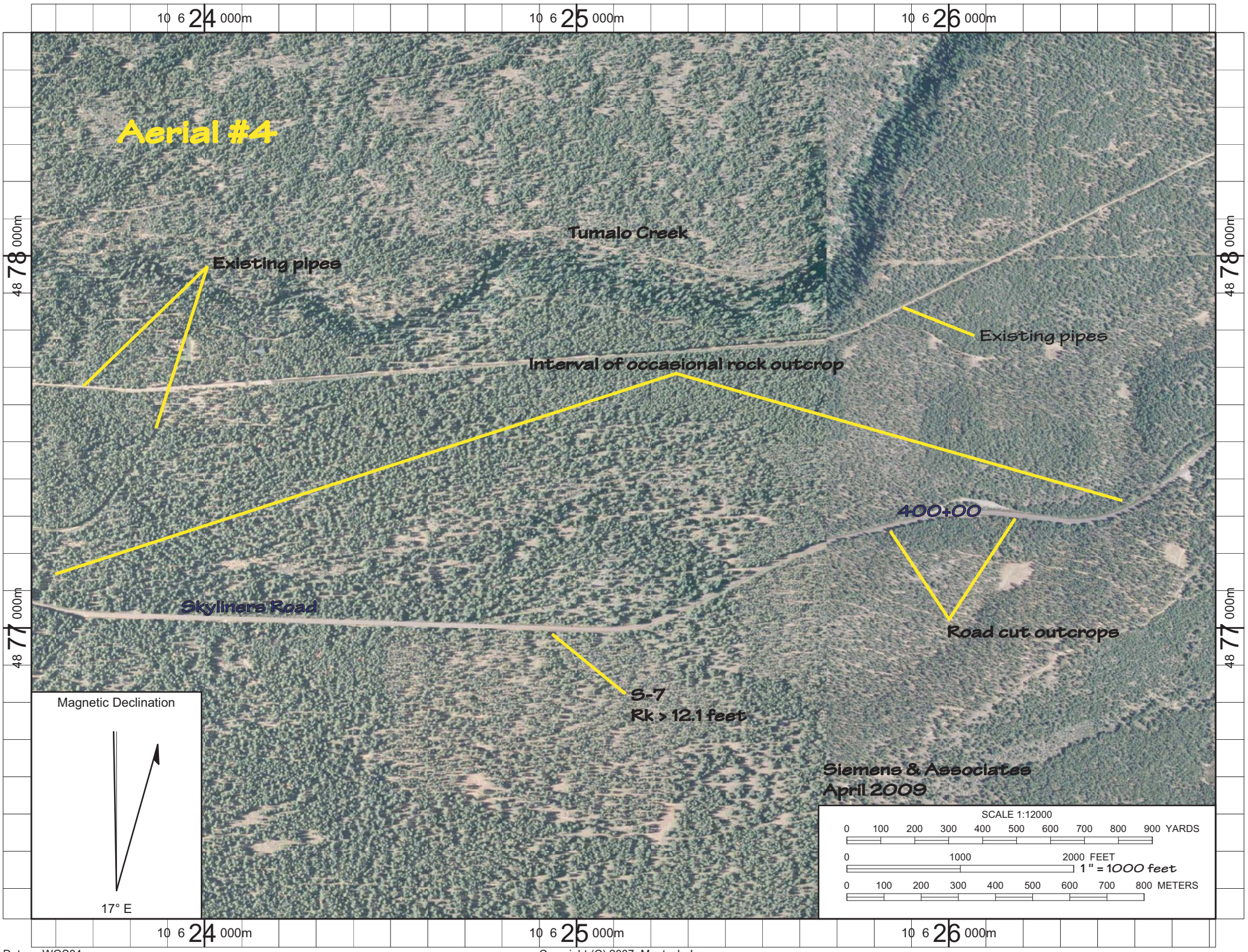

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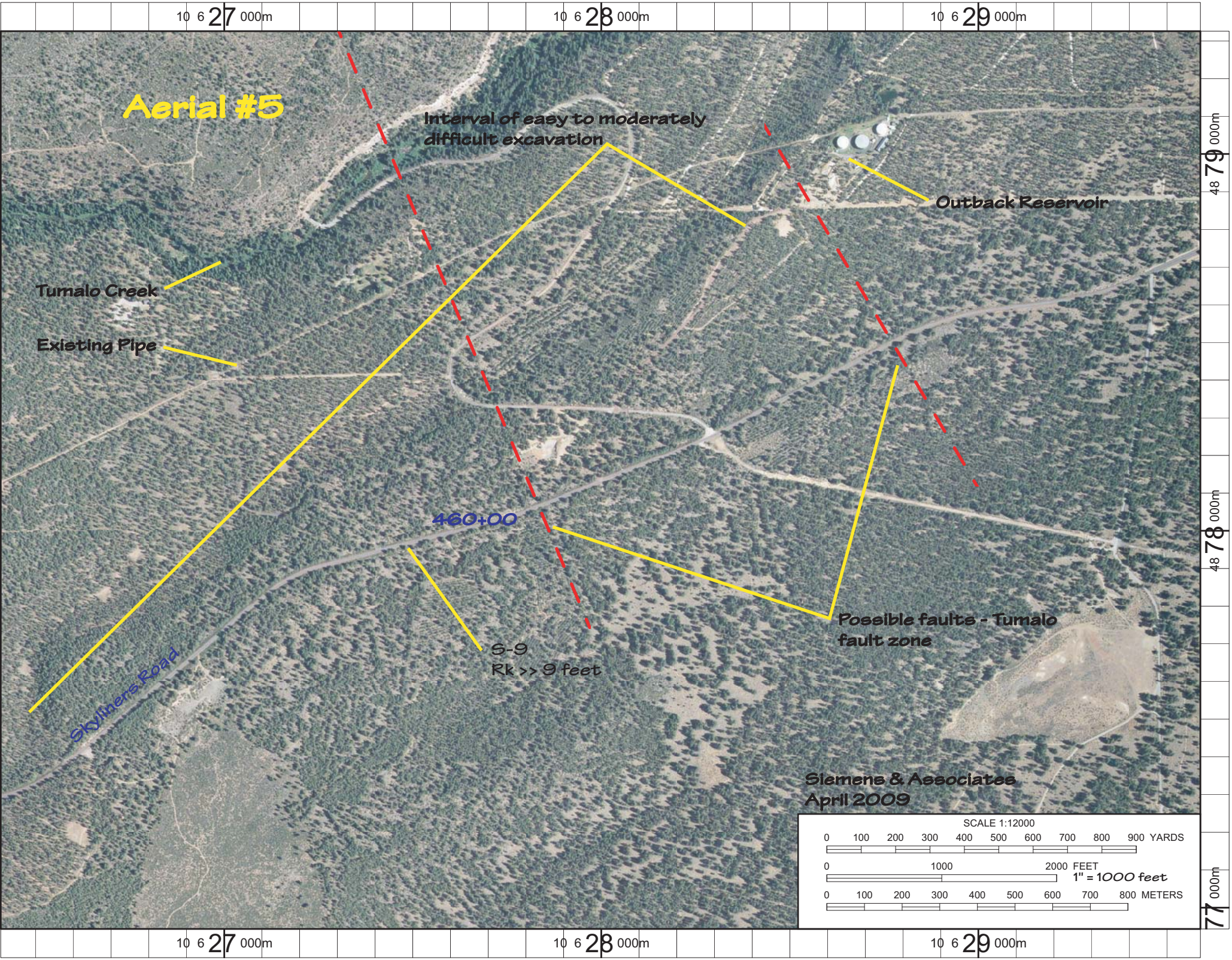

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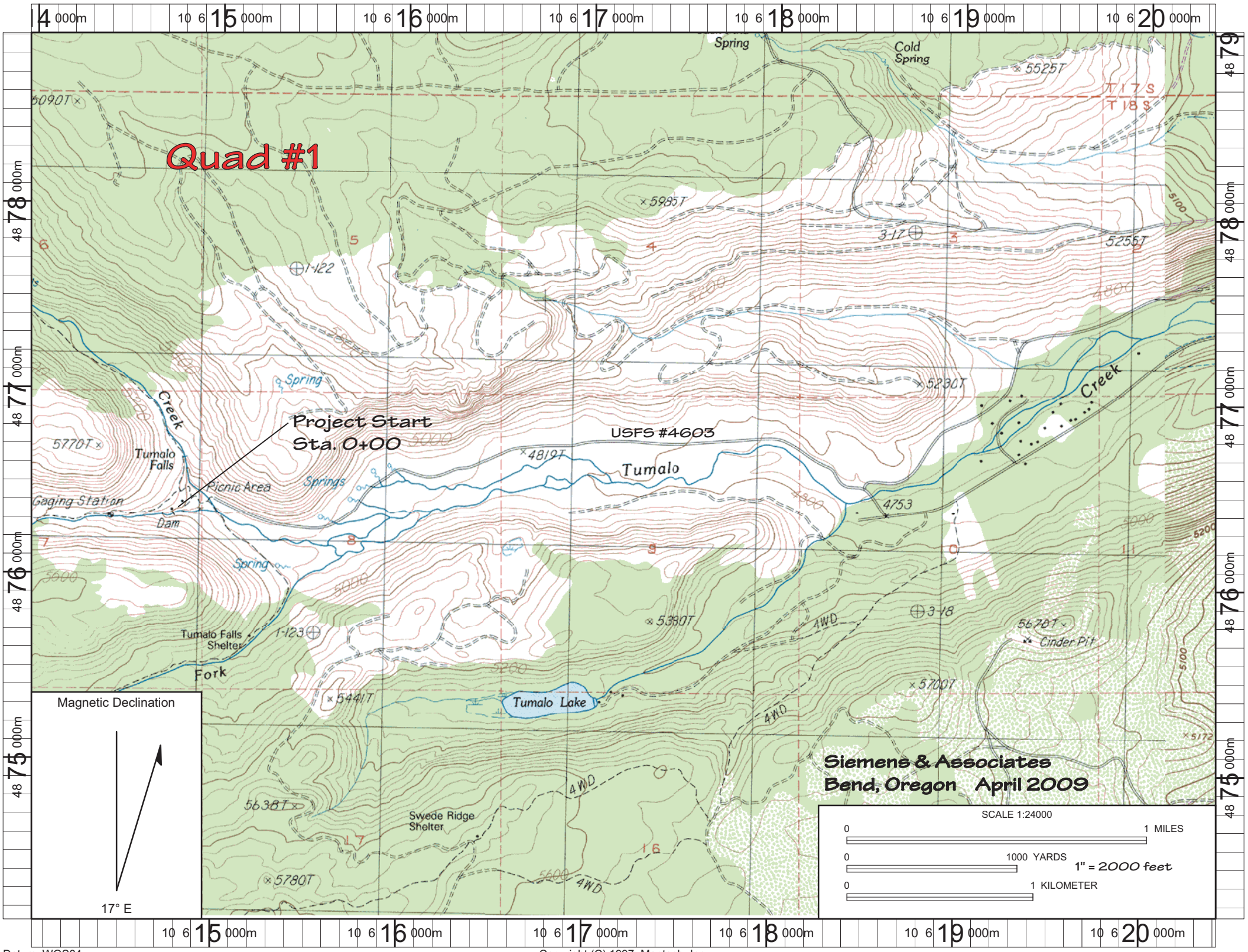

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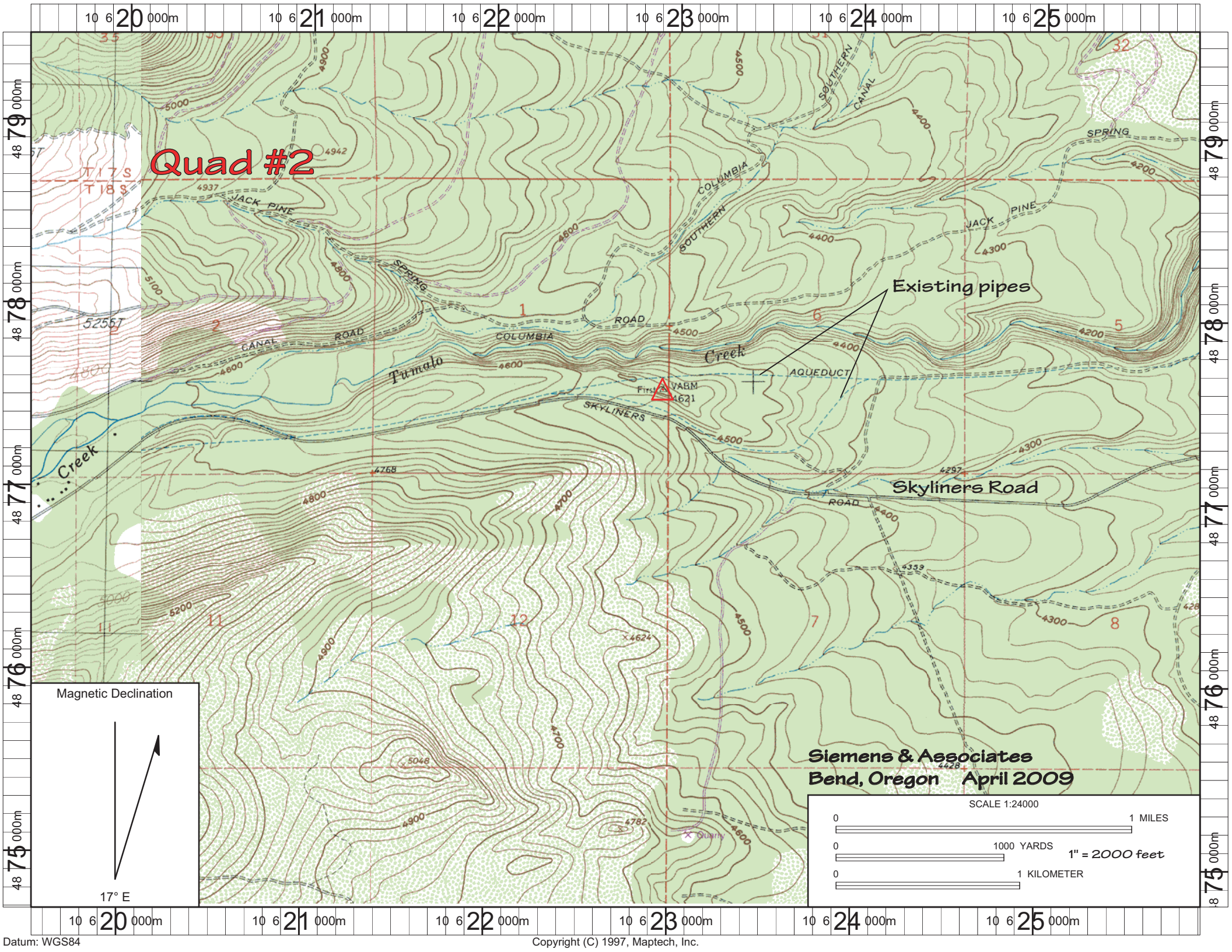

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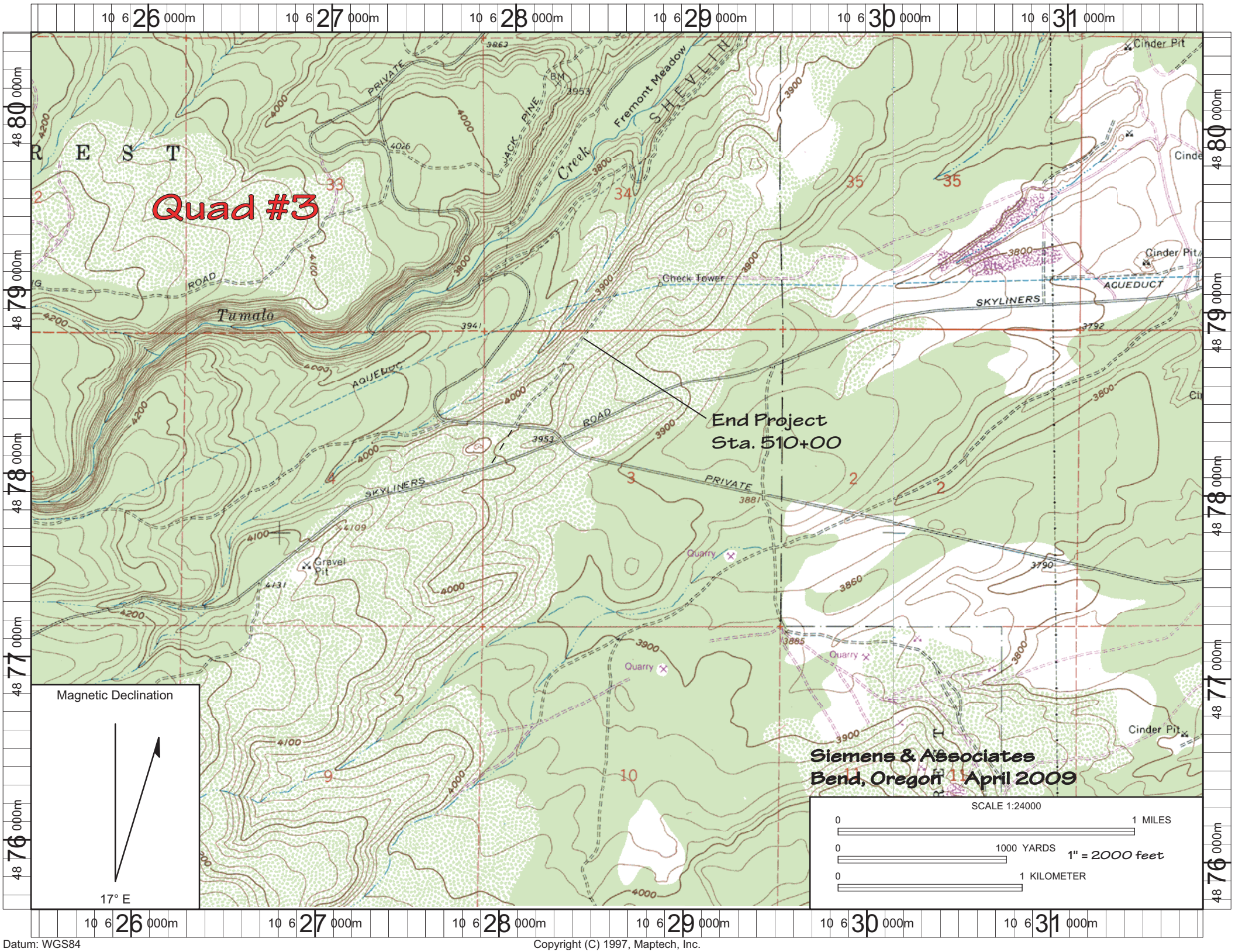

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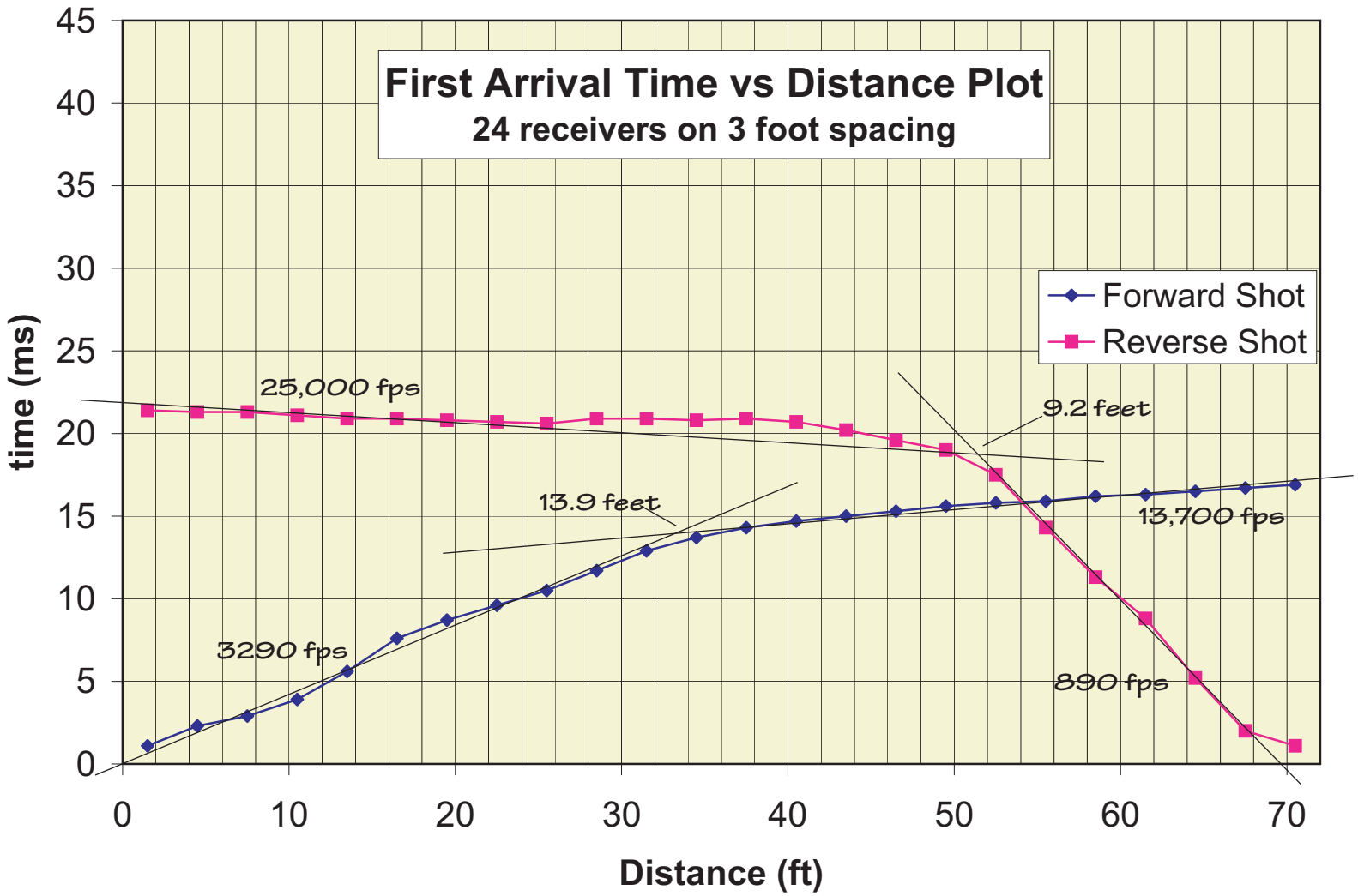
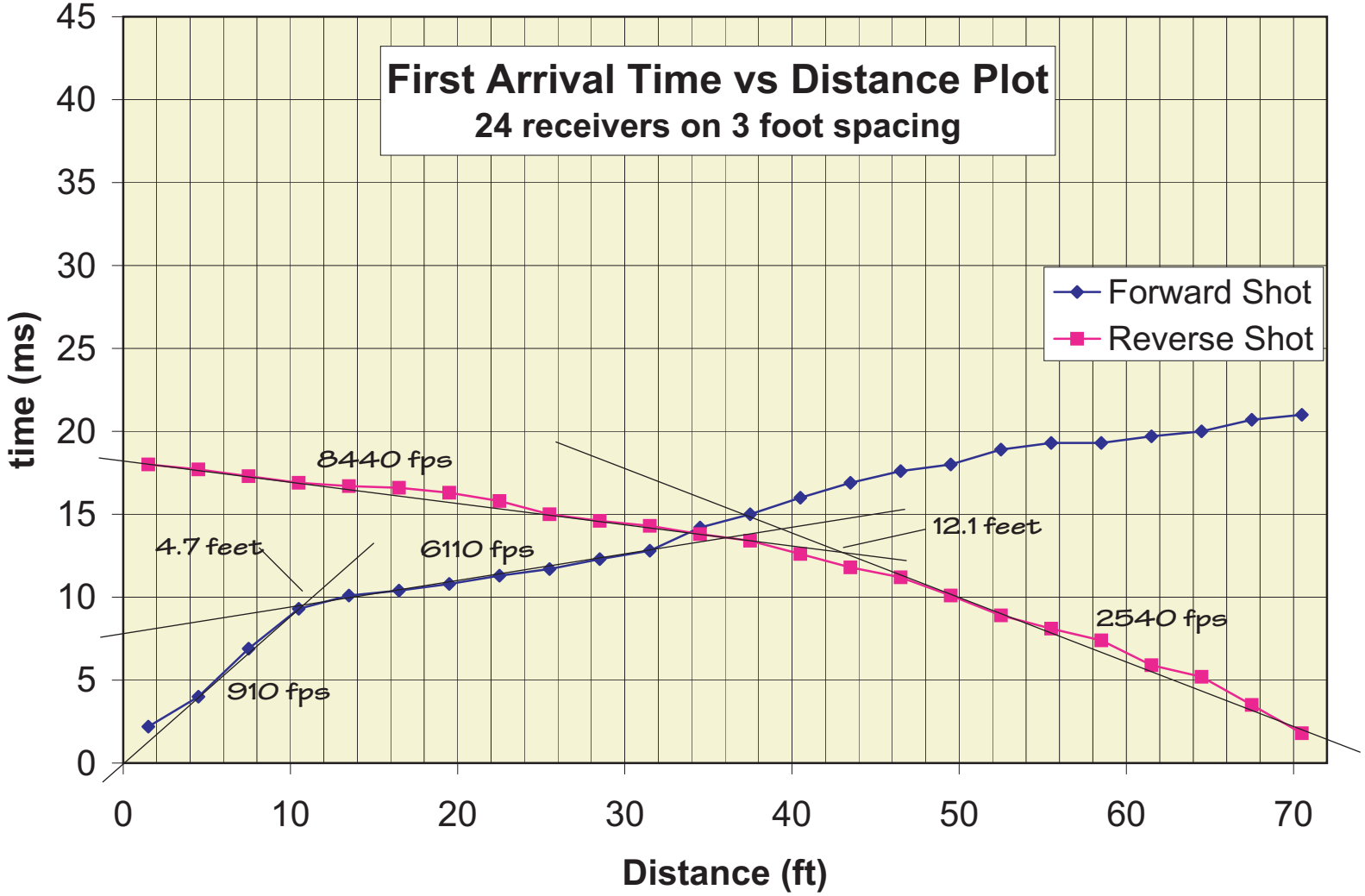
Seismic Refraction S-1 ~ Station 13+00

at Tumalo Creek Crossing, perpendicular to exisitng alignment



Seismic Refraction S-2 ~ Station 24+00

along existing pipe route, adjacent hillside road cut

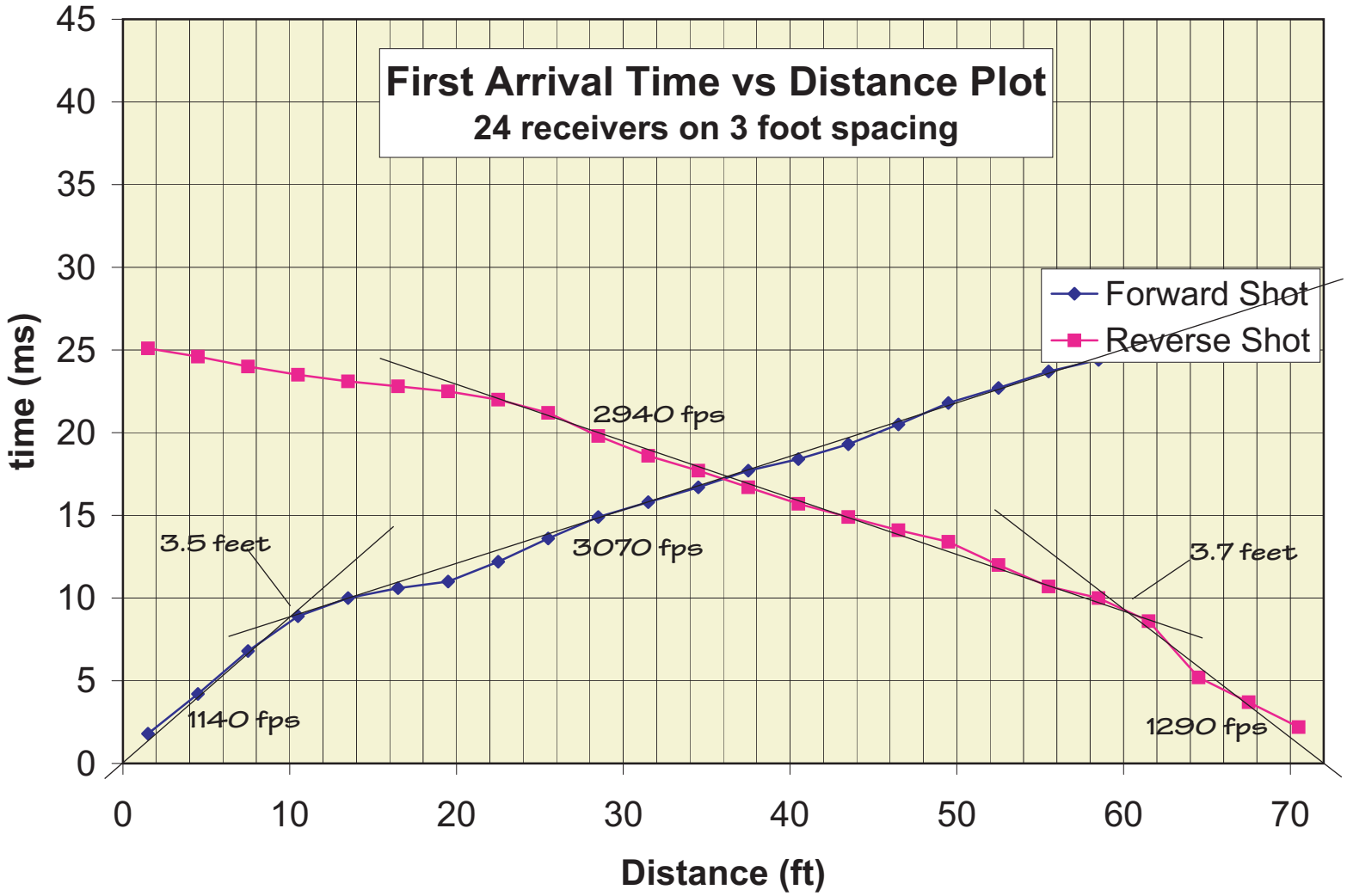


City of Bend Water Supply Alternatives Study
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-3 ~ Station 100+00

random location along USFS Road #4603



Prepared for: Brown and Caldwell

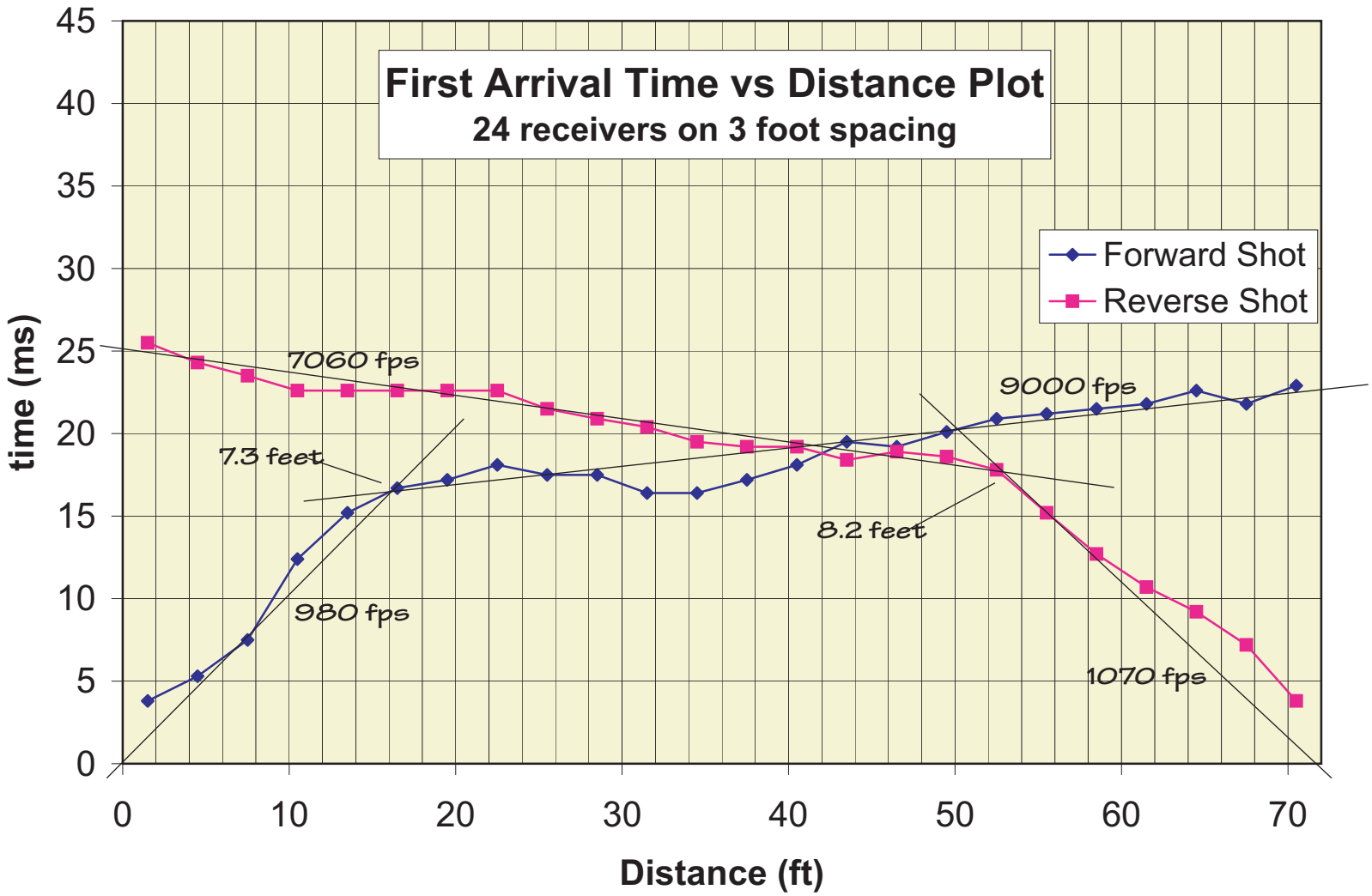
Prepared by: Siemens & Associates
Bend, Oregon

City of Bend Water Supply Alternatives Study
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-4 ~ Station 139+00

at Tumalo Creek crossing, downstream exisitng bridge



Prepared for: Brown and Caldwell

Prepared by: Siemens & Associates
Bend, Oregon

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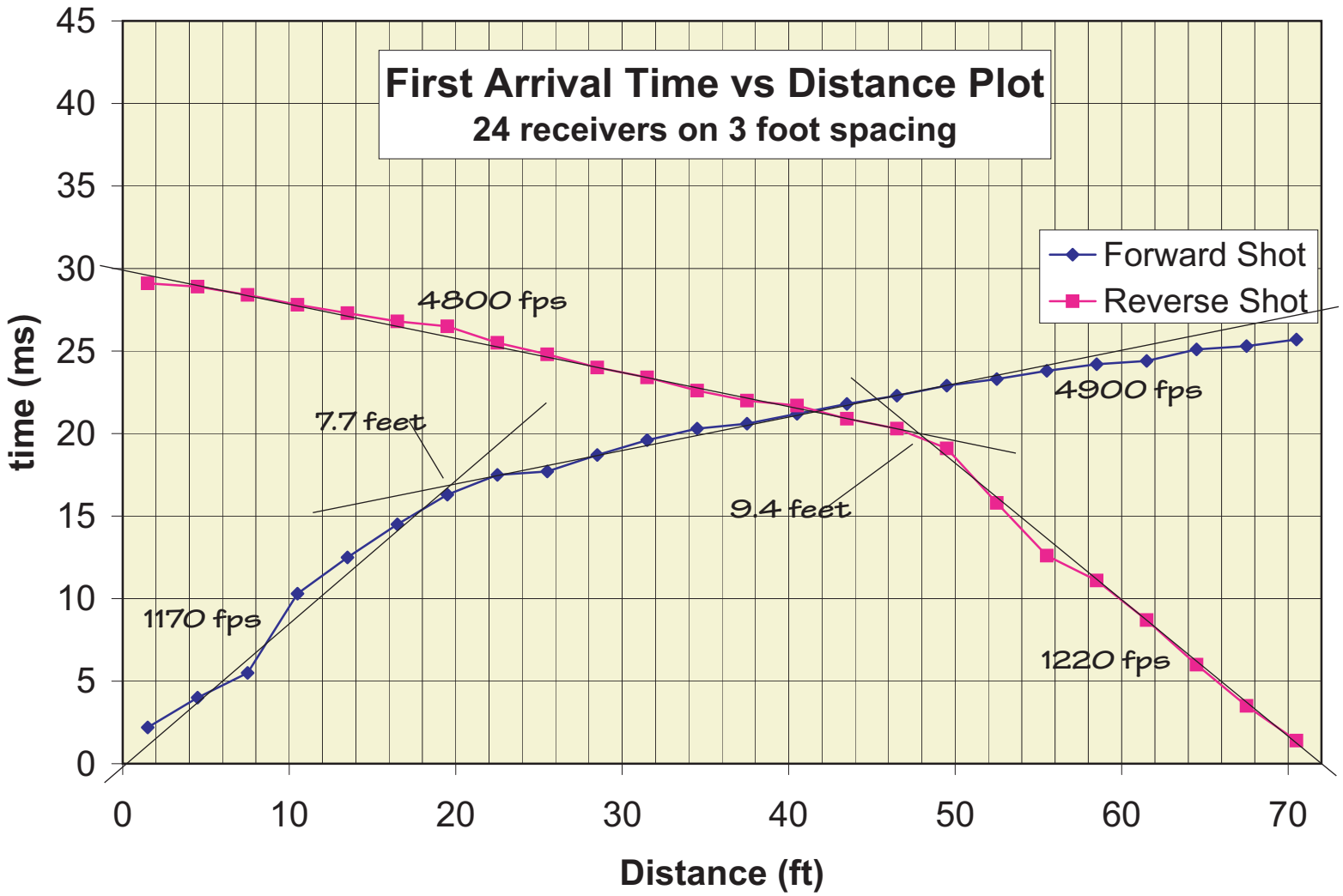
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-5 ~ Station 177+00

random location along Skyliners Road, south side



Prepared for: Brown and Caldwell

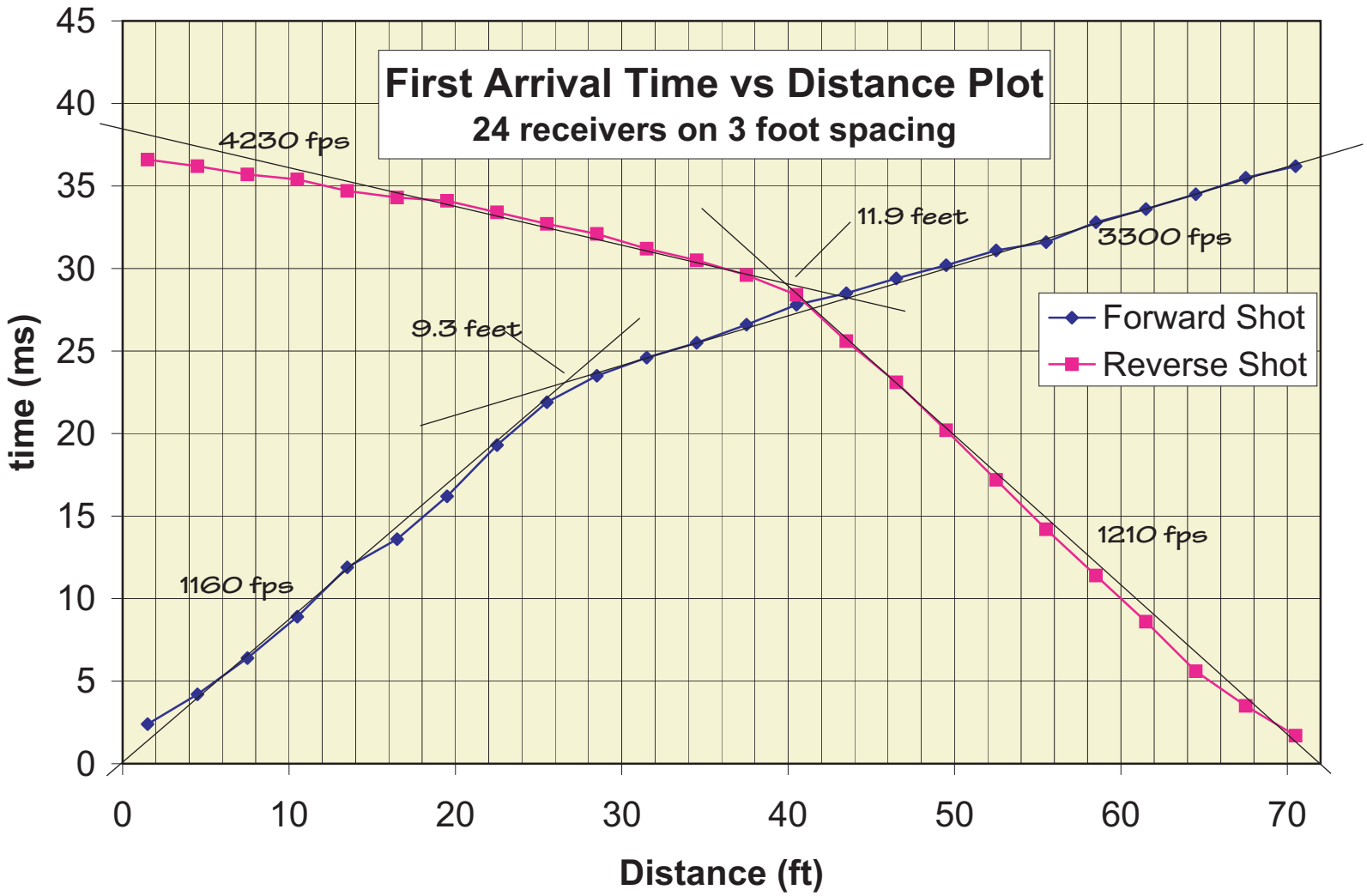
Prepared by: Siemens & Associates
Bend, Oregon

City of Bend Water Supply Alternatives Study
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-6 ~ Station 255+00

along Skyliners Road ~200 feet forward existing rock outcrop



Prepared for: Brown and Caldwell

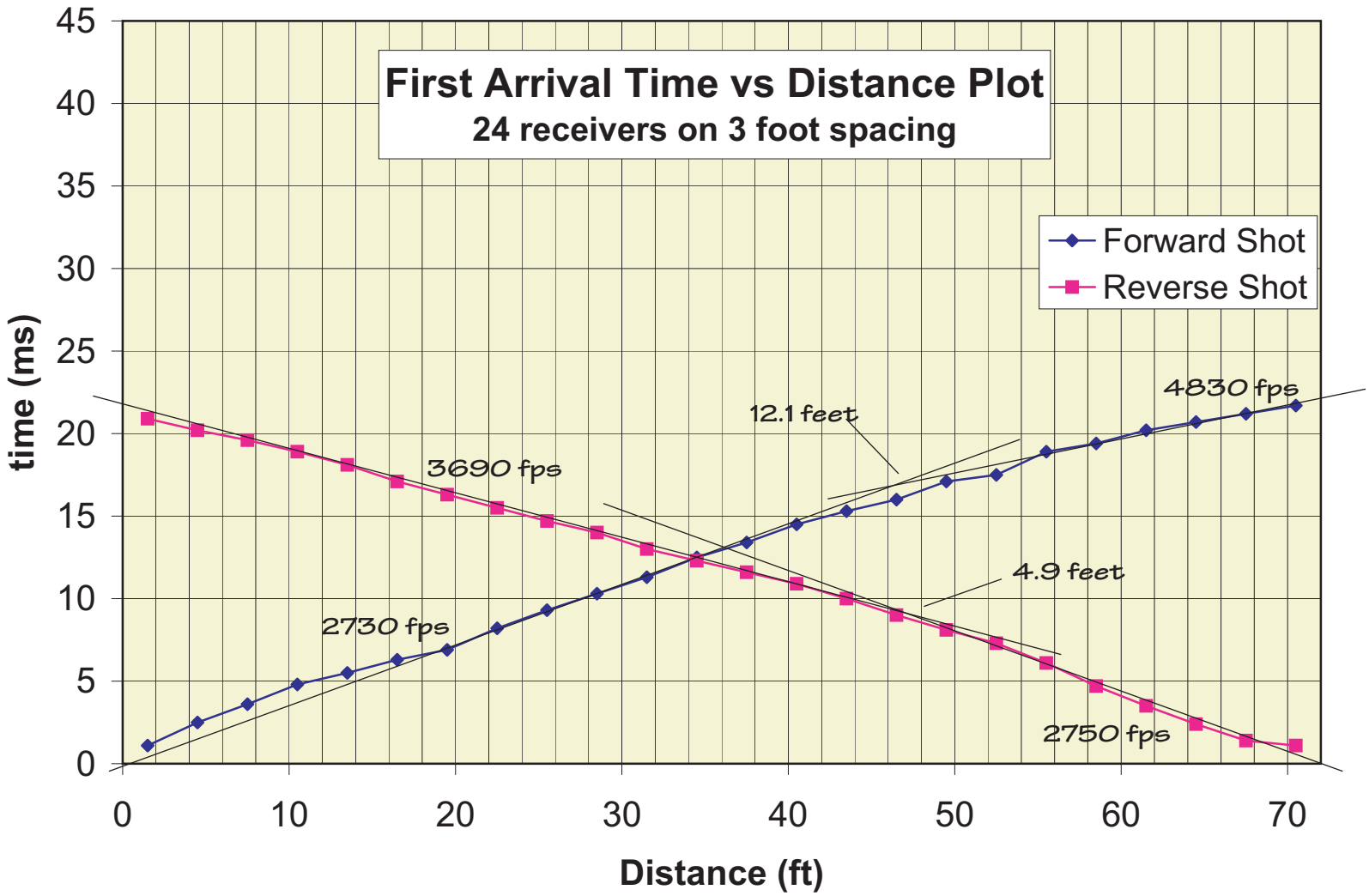
Prepared by: Siemens & Associates
Bend, Oregon

City of Bend Water Supply Alternatives Study
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-7 ~ Station 362+00

along Skyliners Road at mild vertical curve

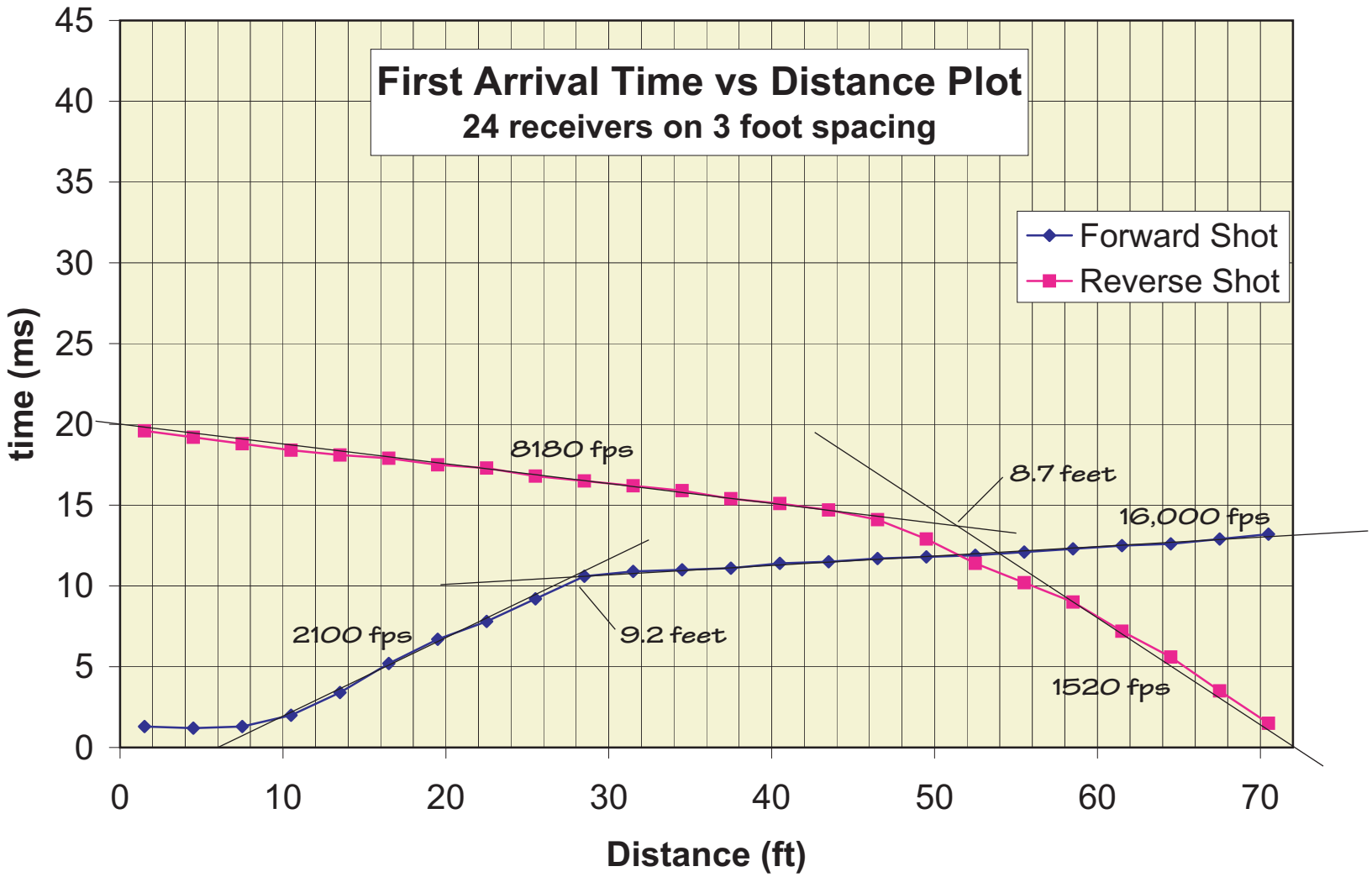


Prepared for: Brown and Caldwell

Prepared by: Siemens & Associates
Bend, Oregon

Seismic Refraction S-8 ~ Station 402+00

at existing road cut through rock - both sides

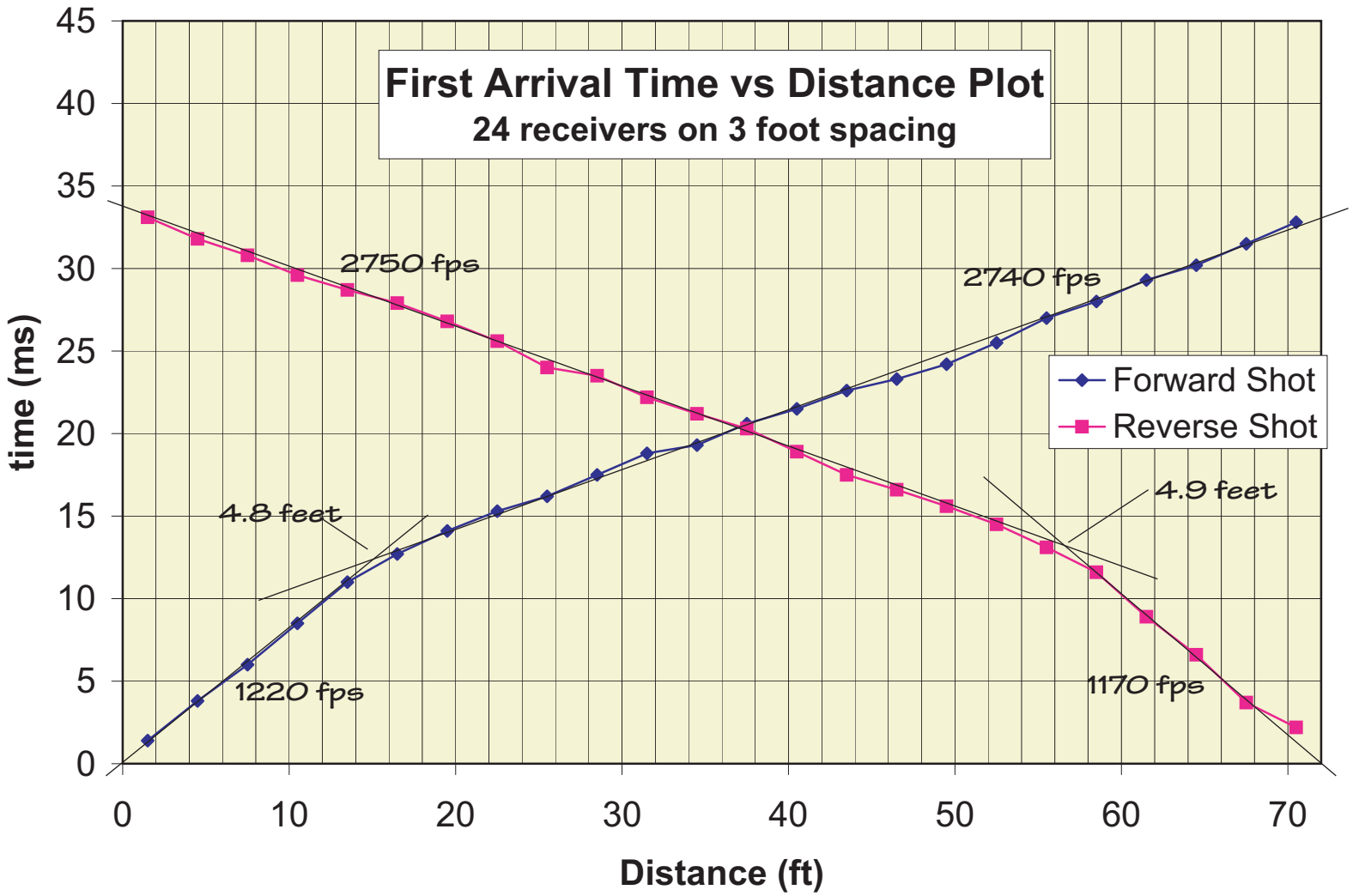


City of Bend Water Supply Alternatives Study
Bend, Oregon

Project # 1091020
April 2009

Seismic Refraction S-9 ~ Station 455+00

along Skyliners Road near end of project



Prepared for: Brown and Caldwell

Prepared by: Siemens & Associates
Bend, Oregon

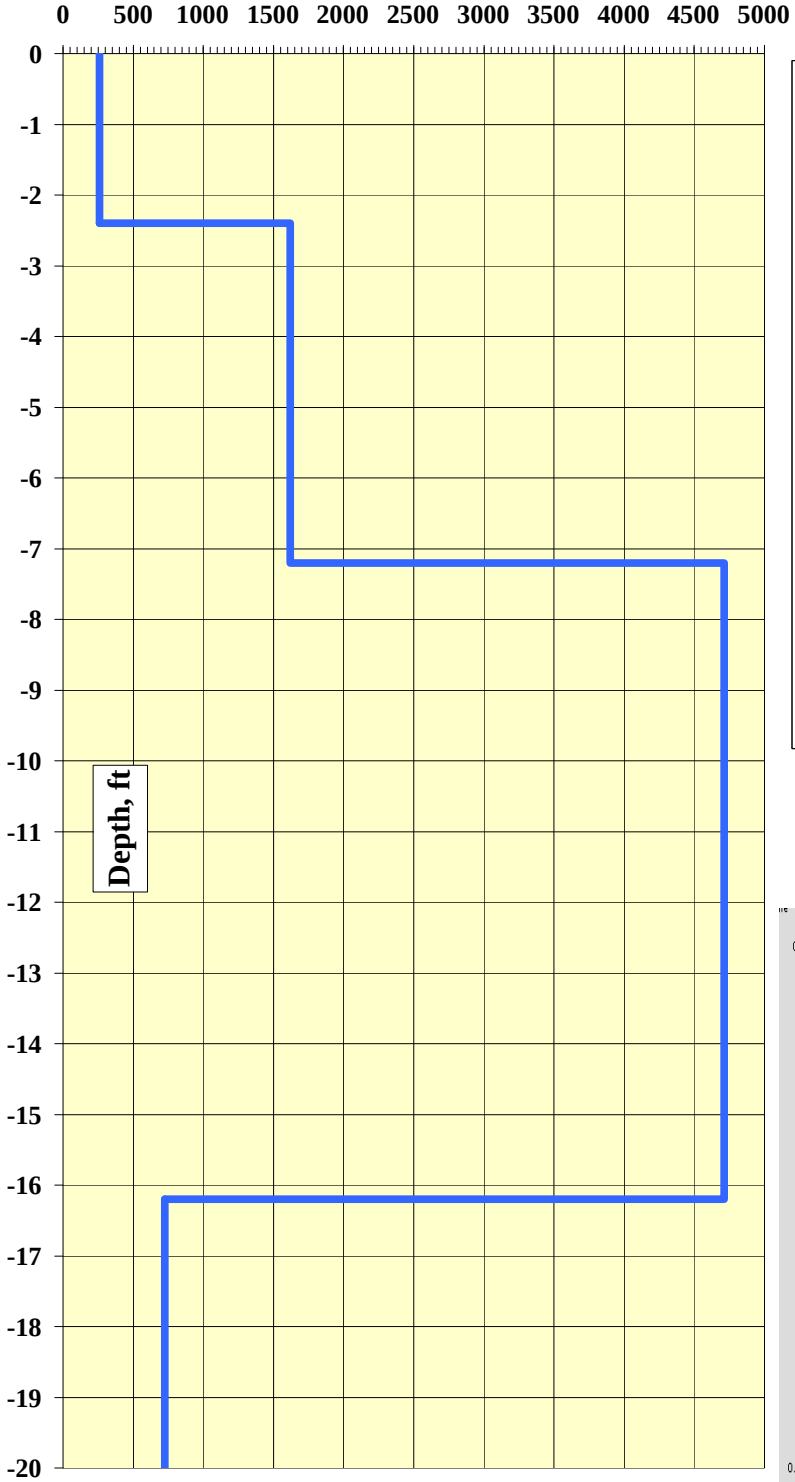
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #1: Sta. ~13+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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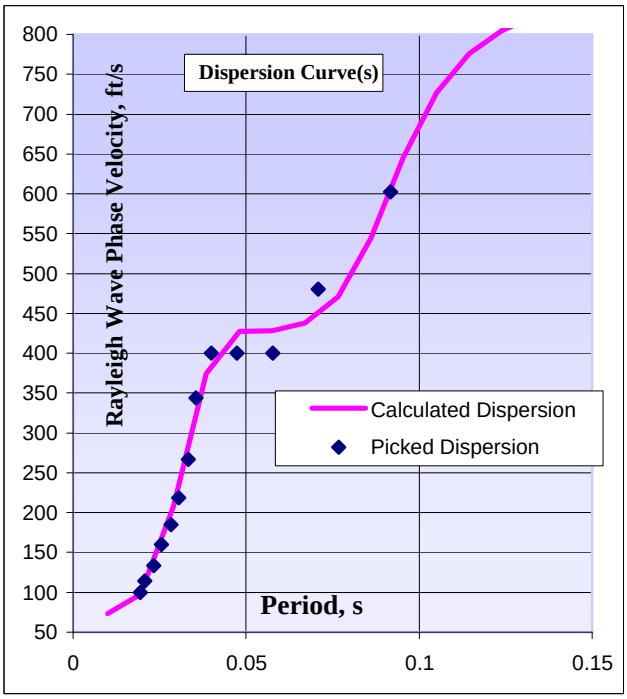
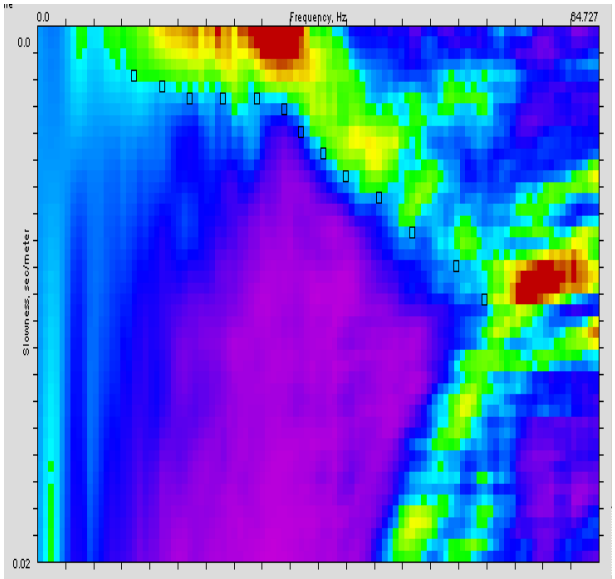


ReMi Spectral Ratio (p-f image)
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

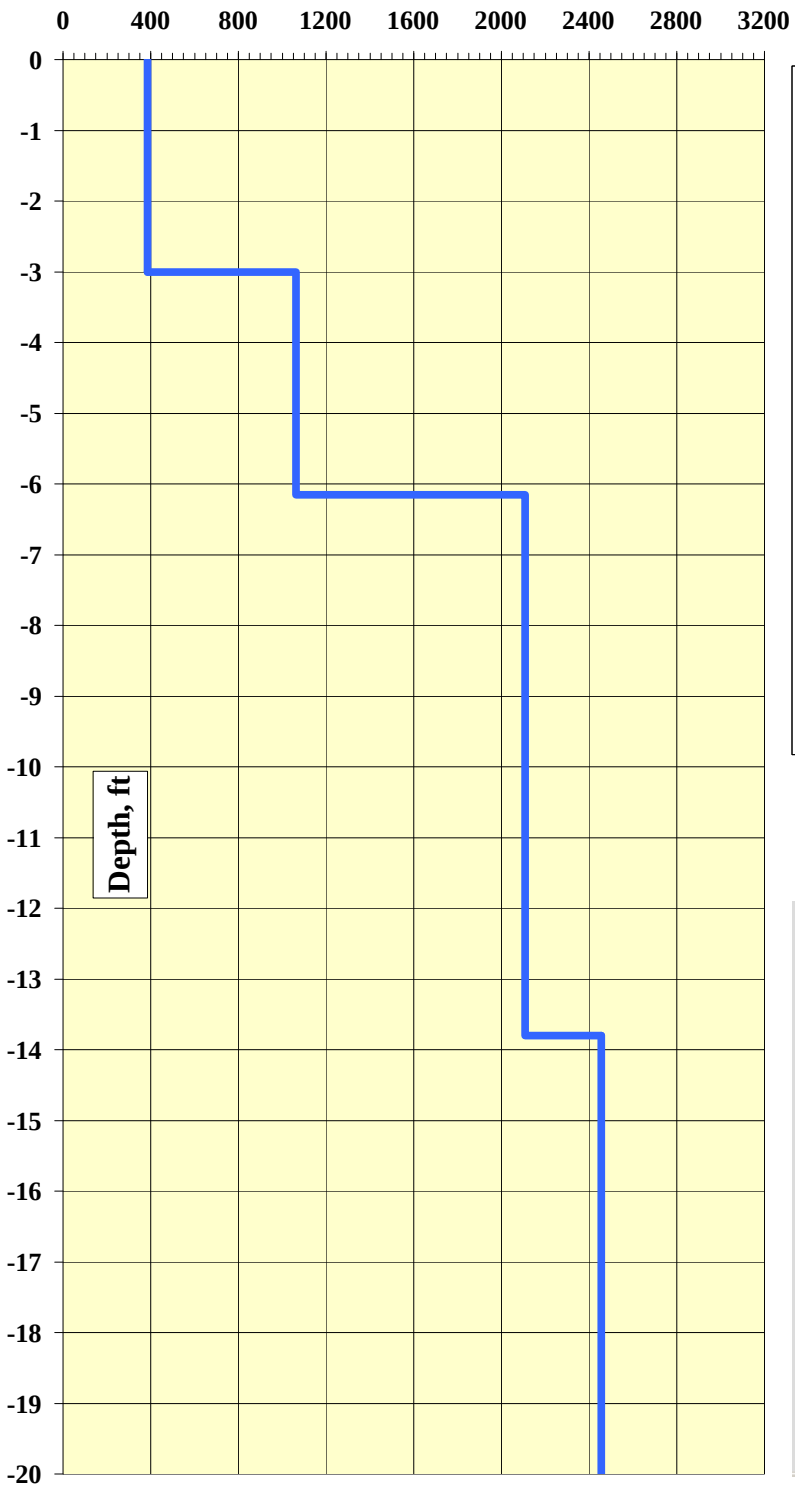
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #2: Sta. ~24+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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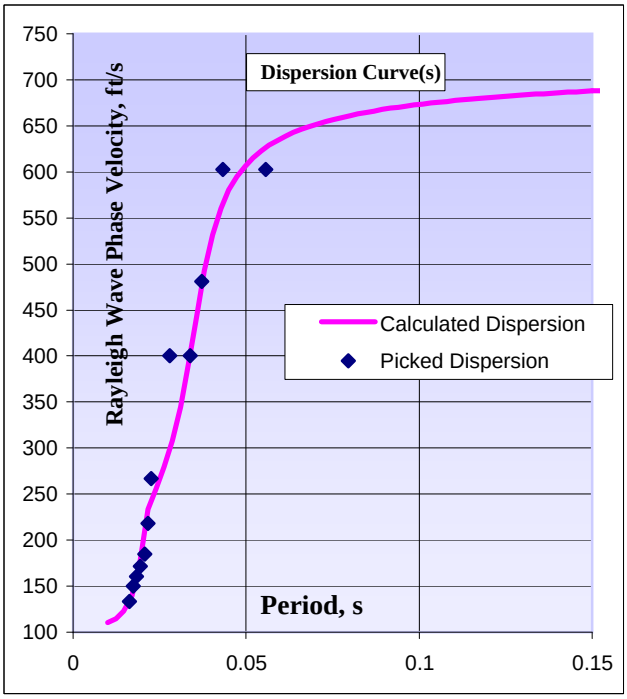
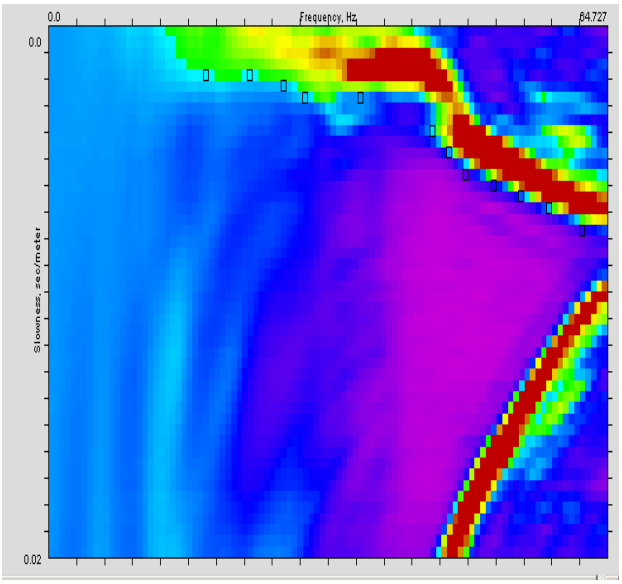


ReMi Spectral Ratio (p-f image)
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

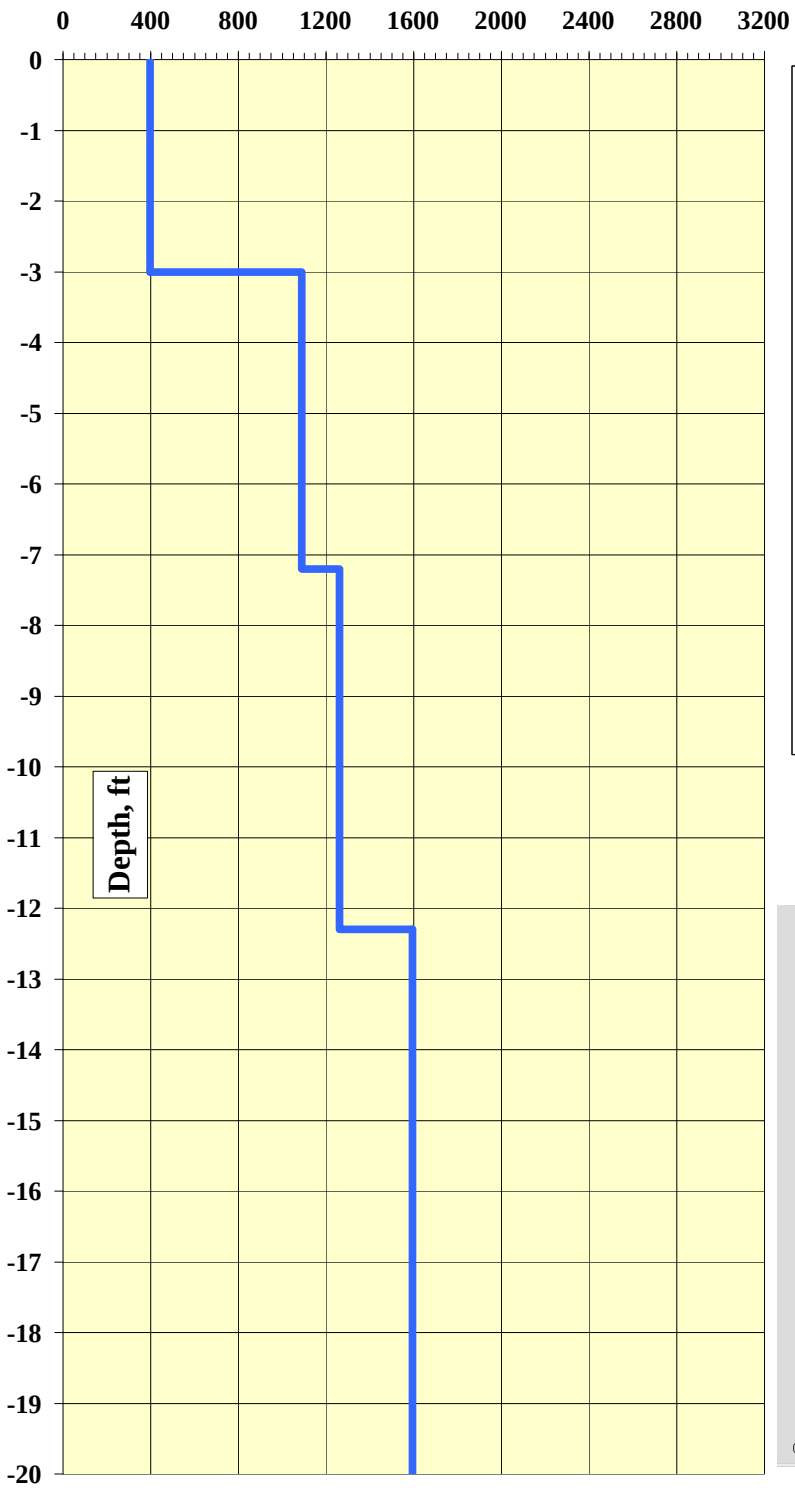
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #3: Sta. ~100+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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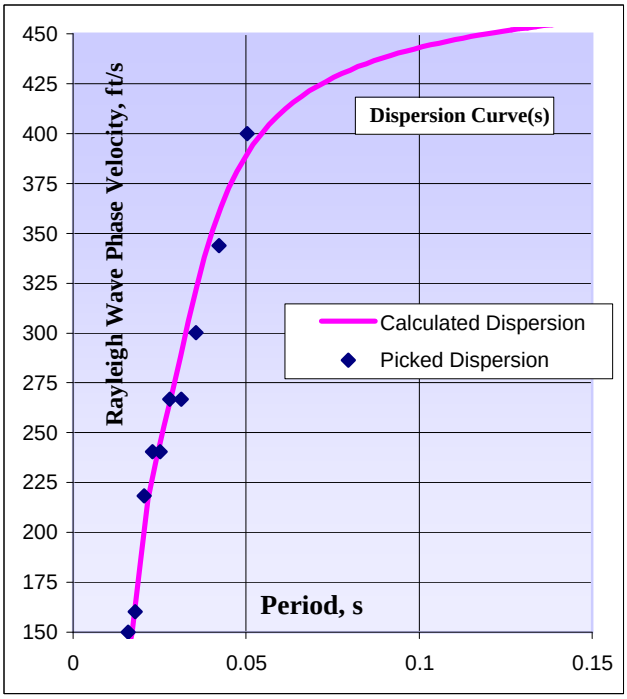

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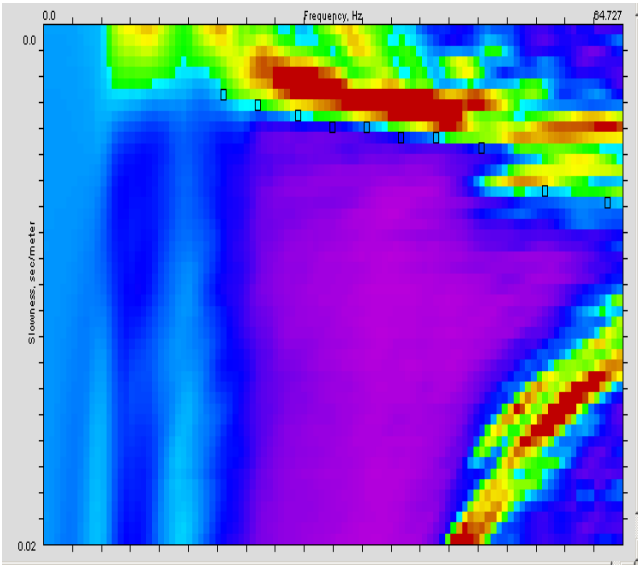
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

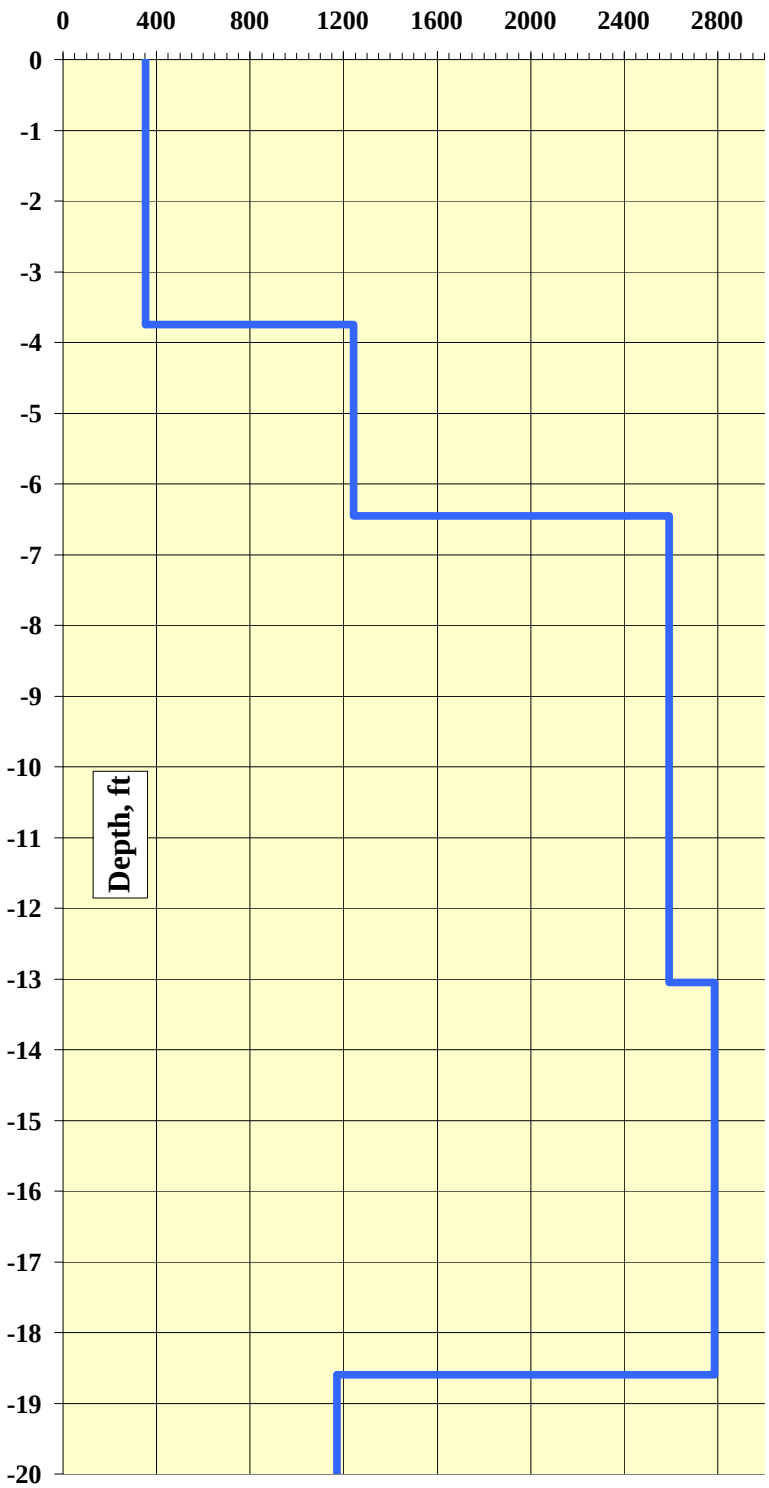
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #5: Sta. ~177+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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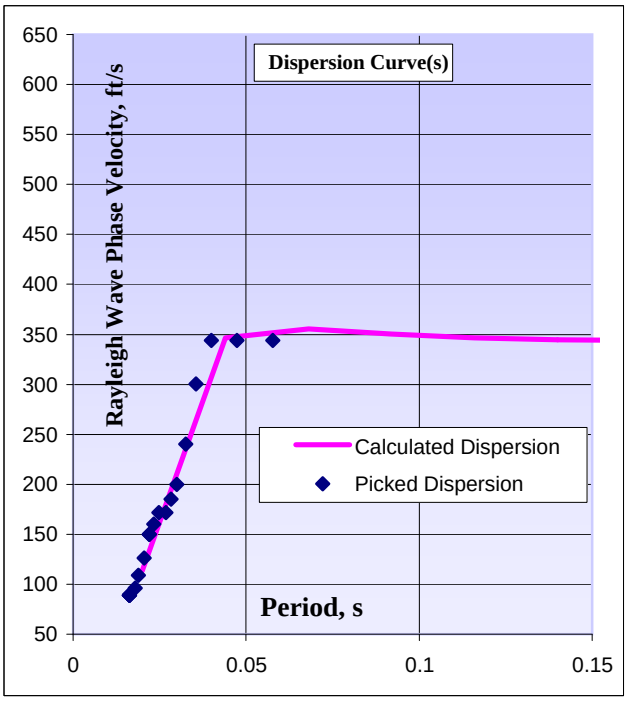
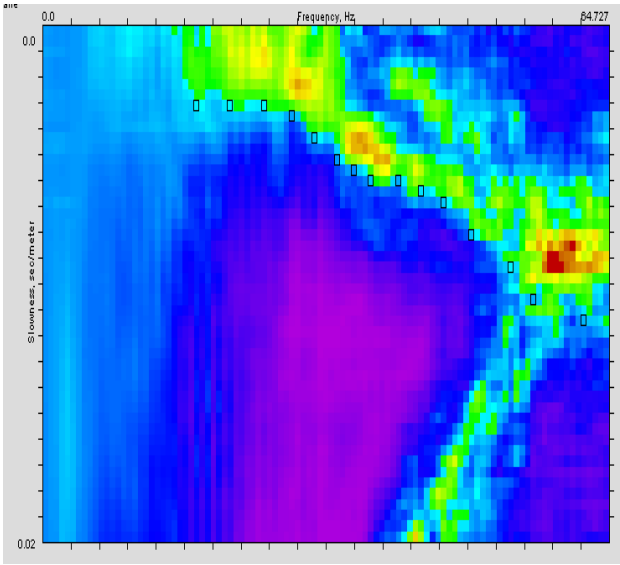


ReMi Spectral Ratio (p-f image)
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

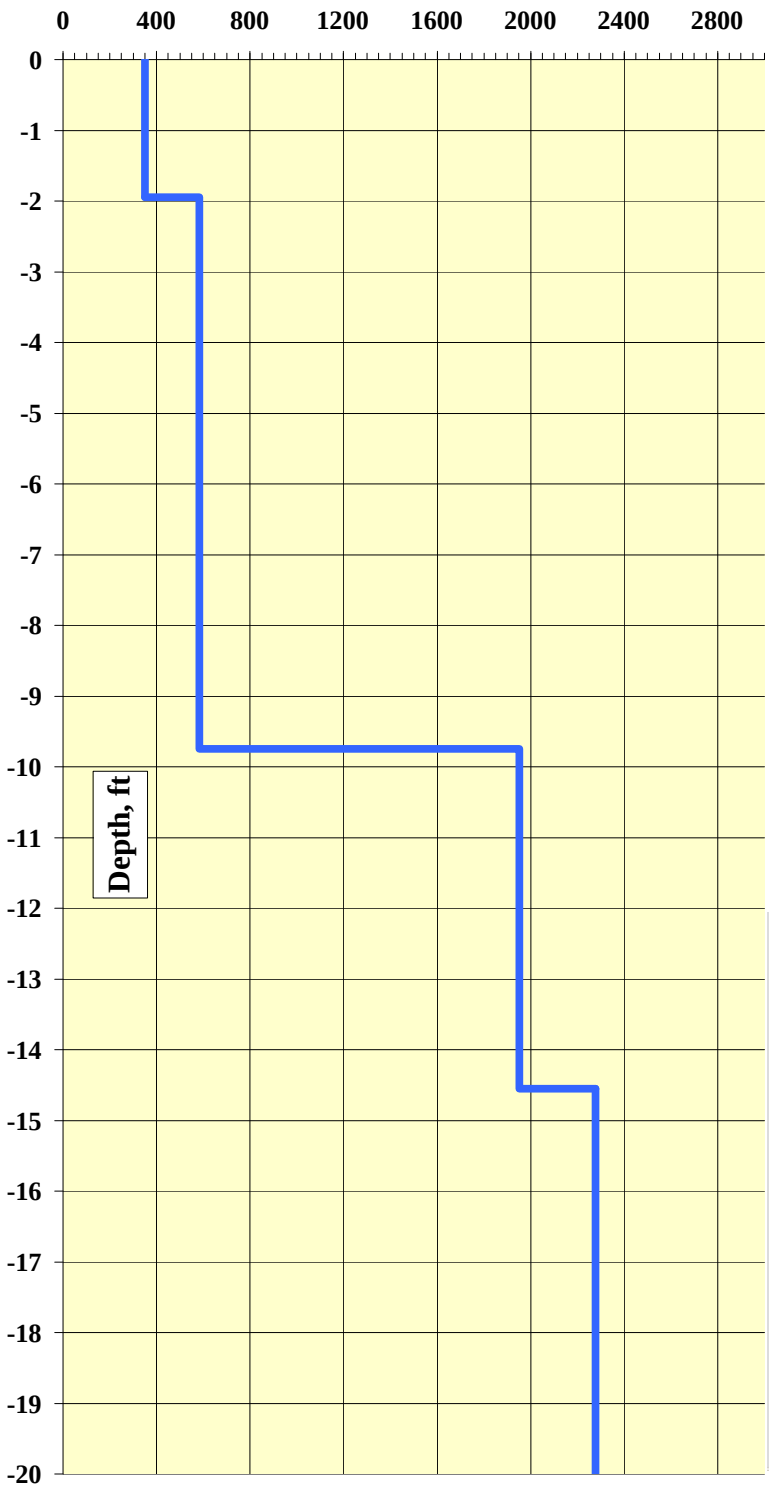
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #6: Sta. ~255+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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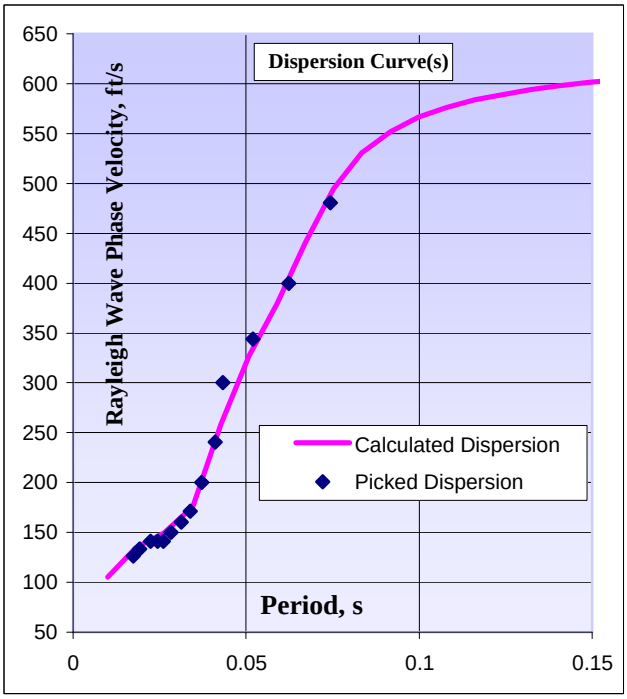

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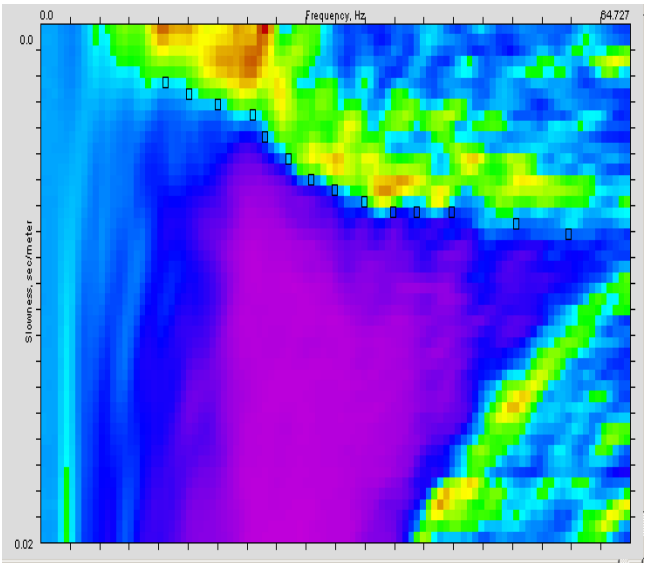
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

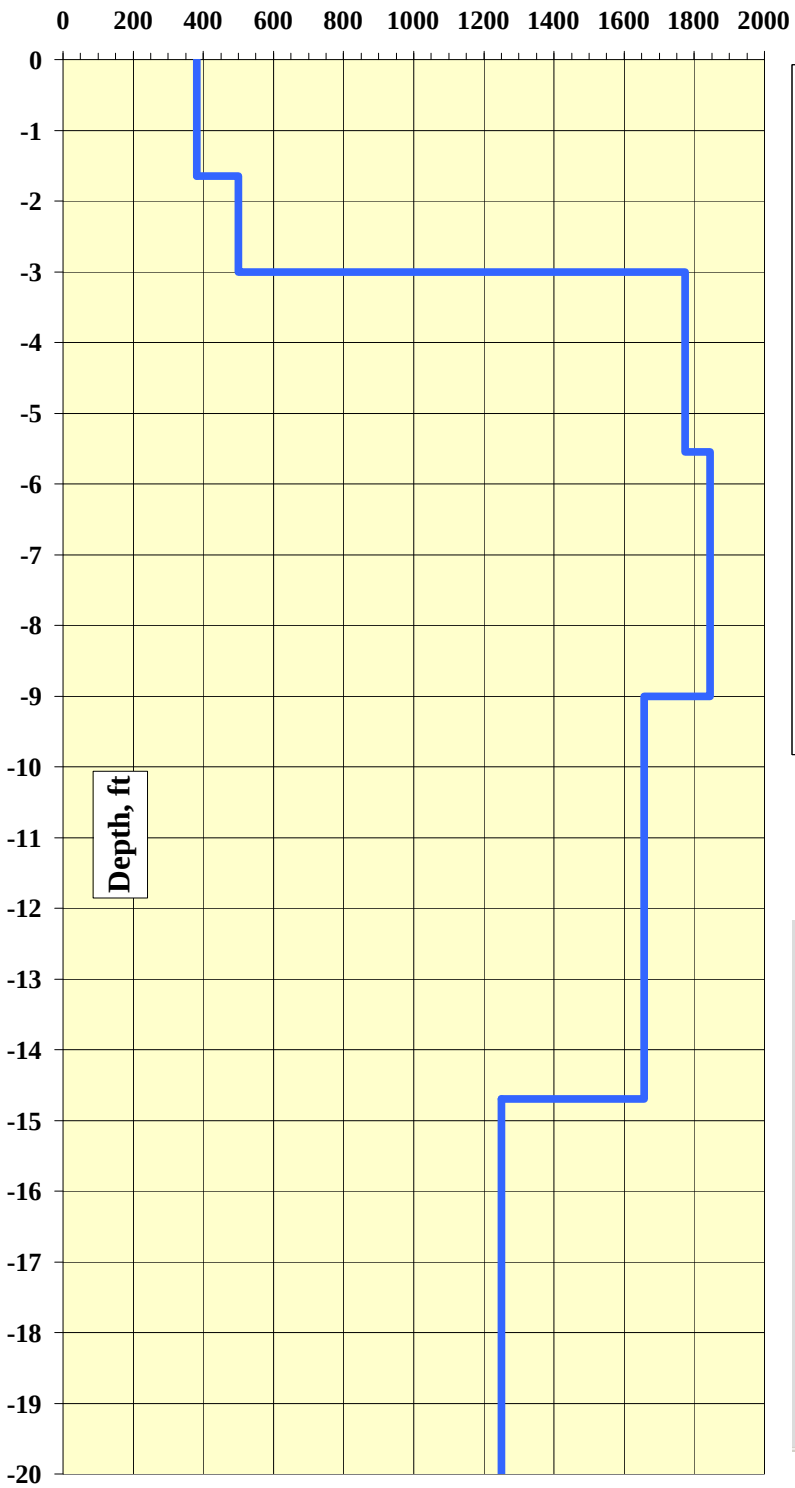
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #7: Sta. ~362+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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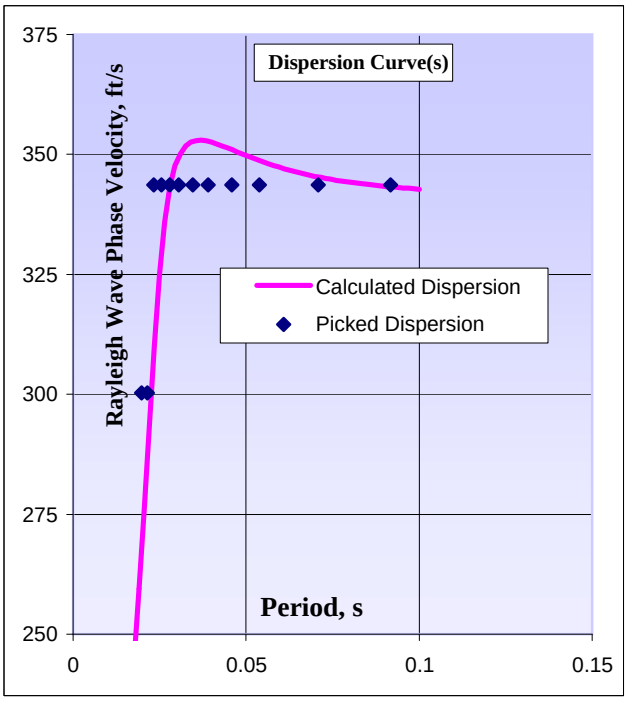

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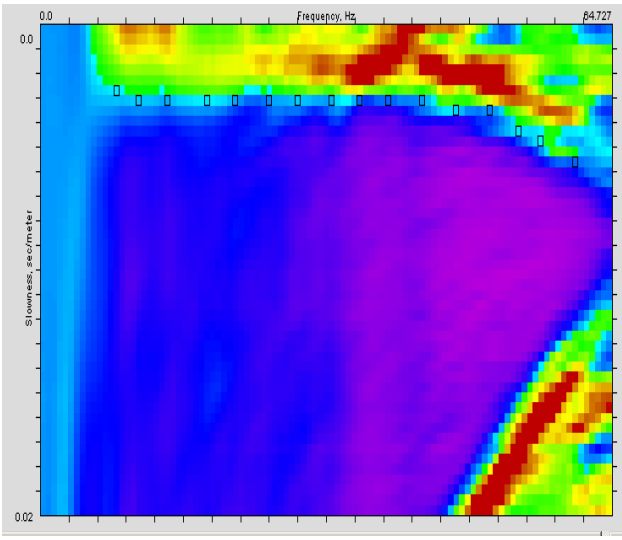
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

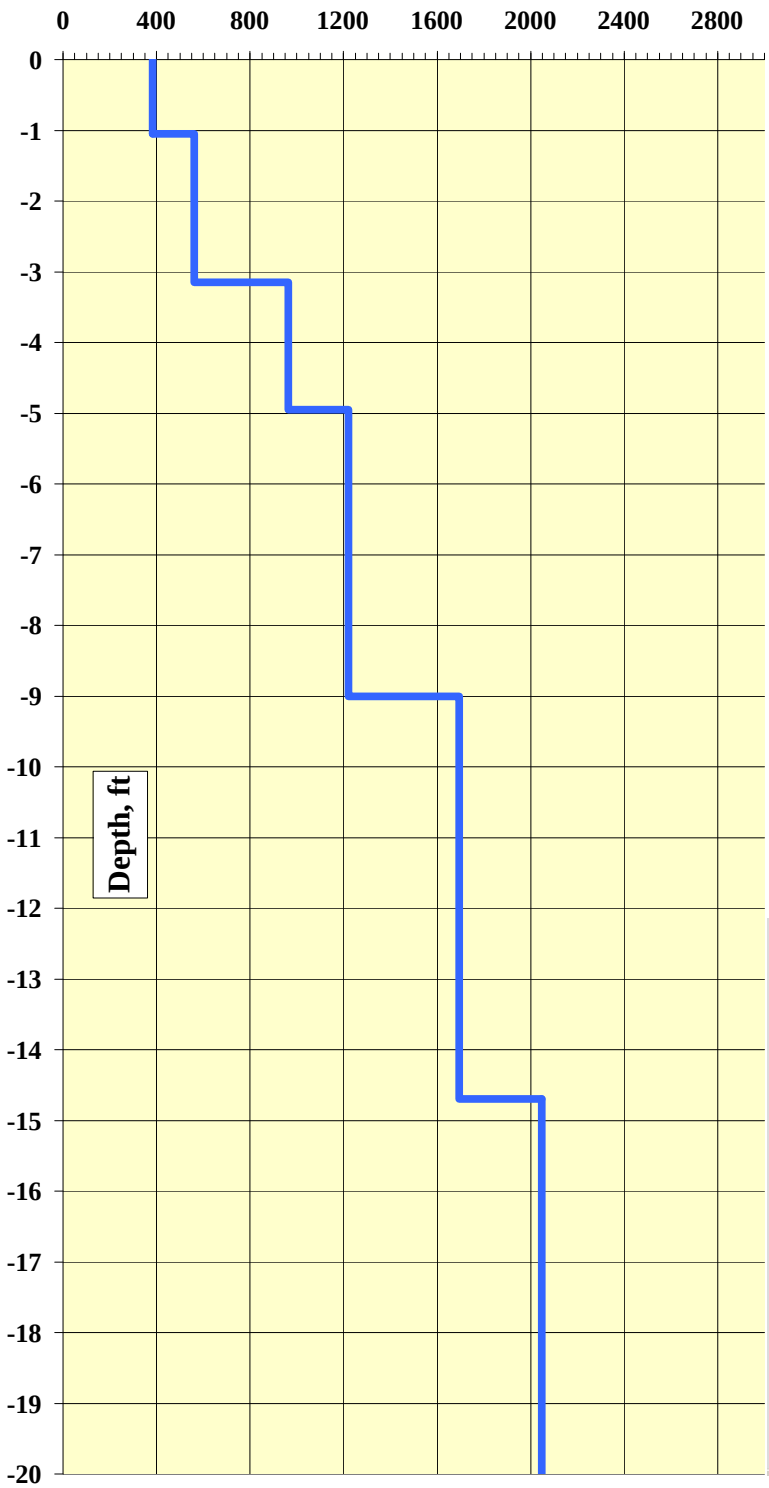
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #8: Sta. ~402+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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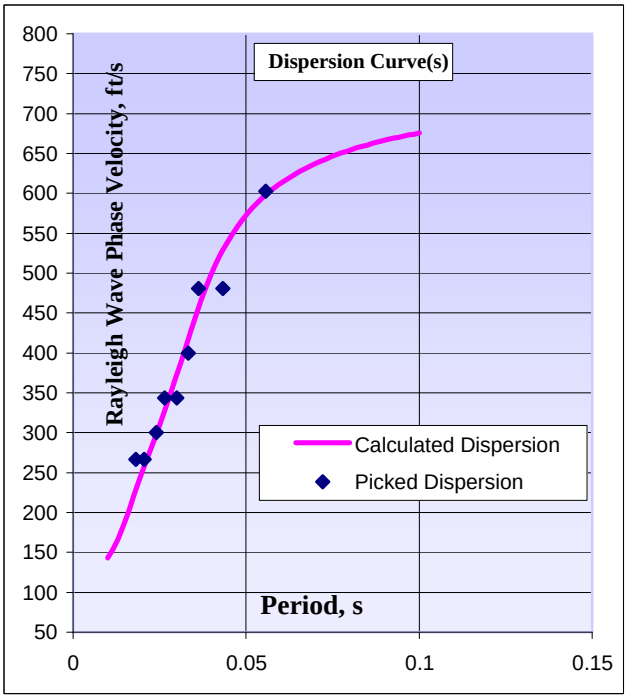

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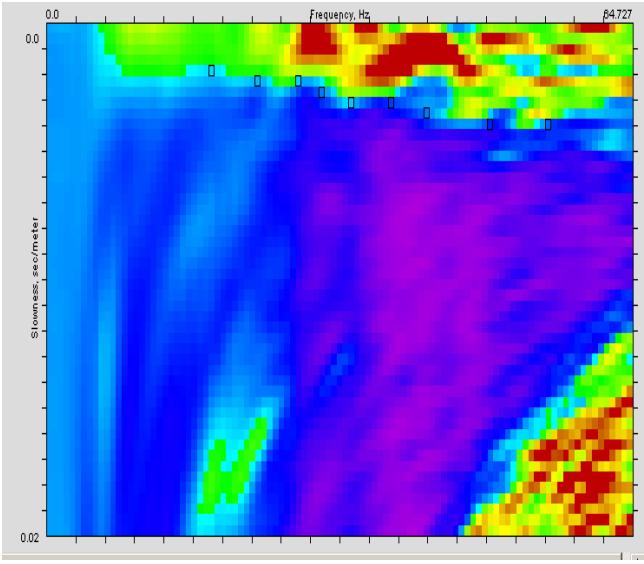
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

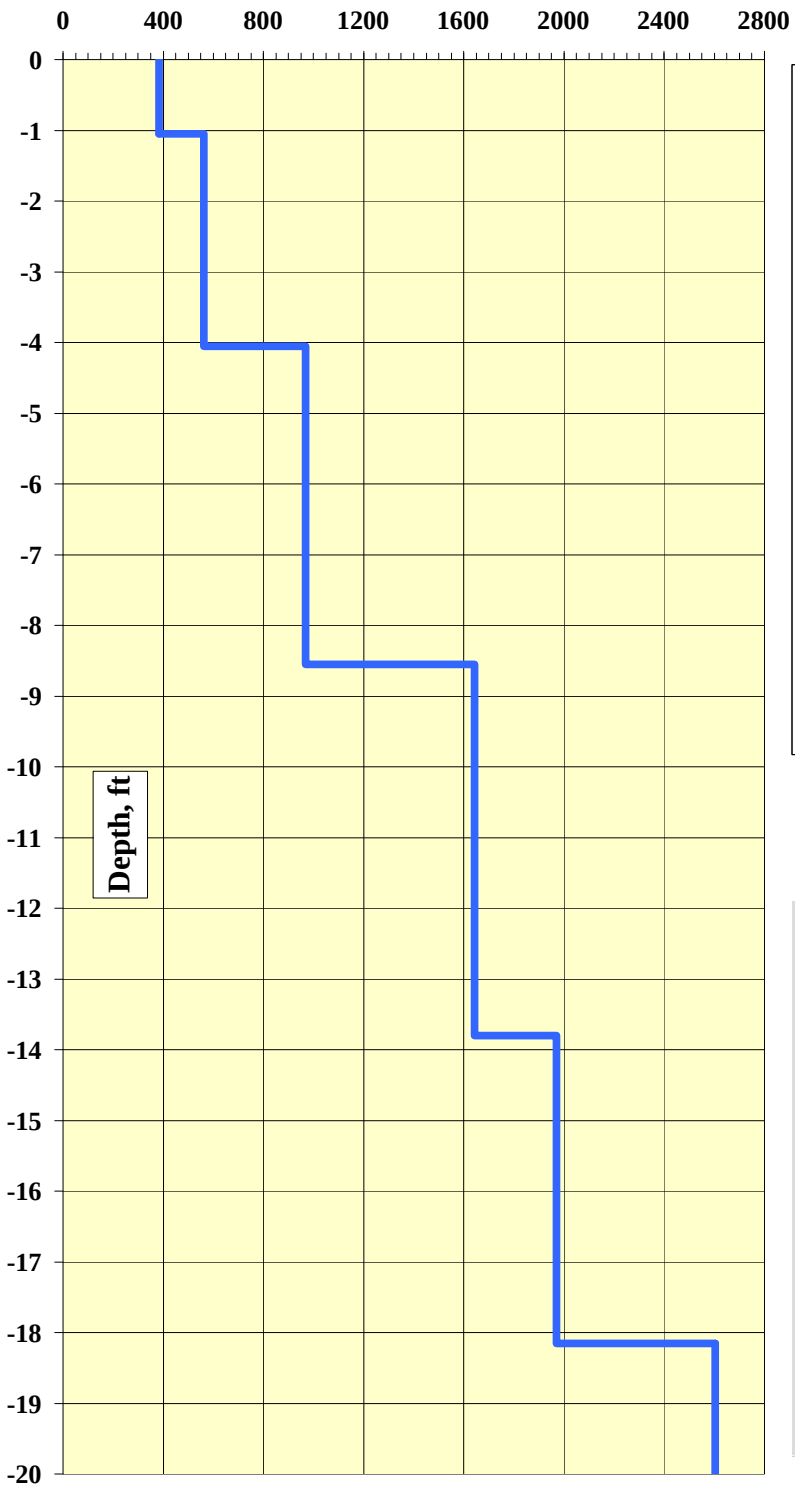
City of Bend Water Supply Alternatives Study
Bend, Oregon

Project Number: 1091020

ReMi #9: Sta. ~455+00

24, 4.5 Hz. Receivers on 3 foot spacing

Shear Wave Velocity Profile: V100 = na
NEHRP Site Classification na



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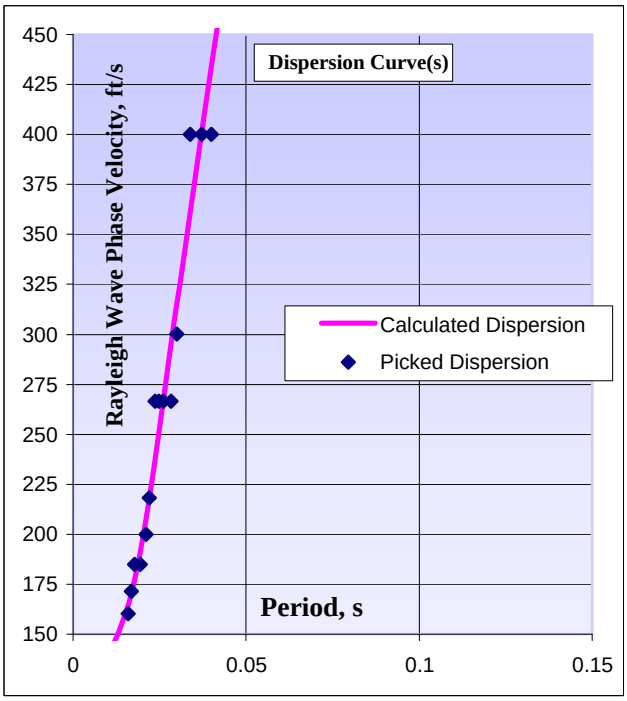
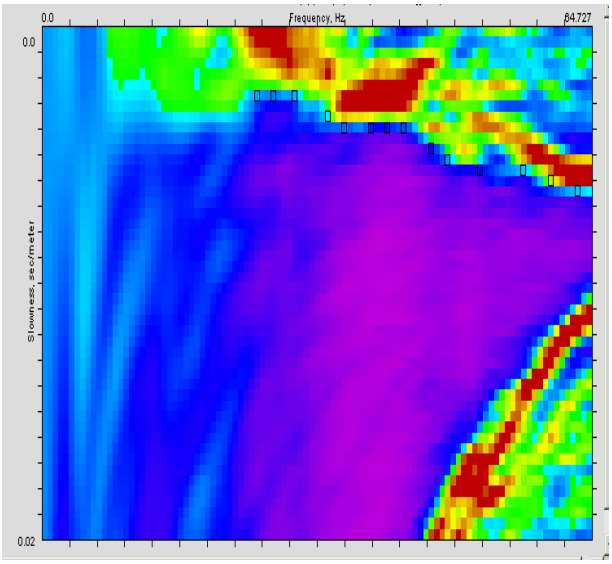


ReMi Spectral Ratio (p-f image)
w/ Modeling Picks



Prepared By: Siemens & Associates
SeisOpt ReMi Software: April 2009

APPENDIX 4-D

Cost Estimate Memorandum

Adjustments to June 3, 2009 Penstock Estimate

Given Estimate			$ 25,504,000
	Adjustmen	**Cost**	**Overall Cost**
Deletions	**Factor**	**Adjustment**	**Adjustment**
Diff in Pipe Cost	1.54	$ 893,000	$ 1,375,000
Diff in Paving if FWHA and FS do Road	1.54	$ 552,500	$ 851,000
Diff in Quantity of FS Road	1.54	$ 230,000	$ 354,000
Diff in 600# valves and vaults	1.54	$ 60,000	$ 92,000
Diff in 300# valves and vaults	1.54	$ 40,000	$ 62,000
Diff in base course rock (FWHA and USFS)	1.54	$116,000	$ 179,000
			$ 2,913,000
Additions			
	Quantity	**Cost**	**Adjustment**
Air valves	21	$ 35,000	$ 735,000
Blow offs	17	$ 24,000	$ 408,000
			$ 1,143,000
Difference from $25,503,026 in June Estimate			$ 1,770,000
Const			**$ 23,734,000**
Engineering, Legal, Administration (18%)			**$ 4,266,000**
Total			**$ 28,000,000**
20-Nov-09			

MEMORANDUM

1053-136732-004

June 3, 2009

TO: BOB WILLIS, PORTLAND

FROM: IAN KRULJAC, WALNUT CREEK

SUBJECT: BRIDGE CREEK PENSTOCK PROJECT
10 PERCENT DESIGN ESTIMATE
BASIS OF ESTIMATE OF PROBABLE CONSTRUCTION COST

The Basis of Estimate Report for the subject project is attached. Please call me if you have questions or need additional information.

IAK:ua

Attachments
Summary Estimate
Detailed Estimate

cc: J. L. Matthews, Jacksonville

BRIDGE CREEK PENSTOCK PROJECT

Introduction

Brown and Caldwell (BC) is pleased to present this estimate of probable construction cost (estimate) prepared for the Bridge Creek Penstock, Portland, Oregon.

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

The Bridge Creek Penstock is a pipeline segment of a larger project that will reconstruct most of the supply system for the City of Bend's Bridge Creek surface water supply system, which provides much of the City's water supply. The reconstruction includes: reconstruction of an existing intake on Bridge Creek, 10 miles of steel penstock, a 2.5 MW hydropower plant, a 13 mgd water treatment plant and new storage and other minor hydropower facilities. The subject of this estimate, the 10 miles of penstock, will be 36 inch diameter coated steel pipeline that will be placed in rural roads lying west of the City of Bend. About 7 of the 10 miles of rural roads are paved, the remainder are gravel. There are no water, sewer or drainage utilities in the road. The penstock will be designed to withstand the 1000 feet of hydraulic pressure that will be placed on the hydropower turbine, and to withstand a full vacuum. The plan is for the penstock to be bid in late 2010 with construction occurring from April of 2011 to August of 2012.

Background of this Estimate

The attached estimate of probable construction cost is based on documents dated April 28, 2009, received by the estimating department on April 28, 2009. These documents are described as 10 percent complete based on the current design progression, additional or updated scope and/or quantities, and ongoing discussions with the project design team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 percent to 15 percent complete. Class 4 estimates are used to prepare planning level cost scopes or to evaluate alternatives in design conditions and form the base work for the Class 3 Project Budget or Funding Estimate.

Expected accuracy for Class 4 estimates typically range from -30 percent to +50 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes, and equipment pricing furnished either by the design team or by the estimator. The estimate includes direct labor costs, including a shift differential if applicable, and anticipated productivity adjustments to labor, and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been used.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of a Windows-based commercial estimating software engine using BC's material and labor database, historical project data, the latest vendor and material cost information, and other costs specific to the locale of the project.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel), and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and workers compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data, 2009.

The contractor's cost for builders risk, general liability, and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost, and are added to the net totals after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Oregon Contractor's license, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work.

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
2. Contractor has limited access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and rates contained in the estimating database.
4. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
5. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
6. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material, is included in the purchase price of major equipment items where so stated in that quotation.
7. Bulk material quantities are based on manual quantity take-offs that have been entered into the estimating program.
8. Soils are of adequate nature to support the structures.
9. Piping will be placed at 4 ft below grade and bedded to spring-line.
10. Excavation will be performed by the General Contractor.
11. No bypass piping is required.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions unless otherwise noted.
5. Landscaping.

Allowances for Known but Undefined Work

An allowance was made for the following.

1. Boulder and rock blasting.

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups, June 2009

Item	Rate for Phase One Work, Percent
Prime Contractor	
Labor (employer payroll burden)	10
Materials and process equipment	8
Equipment (construction-related)	8
Subcontractor	5
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.)	None
Builder's Risk, Liability, and Vehicle Insurance	2
Subcontractor Markups	Same as Prime
Escalation to Midpoint for Labor and Equipment	2.5
Escalation to Midpoint for Materials	5
Contractor's General Conditions	8
Contingency	30
Bonds	1.5

Labor Markup. The labor rates used in the estimate were derived chiefly from the latest published State Prevailing Wage Rates. These rates include costs beyond raw labor for such items as Payroll Tax and Insurance (PT&I), FICA, and Workers Compensation Insurance. In addition to these markups, the General Contractor (GC) typically adds a percentage to each raw labor dollar to cover overhead and profit, payroll and accounting costs, additional insurance, retirement, 401k contributions, and sick leave/vacation cost.

Materials and Process Equipment Markup. This markup consists of the additional cost the contractor must bear beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup. This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all of the equipment needed for the job, but in order to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is similar to the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup. This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Builders Risk, Liability, and Vehicle Insurance. This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity, and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and on the contractor's insurability at the time the project is bid.

Escalation to Midpoint for Labor, Materials and Subcontractors. In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material, and equipment costs beyond values at the time the estimate is prepared.

This project can reasonably be constructed within 16 months, exclusive of unusual weather or site conditions delays. Construction for phase one is anticipated to start April 1, 2011, and complete August 1, 2012. The escalation factors used in this estimate are calculated from the date the estimate is finalized to the anticipated midpoint of construction.

Construction Contingency. The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that can not be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage, and area factors, construction contingency can range from 10 percent to 50 percent.

Range of Accuracy. The amount of contingency in the estimate should not be confused with the accuracy of the estimate. The Expected Accuracy Range defines the window within which the bids are expected to fall based on the project complexity, information available during the estimate process, outside influences (wage rates, material, bidding climate), and includes a level of contingency appropriate to the project definition at the time the estimate was prepared. It is important to understand that AACEI, notes on its ranges of accuracy that,

> "The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value [of the ranges] represents typical percentage variation of

> actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope."

While a 50-percent level of confidence in the contingency may seem broad, typically this results in a 90-percent confidence that the actual cost will fall within the bounds of the low and high ranges.

The caution here is that these estimates are not what are often referred to as "bid quality," i.e., estimates prepared by contractors who are receiving competitive bids from subcontractors, equipment vendors, and materials suppliers. In general, we receive reasonable budget values from those willing to provide quotations.

Performance and Payment Bonds. Based on historical and industry data, this can range from 0.75 percent to 1.25 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity, and current bonding limits. BC uses 0.75 percent for each bond which we have determined to be reasonable for most heavy construction projects.

BROWN AND CALDWELL

Environmental Engineers & Consultants

SUMMARY CONCEPTUAL ESTIMATE REPORT WITH MARK-UPS ALLOCATED
Bridge Creek Penstock Project
10% Design Level Estimate

Project Number:	136732-004-001
BC Project Manager:	Bob Willis
BC Office:	Portland OR
Estimate Issue Number:	01
Estimate Original Issue Date:	6-1-2009
Estimate Revision Number:	04
Estimate Revision Date:	6-3-2009
Lead Estimator:	Ian A Kruljac
Estimate QA/QC Reviewer:	Butch Mathews
Estimate QA/QC Date:	5-8-2009

PROCESS LOCATION/AREA
1100 - Bridge Creek Penstock Project

Description	Total w/ Markups Allocated
--- Base Estimate ---	**25,504,026**
1100 - Bridge Creek Penstock	
01590 - Miscellaneous Equipment Rental without operators	**22,406**
02050 - Basic Site Materials & Methods	**660,213**
02200 - Site Preparation	**30,822**
02300 - Earthwork	**5,967,644**
02310 - Fine grade	**93,348**
02360 - Compaction	**4,222**
02700 - Bases, Ballasts, Pavements & Appurtenances	**1,886,779**
03320 - Grout	**36,462**
11000 - Equipment	**12,820**
15055 - Pipe,watr dstr,plyv chlrd	**25,858**
15100 - Building Services Piping	**39,614**
15190 - CARBON STEEL PIPE, WELDED	**14,996,377**
15200 - Process Piping	**60,657**
15205 - Pipe,grv-jnt st fit valvs	**64,938**
15255 - Valves, iron body	**1,594,876**
15285 - Valves, steel	**6,992**
1100 - Bridge Creek Penstock Total	*25,504,026*

BROWN AND CALDWELL

Environmental Engineers & Consultants

DETAILED CONCEPTUAL ESTIMATE REPORT

Bridge Creek Penstock Project
10% Design Level Estimate

Project Number:	136732-004-001
BC Project Manager:	Bob Willis
BC Office:	Portland OR
Estimate Issue Number:	01
Estimate Original Issue Date:	6-1-2009
Estimate Revision Number:	04
Estimate Revision Date:	6-3-2009
Lead Estimator:	Ian A Kruljac
Estimate QA/QC Reviewer:	Butch Mathews
Estimate QA/QC Date:	5-8-2009

PROCESS LOCATION/AREA
1100 - Bridge Creek Penstock Project

Item	Item Description	Qty	Unit	Total $/Unit	Total Net Cost $
	--- Base Estimate ---				
	1100 - Bridge Creek Penstock				15,562,054
	01590 - Miscellaneous Equipment Rental without operators				
	01590400 - General equipment rental without operators				
7030B	Rent trench box, 3000 lbs 6' x 8' - Rent per day	300.0	days	46.5	13,950
	Miscellaneous Equipment Rental without operators Total				13,950
	02050 - Basic Site Materials & Methods				
	02080400 - Utility Boxes				
0400	Utility structures, utility vaults precast concrete, hand hole, light duty, 1-1/2" thick, 1'-0" x 2'-0" x 1'-9" I.D., excludes excavation and backfill	18.0	EA	693.7	12,487
0450	Utility structures, utility vaults precast concrete, hand hole, heavy duty, 1-1/2" thick, 4'-6" x 3'-2" x 2'-0", O.D., excludes excavation and backfill	16.0	EA	1,688.5	27,016
	02310100 - Finish Grading				
0100	Forest service roads, gravel fill, 8" gravel depth	25,066.1	SY	14.5	363,254
	Basic Site Materials & Methods Total				402,757
	02200 - Site Preparation				
	02220330 - Selective Demolition, Dump Charges				
9999	Dump hauling allowance excess rock and boulders	400.0	ton	33.0	13,200
	02220381 - Selective Demolition, Water & Sewer Piping And Fittings				
1200	Selective demolition, water & sewer piping & fittings, steel pipe, 14"-24", diameter, excludes excavation		LF	24.4	
	02260200 - Cofferdams				
2450	Cofferdams, open sheeting no bracing 10' deep, maximum	1,550.0	SF	2.5	3,946
4500	Cofferdams alternate, trench box, 7' deep, 16' x 8', see 01 54 33 in Reference Section	20.0	days	165.6	3,312
	Site Preparation Total				20,458
	02300 - Earthwork				
	02310100 - Finish Grading				
0200	Fine grading, grade subgrade for base course, roadways	49,280.0	SY	0.4	20,716
	02315120 - Backfill, Structural				
4420	Backfill, structural, common earth, 200 H.P. dozer, 300' haul	38,518.5	L.C.Y.	1.2	46,434
	02315310 - Compaction, General				
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	5,777.8	E.C.Y.	1.1	6,282
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	44,164.5	E.C.Y.	1.1	48,020
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	34,666.7	E.C.Y.	1.1	37,693
	02315416 - Drilling And Blasting Rock				
2900	Drilling and blasting rock, boulders, drilled and blasted (allowance)	5,000.0	B.C.Y.	33.2	166,052
	02315492 - Hauling				
0009	Loading Trucks, F.E. Loader, 3 C.Y.	77,037.0	cuyd	0.9	66,563
4498	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment	77,037.0	L.C.Y.	2.8	218,177
	02315610 - Excavating, Trench				

Item	Item Description	Qty	Unit	Total $/Unit	Total Net Cost $
0600	Excavating, trench or continuous footing, common earth, 1 C.Y. excavator, truck mounted, 6' to 10' deep, excludes sheeting or dewatering	92,444.4	B.C.Y.	5.1	472,356
	02315640 - Utility Bedding				
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	51,353.7	L.C.Y.	48.6	2,497,187
	02370700 - Synthetic Erosion Control				
1100	Synthetic erosion control, silt fence, polypropylene, adverse conditions, 3' high	52,000.0	LF	1.2	64,324
1200	Synthetic erosion control, place and remove hay bales	10.0	ton	640.5	6,405
	Earthwork Total				**3,650,210**
	02310 - Fine grade				
	02310 - Fine grade				
0050	Fine grade, fine grade, for small irregular areas	25,066.1	sqyd	2.3	57,502
	Fine grade Total				**57,502**
	02360 - Compaction				
	02360 - Compaction				
0020	Compaction, sheepsfoot or wobbly wheel roller, 8" lifts, select fill	2,134.0	cuyd	1.2	2,611
	Compaction Total				**2,611**
	02700 - Bases, Ballasts, Pavements & Appurtenances				
	02720200 - Aggregrate Base Course For				
0200	Base course drainage layers, aggregate base course for roadways and large paved areas, stone base, compacted, 3/4" stone base, to 9" deep	49,280.0	SY	13.9	685,817
	02740310 - Asphaltic Concrete Pavement, Highways				
0080	Plant-mix asphalt paving, for highways and large paved areas, binder course, 1-1/2" thick	49,280.0	SY	5.6	275,505
0300	Plant-mix asphalt paving, for highways and large paved areas, wearing course, 1" thick	49,280.0	SY	3.8	189,148
	Bases, Ballasts, Pavements & Appurtenances Total				**1,150,470**
	03320 - Grout				
	03320 - Grout				
0030	Grout,fill	213.0	cuyd	104.5	22,268
	Grout Total				**22,268**
	11000 - Equipment				
	11100 - Pumps miscellaneous				
0030	Water pump, portable, gasoline powered, 10,000 GPH, 2" discharge	4.0	week	1,951.6	7,806
	Equipment Total				**7,806**
	15055 - Pipe,watr dstr,plyv chlrd				
	15055 - Pipe,watr dstr,plyv chlrd				
B0070	Piping, pipe, PVC, C905 DR18, 18" diameter	300.0	lnft	52.6	15,776
	Pipe,watr dstr,plyv chlrd Total				**15,776**
	15100 - Building Services Piping				
	15107660 - Pipe Fittings, Steel				
0830	Gasket and bolt set, for flanges, 150 lb., 36" pipe size	3.0	EA	1,066.9	3,201
0830	Gasket and bolt set, for flanges, 600 lb., 36" pipe size	4.0	EA	2,866.9	11,467
0830	Gasket and bolt set, for flanges, 300 lb., 36" pipe size	4.0	EA	2,366.9	9,467
	Building Services Piping Total				**24,136**
	15190 - CARBON STEEL PIPE, WELDED				
	15190 - Pipe, steel				

Item	Item Description	Qty	Unit	Total $/Unit	Total Net Cost $
0460B	Piping, water dist, Polyl x Polyc, 36" dia Pressure 361.1 Per Northwest Pipe Qoute 04-08-2009	28,000.0	lnft	151.1	4,231,155
0460B	Piping, water dist, Polyl x Polyc, 36" dia Pressure 391.4 Per Northwest Pipe Qoute 04-08-2009	8,000.0	lnft	161.2	1,289,301
0460B	Piping, water dist, Polyl x Polyc, 36" dia Pressure 486.8 Per Northwest Pipe Qoute 04-08-2009	8,000.0	lnft	183.2	1,465,941
0460B	Piping, water dist, Polyl x Polyc, 36" dia Pressure 543.1 Per Northwest Pipe Qoute 04-08-2009	8,000.0	lnft	192.3	1,538,301
2260	Pipe, steel, welding labor per joint, schedule 40, 36 " pipe size	650.0	each	950.0	617,500
	CARBON STEEL PIPE, WELDED Total				**9,142,198**
	15200 - Process Piping				
	15200 - Pipe, steel, fittings				
0830	Pipe, st ftng, flg, FS, slip-on, 150 LB flg, wld frt&back, 36" pipe	3.0	each	2,267.4	6,802
0830	Pipe, st ftng, flg, FS, slip-on, 600 LB flg, wld frt&back, 36" pipe	4.0	each	4,224.7	16,899
0830	Pipe, st ftng, flg, FS, slip-on, 300 LB flg, wld frt&back, 36" pipe	4.0	each	3,324.7	13,299
	Process Piping Total				**37,000**
	15205 - Pipe,grv-jnt st fit valvs				
	15205 - Pipe,grv-jnt st fit valvs				
0010	Pipe, grvd-jt st ftngs, incl cplg&clv type hgr, sched 10, bk, 2" dia	360.0	lnft	16.5	5,945
0050	Pipe, grvd-jt st ftngs, incl cplg&clv type hgr, sched 10, bk, 4" dia	320.0	lnft	28.0	8,967
0700	Pipe,grvd-jt,st cplg&lab req'd not incld,elb,90< or 45<,ptd,2" dia	18.0	each	29.3	527
0730	Pipe,grvd-jt,st cplg&lab req'd not incld,elb,90< or 45<,ptd,4" dia	128.0	each	56.1	7,185
0910	Pipe, grvd-jt, st cplg & lab req'd not incld, T, ptd, 4" dia	16.0	each	88.0	1,409
1080	Pipe, grvd-jt, st cplg, rgd style, ptd, 4" dia	320.0	each	38.9	12,456
3070	Pipe, grvd-jt, st flg, W/grv gskt, bk st, cut 1 grv, lab, 4" pipe	320.0	each	9.8	3,141
	Pipe,grv-jnt st fit valvs Total				**39,630**
	15255 - Valves, iron body				
	02080500 - Valves				
3830	Water Utility distribution Valves, gate valves, cast iron, mechanical joint, with boxes, 150 PSI, 36" diameter, includes valve box and mechanical joint, excludes excavation and backfill	3.0	EA	19,984.0	59,952
3830	Water Utility distribution Valves, gate valves, cast iron, mechanical joint, with boxes,standard 600 PSI, 36" diameter, includes valve box and mechanical joint, excludes excavation and backfill	4.0	EA	165,384.0	661,536
3830	Water Utility distribution Valves, gate valves, cast iron, mechanical joint, with boxes,standard 300 PSI, 36" diameter, includes valve box and mechanical joint, excludes excavation and backfill	4.0	EA	62,384.0	249,536
	Valves, iron body Total				**971,024**
	15285 - Valves, steel				
	15285 - Valves, steel				
1200	Valves, steel, forged, ball valve, 800 lb, threaded, 2" size	18.0	each	236.6	4,260
	Valves, steel Total				**4,260**

Item	Item Description	Qty	Unit	Total $/Unit	Total Net Cost $
	Grand Total				**15,562,054**

Category	Percent	Amount
--- Base Estimate --- Totals		
Labor	**14.16 %**	**2,203,618**
Material	**78.97 %**	**12,289,355**
Subcontractor	**0.02 %**	**3,312**
Equipment	**6.76 %**	**1,052,569**
Other	**0.08 %**	**13,200**
User		
Net Costs		**15,562,054**
Labor Mark-up	10.00 %	220,362
Material Mark-up	8.00 %	983,148
Subcontractor Mark-up	5.00 %	166
Equipment Mark-up	8.00 %	84,206
Esc. to Midpoint labor Oct 2011	2.50 %	81,487
Escal. midpoint-material Oct. 2011	5.00 %	614,468
Contractor General Conditions	8.00 %	1,403,671
Subtotal		**18,949,562**
Construction Contingency	30.00 %	5,684,869
Subtotal		**24,634,430**
Bldg Risk, Liability Auto Ins.	2.00 %	492,689
Subtotal		**25,127,119**
Bonds	1.50 %	376,907
Subtotal		**25,504,026**
Total Estimate		**25,504,026**

Northwest Pipe Company

12005 N. Burgard, Portland, OR 97203
Phone: (503) 285-1400, (800) 824-9824
Fax: (503) 382-2327

To: Corianne Hart
Brown & Caldwell - Portland
Phone: (503) 977-6678
Email: chart@brwncald.com

Date: 08-Apr-09
Project: Bend Springs Water Supply

Budgetary Quotation

We are pleased to offer prices for steel pipe for the above noted project for materials as listed below. The estimating prices are provided for reference only and Northwest Pipe shall not be bound by pricing or any other provisions herein Final pricing and delivery can be provided once project requirements are finalized

SPECIFICATIONS:

Pipe: Manufactured and tested per AWWA C200.
Length: Standard length to be 60 ft.
Joints: Lap welded, or *Butt welded
Coating: Polyurethane per AWWA C222 (DFT = 25 mils)
Lining: Polyurethane per AWWA C222 (DFT = 40 mils)
Freight: Prices are FOB our plant with full freight allowed to jobsite. Jobsite shall specifically mean truckbed delivery as close to installation site as possible with truck under it's own power. All unloading shall be done by the buyer.
Delivery: Delivery of pipe can commence approximately 10 - 12 weeks from receipt of approved drawings.

PRICING
WELDED STEEL PIPE

Item	Qty. (lf)	O.D. (in)	Wall (in.)	Yield (psi)	Working Pres.(psi)	Unit Price $/lf	Extension Total $
				Low Head Option			
PolyL x PolyC	28,000	36	0.250	52,000	361.1	$134.00	$3,752,000.00
PolyL x PolyC	8,000	36	0.271	52,000	391.4	$144.00	$1,152,000.00
*PolyL x PolyC	8,000	36	0.337	52,000	486.8	$166.00	$1,328,000.00
*PolyL x PolyC	8,000	36	0.376	52,000	543.1	$175.00	$1,400,000.00

For Further Information:

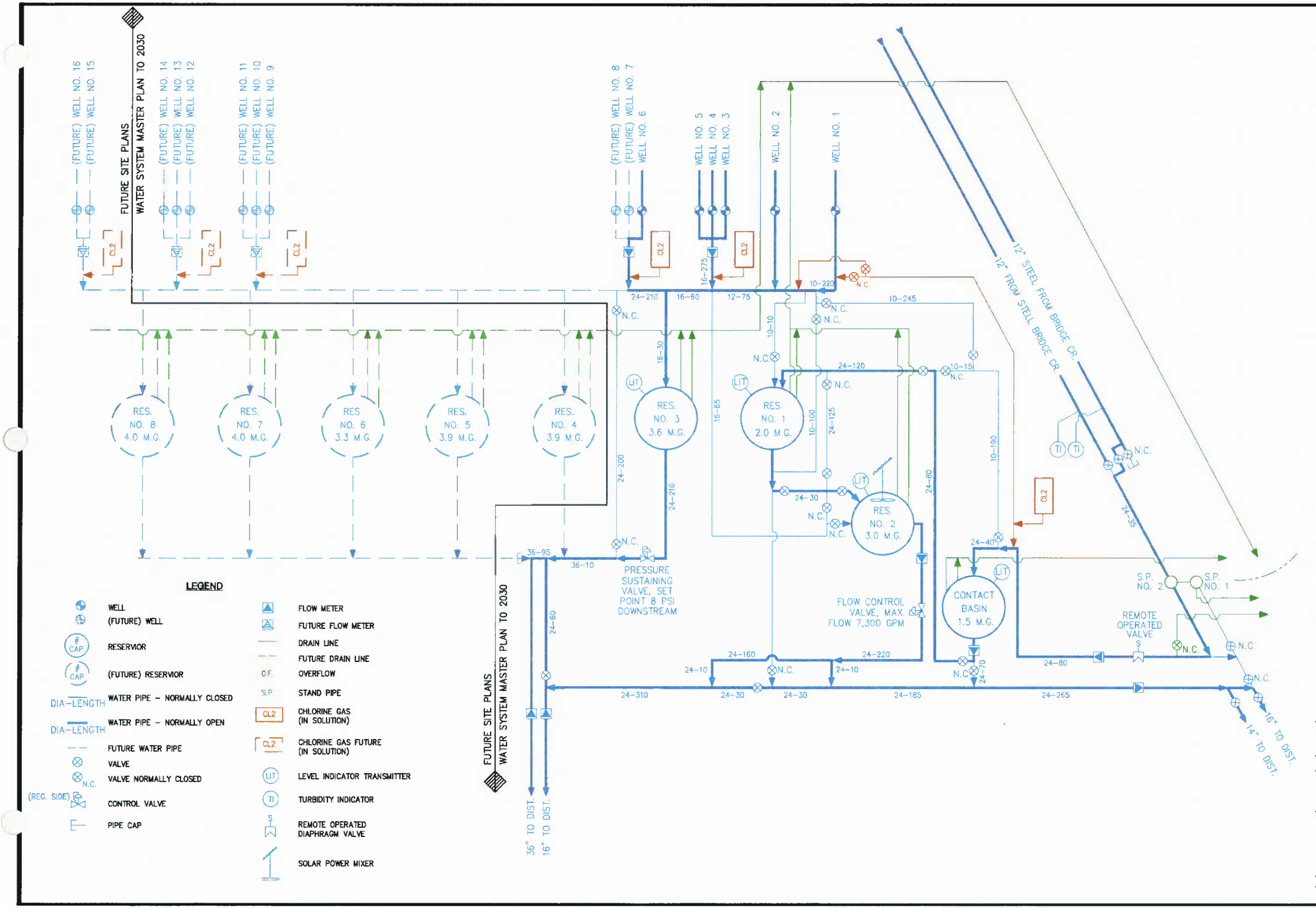
If you have any questions, or need additional information, please contact me in our sales department at (503) 382-2419 dir. Or by cell phone at (971) 212-7530.

Sincerely,

Eric Stokes
Sales Representative
Northwest Pipe Company

APPENDIX 4-E

Process Schematic Plan



CITY OF BEND
OUTBACK RESERVOIRS
PROCESS SCHEMATIC
PLAN 2009

DAVID EVANS AND ASSOCIATES INC.
320 SW Upper Terrace Drive, Suite 300
Bend, Oregon 97701 (541) 389-7614

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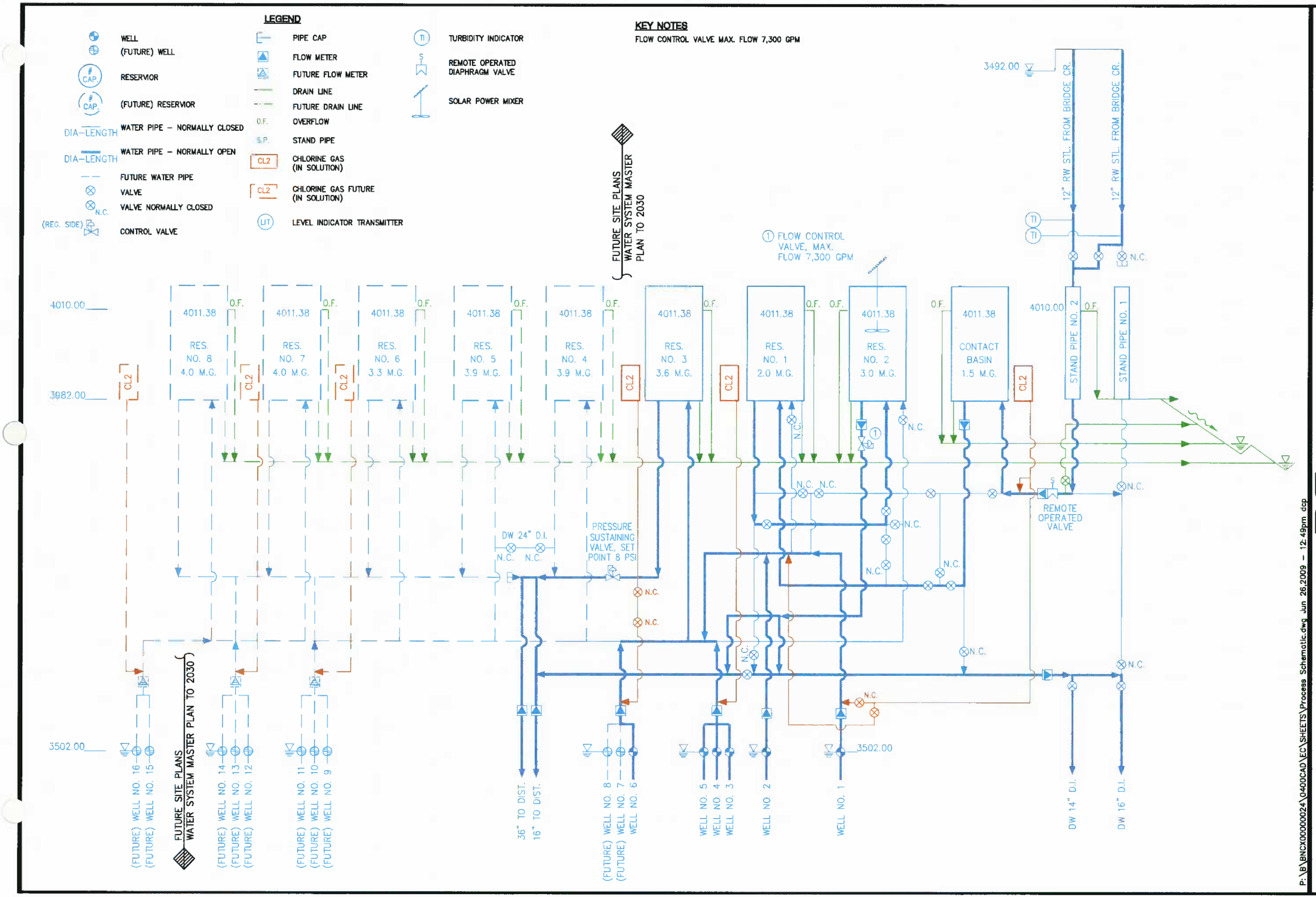
date: 4-8-09
file
design: JJD
drawn: WXS



CITY OF BEND
OUTBACK RESERVOIRS
PROCESS SCHEMATIC
PROFILE 2009

DAVID EVANS AND ASSOCIATES INC.
320 SW Upper Terrace Drive, Suite 200
Bend, Oregon 97701 (541) 389-7614

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drawn: WXS