U.S. Department of Energy

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Office of River Protection

BECHTEL

07-ESQ-181

OCT 1 2 2007

CCN: 161115

Ms. Jane A. Hedges, Program Manager
Nuclear Waste Program
Washington State
Department of Ecology
3100 Port of Benton Blvd.
Richland, Washington 99354

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Dear Ms. Hedges:

CATHODIC PROTECTION AT THE WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) FINAL DESIGN REPORTS

Reference: Ecology letter from S. Dahl to S. J. Olinger, ORP, and W. S. Elkins, BNI, "Cathodic Protection for Underground Waste Transfer Piping," dated September 12, 2007.

This letter transmits the "Buried Pipeline and Ancillary Equipment vs Soil Environment Compatibility Report" (Attachment 1) and the schedule for completing and energizing the cathodic protection system for the underground waste transfer lines (Attachment 2) that were requested in the Reference. An advanced copy of Attachment 1 was provided electronically to the Washington State Department of Ecology staff on September 14, 2007.

Construction is scheduled to be completed on the cathodic protection system for the underground waste transfer lines, designated as Rectifier CPE-RECT-50005, on November 11, 2008, with testing completed on February 20, 2009. The remaining rectifiers in Attachment 2 provide cathodic protection for the underground pipelines indicated below:

- Rectifiers CPE-RECT-50001 through -50004 cover the general plant service air lines
- Rectifier CPE-RECT-50006 covers the diesel fuel oil pipelines between the Diesel Fuel Oil Tank and the Steam Plant Facility, Building 85
- Rectifier CPE-RECT-50008 covers the important to safety plant service air line between the Pretreatment and High-Level Waste Buildings.

The schedule is based on energizing and testing all seven cathodic protection systems at the same time as opposed to energizing a single cathodic protection system as soon as installation is completed. The rationale for energizing all seven cathodic protection systems at the same time is

to minimize possible stray currents from an operational cathodic protection system that could cause pitting type corrosion on unprotected pipelines that are crossing or within the zone of influence. The zone of influence may be up to 30 feet from the protected piping, depending on the environmental conditions (e.g., resistivity of the soil). Waiting to energize all seven cathodic protection systems at the same time will provide minimal risk to installed WTP piping systems. In addition, corrosion damage is not expected to occur for 15 to 70 years with 70 years being more likely as discussed in Attachment 1.

If you have any questions, please contact either of us, or your staff may contact Lori A. Huffman, Office of Environmental Safety and Quality, (509) 376-0104, or Stan Hill, BNI, (509) 371-3432.

Shirley J. Olinger, Acting Manager
Office of River Protection

W. S. Elkins, Project Director
Bechtel National, Inc.

ESQ:LAH

Attachments:
1. Buried Pipeline and Ancillary Equipment vs Soil Environment Compatibility Report
2. Schedule for Completing and Energizing the Cathodic Protection System for the Underground Waste Transfer Lines

cc w/attachs:
W. T. Clements, BNI
W. S. Elkins, BNI
J. S. Hill, BNI
P. E. Peistrup, BNI
B. Becker-Khaleel, Ecology
E. A. Fredenburg, Ecology
Administrative Record (WTP H-0-8)
BNI Correspondence

Attachment 1
07-ESQ-181

Buried Pipeline and Ancillary Equipment Vs Soil Environment Compatibility Report

INTERIM
BURIED PIPELINE AND ANCILLARY EQUIPMENT VS SOIL ENVIRONMENT COMPATIBILITY REPORT

for the
Planned River Protection Project - Waste Treatment Plant
Hanford, Washington

The U.S. Department of Energy (DOE) is now constructing the dangerous Waste Treatment Plant (WTP) at their Hanford, Washington facility. Construction of the plant is part of the DOE River Protection Project. The plant will receive waste for storage, neutralization, and transfer to a vitrificationtion system. The process of treating the waste is to be conducted in a series of vessels to be constructed at the WTP. Transfer of waste between some vessels for the various steps of the treatment process will be in buried steel piping. That transfer piping is the subject of this compatibility report. A description of the plant is provided in Bechtel document 24590-PTF-3YD-PWD-0001.

This report is being prepared to assure compliance with the State of Washington Department of Ecology regulation described in WAC 173-303-640 and its guidance 94-114.

Pipeline Design

The buried transfer piping for the WTP being constructed is a sloped coaxial system. The coaxial system for transfer of the waste is made up of a carrier pipe made of 316L stainless steel to contain the waste. That carrier pipe runs inside an encasement pipe that is made of carbon steel. The encasement pipe is a secondary containment system in the event of a leak from the carrier pipe. The encasement pipe also isolates the carrier pipe from corrosion by the surrounding soils. The encasement pipes are 6-inch diameter Schedule 40 carbon steel. The pipe has a nominal wall thickness of 0.280 inches. A leak detection system is incorporated into the pipeline design to provide an alarm in the event of a leak from the carrier pipe. The exterior of the encasement pipe is coated with a factory applied fusion bonded epoxy (FBE). The FBE coating is a primary method of corrosion control by isolating the pipe steel from contact with the soil. Specifications for the coating and its application are described in Bechtel documents 24590-WTP-3PS-PX04-T0001 and 24590-WTP-3PS-PX04-T0004. The specification for the WTP recognized that the FBE would not be 100 percent effective and called for the installation of

cathodic protection to supplement it. Details of the Bechtel's plan for cathodic protection are described in their documents 24590-WTP-3PS-EQ00-T0002 and 24590-WTP-3YD-CPE-00001.

The drawings 24590-PTF-M6-PWD-P0057 and -P0058 identify the transfer pipelines that are the subject of this report. All of the pipelines shown on these drawings are within the scope of this report. The three transfer lines from the Hanford Tank Farms to the Pretreatment Facility in the WTP (FRP-PZ-01749-W62F-03, FRP-PZ-01750-W62F-03, and FRP-PZ-01751-W62F-03) are not the subjects of cathodic protection discussed in this report and as described in the cathodic protection engineering specification. This report considers the metallic pipe that makes up the transfer piping at the WTP. It does not address any FRP piping nor does it address any steel piping that is isolated from the soil environment by encasement in high-density polyethylene.

The compatibility of the carrier pipe with the wastes being transferred inside it is not the subject of this report. That compatibility is the responsibility of others. Any corrosion that might occur in the annular air space between the carrier pipe and the encasement pipe should be minimal to nil but that compatibility evaluation is also the responsibility of others.

This report is to evaluate if the FBE coating and cathodic protection system make the encasement pipe compatible with the soils at the site.

A detailed description of the make up of the piping network at the WTP is described in the following Bechtel documents:

24590-BOF-3PS-CE0I-T0001
24590-WTP-PER-J-02-002
24590-PTF-M-02-003
24590-WTP-PER-PL-02-001
24590-WTP-3PS-NWPO-T0001
24590-WTP-3PS-PB01-T0001
24590-WTP-3PS-PS02-T0001
24590-WTP-3PS-PS02-T0002
24590-WTP-3PS-G000-T0002

Soil Environment

To evaluate the relative corrosion performance of metals in different soils a number of properties of the soil are evaluated. The principal properties evaluated are outlined in WAC 173-303–640(3)(a)(iii)(A)(I-VIII) and include:

(A) Soil moisture content
(B) Soil pH
(C) Soil sulfides level
(D) Soil resistivity
(E) Structure to Soil Potentials
(F) Influence of nearby underground metallic structures
(G) Existence of stray electric currents

(H) Existing corrosion protection methods

The moisture content of soils at the WTP site varies seasonally between 2-4 %. The pH of the soils measured at the site ranged from 5.84 to 7.94 with an average of 6.88. Sulfates and chlorides measured at the site were below detectable limits or below any threshold that would impact corrosion of carbon steel. In-situ soil resistivity ranged from 14,300 to 143,000 ohm-cm with an average of 61,300 ohm-cm. Laboratory testing indicated resistivity between 61,000 and over a million ohm-cm. The site for the WTP is near the Hanford 200 East area and stray current is a consideration from the cathodic protection system for the tanks there as well as the pipelines from there to the WTP. Moreover other steel and ductile pipelines adjacent to the waste transfer pipelines are to be cathodically protected and provide another source of stray current. A summary of all the soil properties is tabulated and discussed in the Shannon & Wilson Report WTSC99-1036-42-17.

The "design" compatibility report evaluated these soil properties and concluded that corrosion of the coated encasement pipe by interaction with these soils would likely be very low. However the report also recognized that the construction process is not perfect and the potential for setting up of small localized corrosion cells was possible with much higher corrosion rate. The local cells can be setup by welding of the pipe joints, connection of copper test and bond wires, contact with foreign objects inadvertently left in the trench, etc.

Many other conditions at the site could lead to corrosion for the intra plant-piping network at the WTP site. The encasement pipe as specified is alloyed carbon steel creating the initial anode / cathodes cells resulting in some general corrosion even in these soils. The FBE coating specified is an excellent coating and even with the tight quality control used in installing the waste pipelines will still likely have some holidays that could go undetected. Further the coating experienced some nicks and scrapes during installation, most of which were found by holiday testing and coating repairs made. However some of this damage may have went undetected.

Also the piping was inter-tied with valves, pumps, leak detection probes, etc which are made up of different metals creating galvanic couples. In my opinion the heat shrink applied to the weld joints cannot fully match the quality achieved at the factory. Further the piping in the WTP may pass under roads or paved areas in one area while in other areas in may be under native soil. Areas under the paved areas will have reduced moisture content and lower aeration content than the native soil areas. The encasement pipe for the waste transfer pipelines clearly will experience corrosion by interaction with the soil environment.

As a result the design compatibility report agreed with Bechtel's plan to install cathodic protection considering the nature of the waste being transferred and the 40 year design life for the plant.

Discussion

The determination if a structure is compatible with its environment depends on what the corrosion rate is and how long the owner plans to use the structure. Moreover it depends on what would be considered to be a failure of the structure i.e. collapse, leak, etc.

The soil conditions at the WTP described above would be classified as only mildly corrosive to carbon steel. The Table below was published over thirty years ago as part of the National Association of Corrosion Engineers (NACE) Basic Corrosion Course. It is intended to be a guideline of possible corrosion in homogenous soil.

Rough Indications of Soil
Corrosivity vs. Resistivity

Ohm-cm	Description
Below 500	Very corrosive
500-1,000	Corrosive
1,000-2,000	Moderately corrosive
2,000-10,000	Mildly corrosive
Above 10,000	Progressively less corrosive

If you were to use it as a guide for the WTP it suggest that you would expect very little corrosion of buried metals at the site. However, since the resistivity at the site is not homogenous but rather is heterogeneous, the different corrosion cells created by different resistivities at the site will increase corrosion above that indicated by the above table. The pipeline original design called for a special backfill material called Controlled Density Fill (CDF) to be placed immediately around the buried pipeline. This material would minimize the corrosion cells caused by the heterogeneous nature of the soil in contact with the pipelines as well as the migration of moisture to the lines. The original design was changed to have a different backfill material, Dritherm, placed around the pipe at the exit and entrance to each building. Both backfill materials have high resistivities and reduce migration of moisture to the pipes. However the use of two backfill materials creates new corrosion cells between pipe in the CDF and pipe in the Dritherm.

A NACE publication "Corrosion Data Survey" has compiled empirical historical data on corrosion rates of carbon steel in various soil resistivities. From this information we find a range of corrosion rates for the resistivity at the WTP. Corrosion rates could be as little as 2 mils per year to as high as 10 mils per year. If this relative guide were used we would expect serious damage from anywhere between 15 to 70 years. Since most of the resistivity data is well above the 10,000 ohm-cm level it is more likely closer to the 70 years than 15. However this determination of corrosion rates is subjective based on the experience of the corrosion engineer. Neither use of this approach nor the table above provides a satisfactory way for determining compatibility of the piping network at the WTP site.

If it were known the metals were buried in a homogenous soil then laboratory testing could be conducted to determine a more objective prediction of corrosion rates. The laboratory approach would be to complete a linear polarization curve to determine the polarization resistance. Then, that data would be combined with an electrochemical constant and the surface area of the test sample in equations that results in corrosion rates in mils per year. However we don't have uniform soils at the site and this approach is not possible either. Moreover the pipelines on the site will be subjected to some increased corrosion as indicated by the other corrosion

consideration noted above. The corrosion impact of these factors would be left out of any corrosion rate calculation.

The determination in this case as in most soils leaves the expected corrosion rates determination to a subjective determination of a corrosion engineer based on his experience. This is unsatisfactory for this site considering the planned activity of the DOE at the WTP.

Even if a corrosion rate for the WTP site could be defined, the other information needed to determine the pipe-soil compatibility is the planned life of the pipelines. The amount of waste to be processed at the WTP and the time needed to process the waste are now just estimates. Considering that the time required to process the waste may be longer than estimated use of the plant may be longer than the planned life of 40 years. Moreover estimates are based on specific waste streams but other waste streams may be added later. Therefore with only a rough indication of corrosion rate in these soils and with only an estimated life of 40 years in my opinion without corrosion mitigating measures the waste pipelines would not be considered compatible in this environment.

The methods available to mitigate corrosion cells include the following:

1. Remove or insulate the electrical path between anodes and cathodes
2. Change or treat the soil
3. Isolate the pipe from the soil.
4. Apply anodic or cathodic protection

The first two approaches are not practical for any buried piping network. The most common method of accomplishing the third approach is to apply a non-conductive coating to the pipeline surface. A good coating system effectively isolates nearly all the pipe from the soil. However pinholes and holidays will exist in most coatings and some metal will remain in contact with the soil. Some corrosion can be expected to continue. Anodic protection is impractical for a buried pipeline system. A correctly designed and operated cathodic protection system will effectively mitigate <u>all</u> corrosion on the pipeline by sacrificing another material (anode) that is remote from the metal surface. With an effective cathodic protection system installed at the WTP, there would not be any corrosion of the pipeline and it would be considered compatible with the soil.

Applying cathodic protection to a bare steel pipeline would have resulted in high installation cost and high operating expenses. Good corrosion engineering practice is to apply a coating to the pipeline and also install cathodic protection. The cost of installing and operating a cathodic protection system for a coated pipeline is 5% or less than that required for a bare pipe. The cathodic protection system for a coated pipeline is protecting just the pinholes or holidays in the coating that comes in contact with the soil. The WTP plan calls for this approach of applying cathodic protection to a coated piping network. This plan for the WTP piping is good engineering practice. The question remains is does the coating system specified and the cathodic protection specified adequate to make the pipelines at the WTP compatible with the site soils?

The design compatibility report on the cathodic protection system design determined the design should be more than adequate to mitigate all corrosion on the waste transfer pipelines. The design was completed by experienced corrosion personnel and reviewed by a corrosion expert.

Interim and Future Compatibility

This interim compatibility report is being prepared because of a slow down of construction activity on the WTP site. The slow down in construction is because a number of plant design reviews are underway.

While total work at the site slowed down during 2006 work continued on the RAD waste transfer pipelines. On my last site visit in November 2006 the majority of the RAD lines were installed and buried. In the area between the HLW building and the PT building the lines were all welded and awaiting a decision to backfill. Two sections of the lines from the HLW and the PT were awaiting a decision on the factory applied heat shrink prior to backfill. The delay in backfilling the lines from the LAW in this area are waiting approval of the slope of the lines. These questions should be resolved by late January or early February 2007 and the lines backfilled in March or April 2007.

I have been advised that once the RAD waste pipelines are buried that work on the cathodic protection system will be suspended until construction is again ramped up. Currently nearly all underground portions of the cathodic protection system have been installed along with the RAD waste lines. These portions of the cathodic protection system installation includes: anodes, reference electrodes, bond wires, negative bond wires, test wires, anode header cables, etc. At this time all wires have been protected in PVC sleeves and are buried below grade. Each of these locations has been surveyed so they could be located for connection to rectifiers or test stations at a future date.

I have monitored the installation of RAD waste pipeline and related cathodic protection system since January 2004. My observations lead me to conclude that BNI completed the installation of the RAD waste lines and cathodic protection system in full compliance with the design specifications. Those items monitored related to corrosion of the pipelines included: Procurement of cathodic protection hardware, application of heat shrink to weld joint, holiday testing, attachment of bond and test wires, placement and installation of anodes, placement and installation of reference electrodes. Installation of these items was documented by BNI quality program. In addition the installation was monitored daily by a third party engineer, Caliber, Inc.

It is my opinion that BNI has done a very good job of installing the RAD waste pipelines and the buried portion of the cathodic protection system. However at the time of the writing of this report the RAD waste pipelines <u>are not</u> compatible with their environment. They will only be considered compatible with their environment when the cathodic protection system is completed and energized. The pipelines are now experiencing active corrosion.

I have not been advised of when the suspension of work on the cathodic protection system will begin or how long the suspension will last. However a delay of any length has the potential of causing serious corrosion damage to the pipelines. Some portions of the pipelines have been buried since midyear 2004 and are already experiencing some corrosion activity.

It is common practice in the pipeline and other industries to energize a cathodic protection system as soon as possible following installation of the pipeline. Indeed several federal and state regulations specify specific time limits for energizing cathodic protection systems. The Federal Department of Transportation in Parts 191 and 192, Title 49 of the Code of Federal Regulations (CFR) governing natural gas pipelines directs operators to "install and place in operation within one year after completion of construction" a cathodic protection system. A similar regulation in the CFR Title 49, Part 195 governing oil pipelines has the same requirement to energize the cathodic protection system within a year of the completion of construction. The federal Environmental Protection Agency and the Washington State Department of Ecology regulations governing underground storage tanks and this project does not provide a specific deadline but implies a cathodic protection system should be energized immediately following construction.

All three of these regulations recognize that corrosion / corrosion control is not a precise engineering discipline and some subjective decision making may be made by a "corrosion expert". These decisions include the decisions if cathodic protection is needed and when it should be energized. For this project in the design phase both Bechtel corrosion experts and a third party corrosion engineer agreed that cathodic protection was needed. Moreover the original project schedule called for the cathodic protection system to be energized very quickly following installation of the pipelines. The question now is what are the possible consequences of delaying energizing the cathodic protection systems?

A corrosion engineer might come up with an estimate of how much corrosion that would occur during a delay. It would be up to others to evaluate if that is acceptable for the pipelines in question. The design compatibility report suggested the soil conditions at the site would result in low corrosion rates. An "Underground Fuel Storage Tank Corrosion Study" by W.C. Carlos published in February 1992 by Westinghouse Hanford Company for U.S. Department of Energy tried to identify corrosion rates for buried steel in the Hanford area. Mr. Carlos executive summary indicates the study reviewed 30 tanks that were buried at various Hanford facilities for 9 to 46 years. His findings were that there was little general (rusting) corrosion. He found a maximum pitting rate of 3.5 mils per year. He also found that tanks with cathodic protection had neither general corrosion nor pitting corrosion. However Mr. Carlos cautioned against using the corrosion rates he found to predict corrosion performance for new installations. They should only be used after a careful comparison of the burial condition and the materials involved.

I concur with Mr. Carlos that using his numbers to predict the corrosion rate for a new structure is risky because each trench is unique. The only real conclusion that can be drawn from his study is the corrosion rates for buried metals in the Hanford area are low as was indicated in the design compatibility report. However corrosion rates cannot predict the local corrosion cells that can be created in a number of different ways. A local action cell can be created by a metal tool or part left in the trench jammed against the pipeline. A local action cell could be created if a pipeline shifted during backfilling and the neoprene isolating the pipeline from construction supports slips out. Some local action cells are known to exist on the pipelines themselves with all the copper wires bonded to the pipeline. Corrosion rates in any of these scenarios could be several times those reported by Mr. Carlos.

Considering the above it is the recommendation of this writer that BNI proceed to complete the installation of cathodic protection without suspension. It should be installed at the earliest possible date and energized. The pipelines are not compatible with the soil environment and will not be until the cathodic protection system is energized.

_____ _____

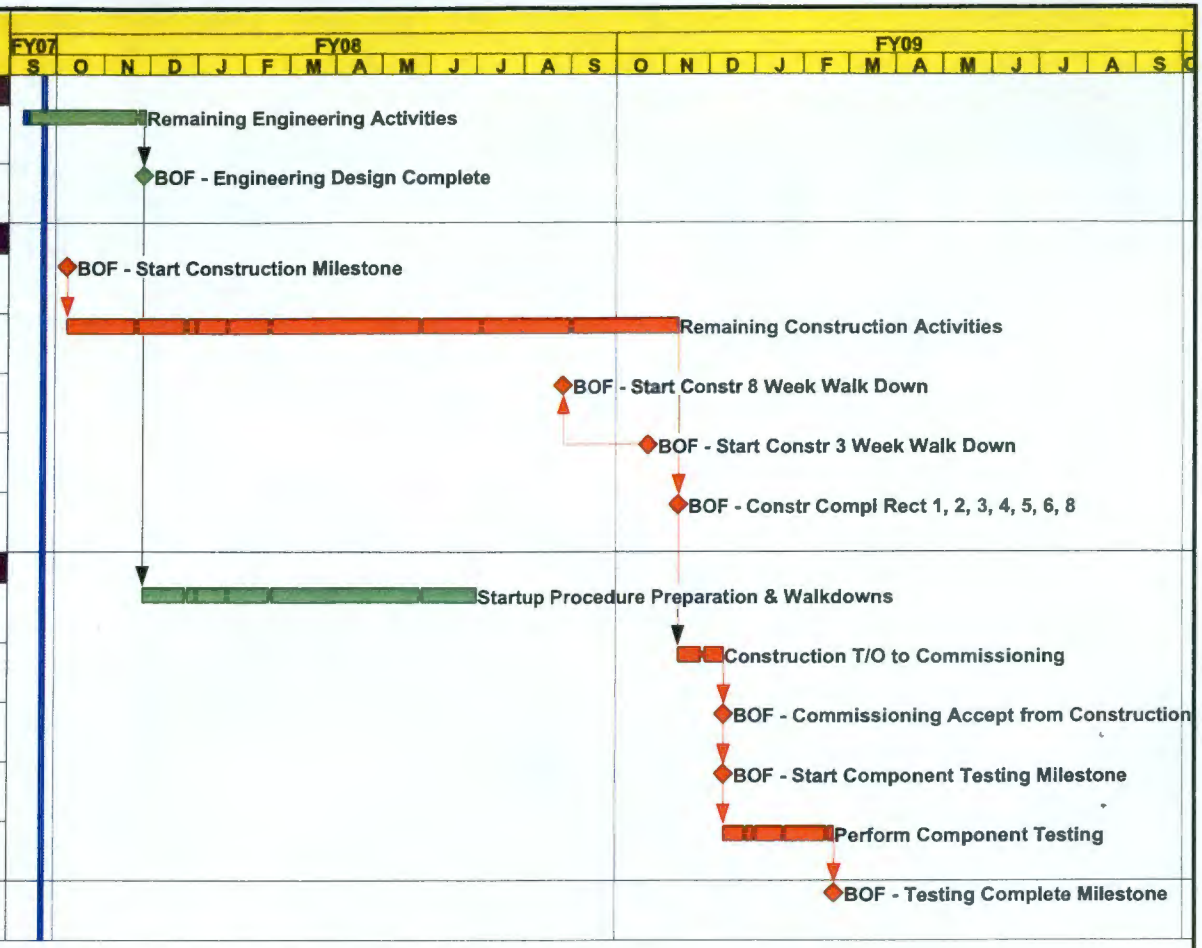
Dennis R. Helgeson, P. E.
Corrosion Specialists # 2736

Date

Attachment 2
07-ESQ-181

Schedule for Completing and Energizing the Cathodic Protection System for the Underground Waste Transfer Lines

Activity ID	Activity Description	Early Start	Early Finish
Engineering			
3ESUMMARY	Remaining Engineering Activities	10SEP07A	28NOV07
5HBC1BA0E1	BOF - Engineering Design Complete	28NOV07	
Construction			
5HBC1BA0C1	BOF - Start Construction Milestone	08OCT07	
4BSUMMARY	Remaining Construction Activities	08OCT07	11NOV08
5HBC2BACW0	BOF - Start Constr 8 Week Walk Down	27AUG08	
5HBC2BACW3	BOF - Start Constr 3 Week Walk Down	23OCT08	
5HBC2BA0R1	BOF - Constr Compl Rect 1, 2, 3, 4, 5, 6, 8	11NOV08	
Commissioning			
5HSUMMARY1	Startup Procedure Preparation & Walkdowns	28NOV07	01JUL08
5HSUMMARY2	Construction T/O to Commissioning	11NOV08*	10DEC08
5HBC2BA041	BOF - Commissioning Accept from Construction		10DEC08
5HBC2BA080	BOF - Start Component Testing Milestone	11DEC08	
5HSUMMARY3	Perform Component Testing	11DEC08	20FEB09
5HBC2BA081	BOF - Testing Complete Milestone		20FEB09



Start Date	12AUG07
Finish Date	22SEP09
Date Date	24SEP07
Run Date	26SEP07 14:00

Early Bar
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Critical Activity

ZZZZ

Sheet 1 of 1

WTP Project
Early Energization of the Cathodic Protection System
Rectifiers 1-6 & 8
Summary Schedule

RPP WTP

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