WATER CONSERVATION STUDY FOR CAMP RIPLEY

STATE PROJECT NUMBER 15124

For Facilities Management Office
Minnesota Department of Military Affairs

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Consultant's Report

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I. INTRODUCTION

The goal of the Water Conservation Study for Camp Ripley is to provide recommendations to conserve water, reduce surface water and wastewater discharge to the Mississippi River. Primary tasks of the Study include:

- Review of certain sewer and water services to reduce the number that need to remain running throughout the winter to prevent services freezing.
- Provide analysis for installing water meters in 18 buildings.
- Study installing a meter monitoring system for a number of buildings.
- Provide recommendations to detect and reduce water lost from system leaks.
- Review the Camp wells and provide recommendations on condition and potential savings.
- Evaluate the Cantonment stormwater system and provide recommendations to reduce the discharge to the Mississippi River by capturing the runoff from a 1.5 inch rainfall event.
- Develop options for reuse of 50% of the effluent from the Wastewater Treatment Plant.
- Evaluate the Area 17 wash rack water reclamation system.
- Investigate reuse of water for irrigation purposes.

Following is a discussion of the results of the Study.

II. WATER CONSERVATION

A. Water and Sewer Service Line Assessment

In the winter, several building water services are left running to prevent freeze-up of either the water service or sewer service. This water waste can be eliminated or substantially reduced by replacing the services deeper or insulating them to prevent freezing. The buildings discussed by this study include:

Recommended Upgrades

In this region of Minnesota, watermains and water services are typically buried to a minimum depth of 8 feet to top of pipe to prevent freezing. Due to temperature and flow variability, there is no single recommended bury for sanitary sewer mains and services. Due to the low flow of sanitary sewer services within the Camp, a minimum depth of 8 feet to invert is recommended. Pipes may be installed or maintained shallower in certain circumstances if appropriately insulated.

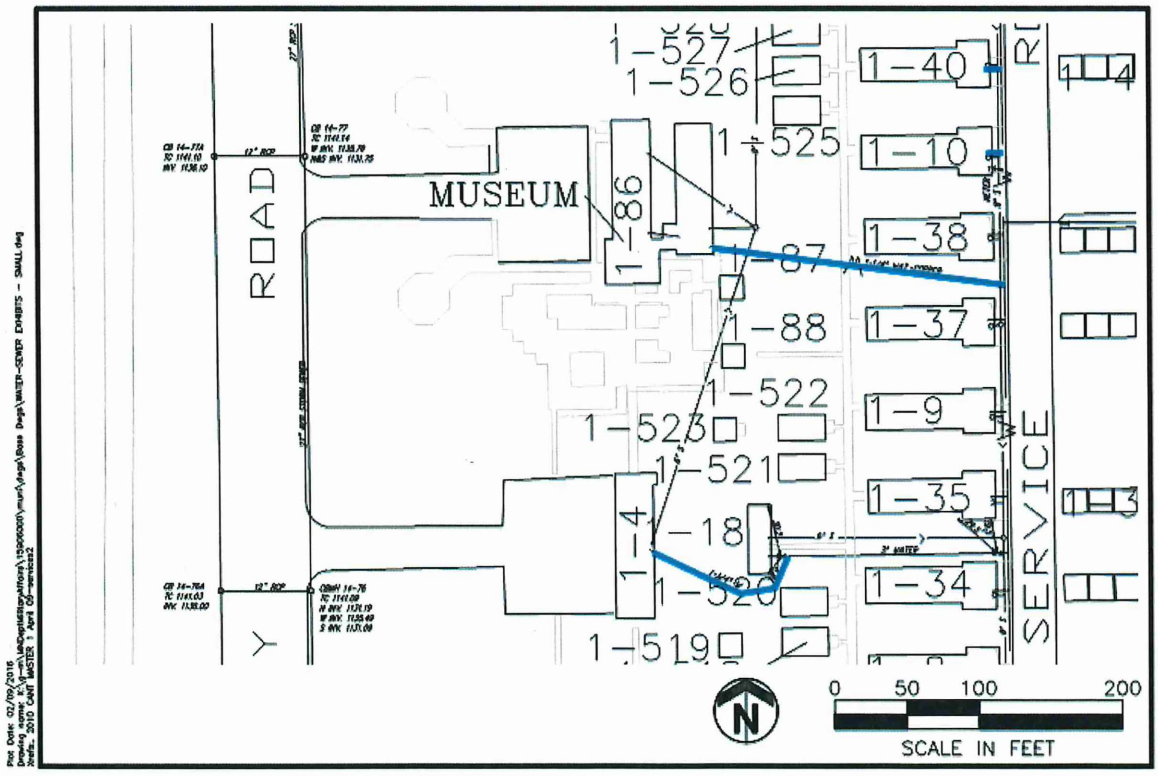
Several pieces of information were considered to identify problems and develop solutions. Descriptions provided by the Camp and discussions with Camp personnel guided the investigation. Information provided on the Camp base map was used to determine sanitary sewer depths at manholes in many locations and LIDAR data was used to check ground surface elevations. A site visit was performed including inspection of visible features, use of electronic locating equipment and measuring the depths of gate valves. Interference from buried objects and other utilities with the locating equipment prevented collection of this information except for eight services. These are noted in the descriptions below.

Following is a description for each subject building and recommended action to address the problem.

1. **Building 1-4** – Water Service - The service for Building 1-4 is a shared service with Building 1-18. The service line for Building 1-18 is a 3" diameter service from the East Service Road watermain approximately 150' to the west. This portion of the service line was electronically measured at 6'-8" to 7'-8" of depth. This portion of the line is believed to have sufficient cover because there have been no reported freeze-ups to Building 1-18.

   The 1-1/4" service line for Building 1-4 is connected to the 3" service to Building 1-18 on the east side of building 1-18 and runs around the south side of Building 1-18 to Building 1-4. Electronically measured depths of the 1-1/4" service line were as follows: around the south east corner of Building 1-18 measured between 5'-5" to 6'-6", around the southwest corner of Building 1-18 was 8'-2", and 24' east of Building 1-4 was 7'-2".

   <u>Recommendation</u> – Lower the 1-1/4" water service line along the existing alignment from the connection with the 3" service line for Building 1-18 for approximately 90' until an existing depth of 8' is achieved.



2. **Building 1-10** – Water Service - The service for Building 1-10 is less than 10' long from the watermain in the west boulevard of East Service Road to the building. The East Service Road watermain was replaced in 2011 with an 8' minimum cover. It is likely the service freezes when the service comes up to enter the building foundation.

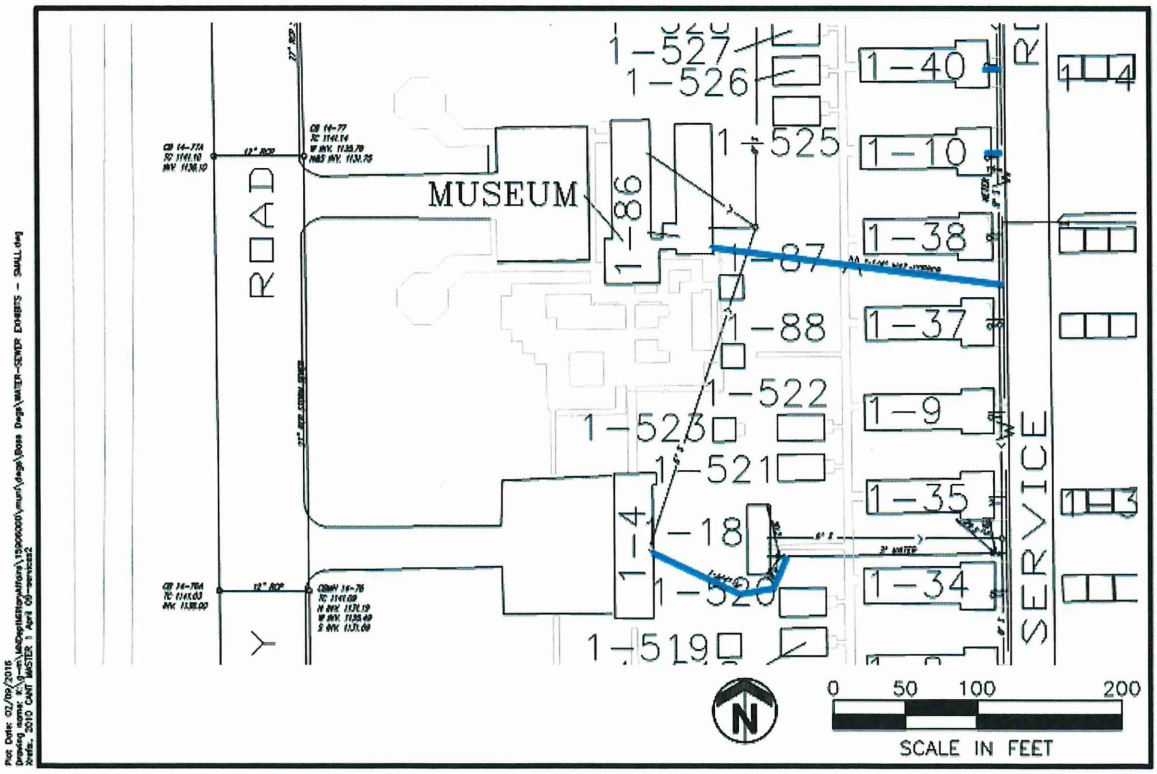
   Recommendation – Expose and insulate the service line from the building foundation to the existing curb.

3. **Building 1-40** – Water Service - The service for Building 1-40 is less than 10' long from the watermain in the west boulevard of East Service Road to the building. It is likely the service freezes when the service comes up to enter the building foundation.

   Recommendation – Expose and insulate the service line from the building foundation to the existing curb.

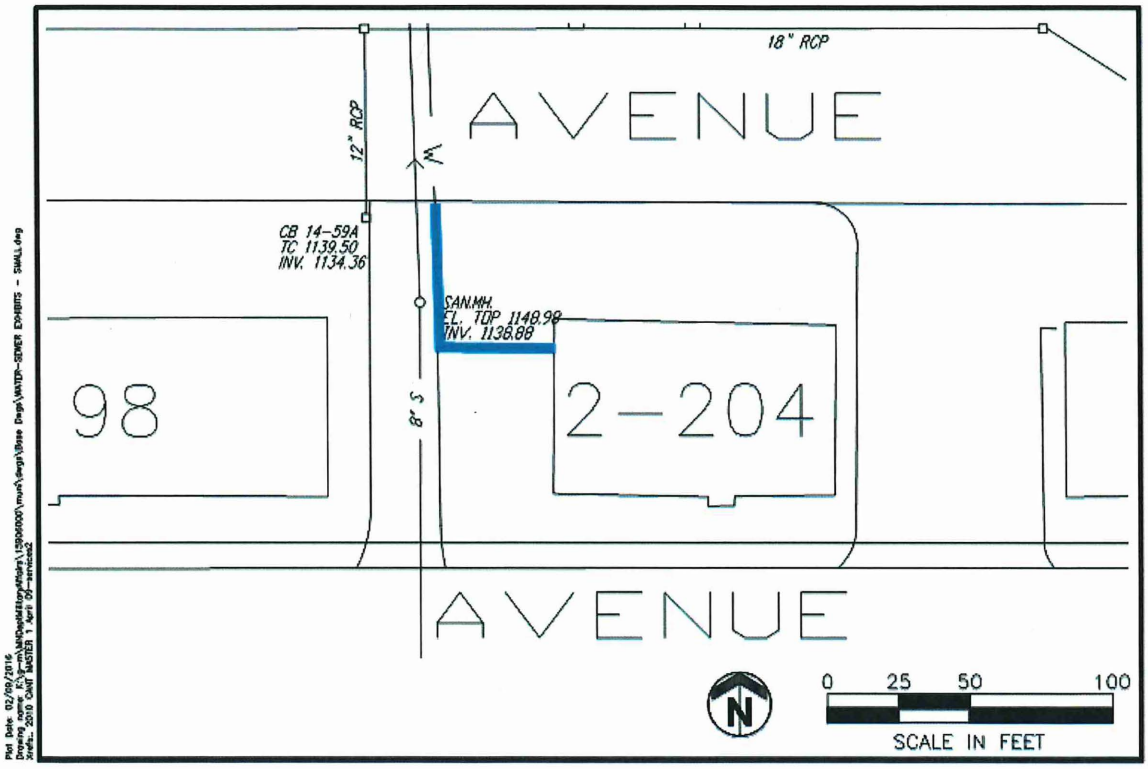
4. **Building 1-86 (Museum)** – Water Service - The 1-1/4" water service for Building 1-86 is approximately 190' long from the East Service Road watermain to building 1-86 and has been reported by Camp personnel as "shallow". Electronic depth location was unsuccessful due to the length of the service and interference with other underground utilities.

   Recommendation – Lower the entire 190' length of 1-1/4" service from the East Service Road watermain to Building 1-86.



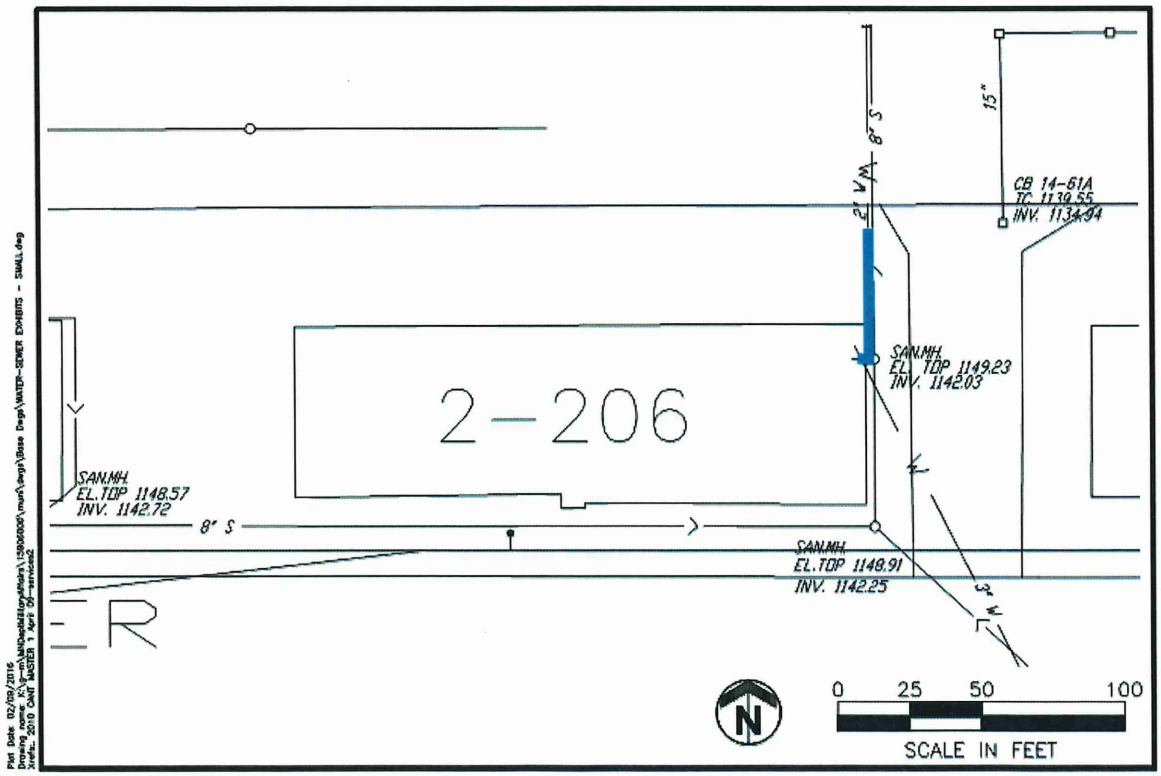
5. **Building 2-204** – Water Service - The 1-1/4" water service for Building 2-204 extends from the watermain in the north boulevard of Bettenburg Avenue south across the roadway, turns east and enters the west side of the building. This service has been reported as "shallow" by Camp personnel and has been kept running every year. Electronic depth location was unsuccessful on this service. The water line was observed during Phase 1 & 3 Road and Utility Infrastructure Improvements, but the on-site inspector made no notes about the line being shallow at the sewer crossing in the north half of Bettenburg Avenue. If the service line is shallow, it is likely shallow south of the sewer line in Bettenburg Avenue to Building 2-204 under the paved boulevard.

   Recommendation – Perform exploratory excavation, starting at the building and extending to the curb line. If the line is found to be shallow, provide insulation or lower service to provide 8' of cover.



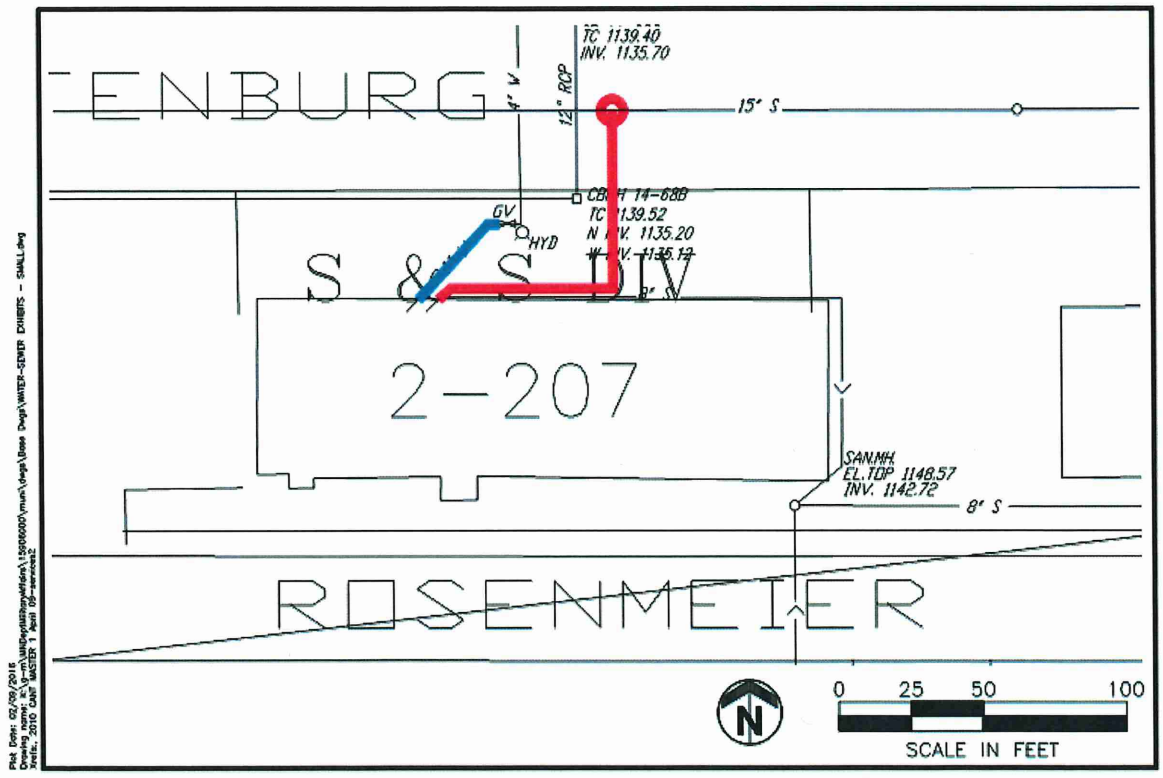
6. **Building 2-206** – Water Service – The 2" water service for Building 2-206 extends from the watermain in the north boulevard of Bettenburg Avenue south across the roadway, turns west and enters the east side of the building. This service has been reported as "shallow" by Camp personnel and has been kept running every year. Electronic depth location was unsuccessful on this service. The water line was observed during Phase 1 & 3 Road and Utility Infrastructure Improvements, but the on-site inspector made no notes about the line being shallow at the sewer crossing in the north half of Bettenburg Avenue. At the northeast corner of Building 2-206 the service continues on to serve other nearby buildings whose services were not reported as "shallow" by Camp personnel and not listed as having its water run. If the service for Building 2-206 is shallow it is likely shallow near Building 2-206 south of the sewer line in Bettenburg Avenue under the paved boulevard.

   Recommendation – Perform exploratory excavation, starting at the building and extending to the curb line. If the line is found to be shallow, provide insulation or lower service.



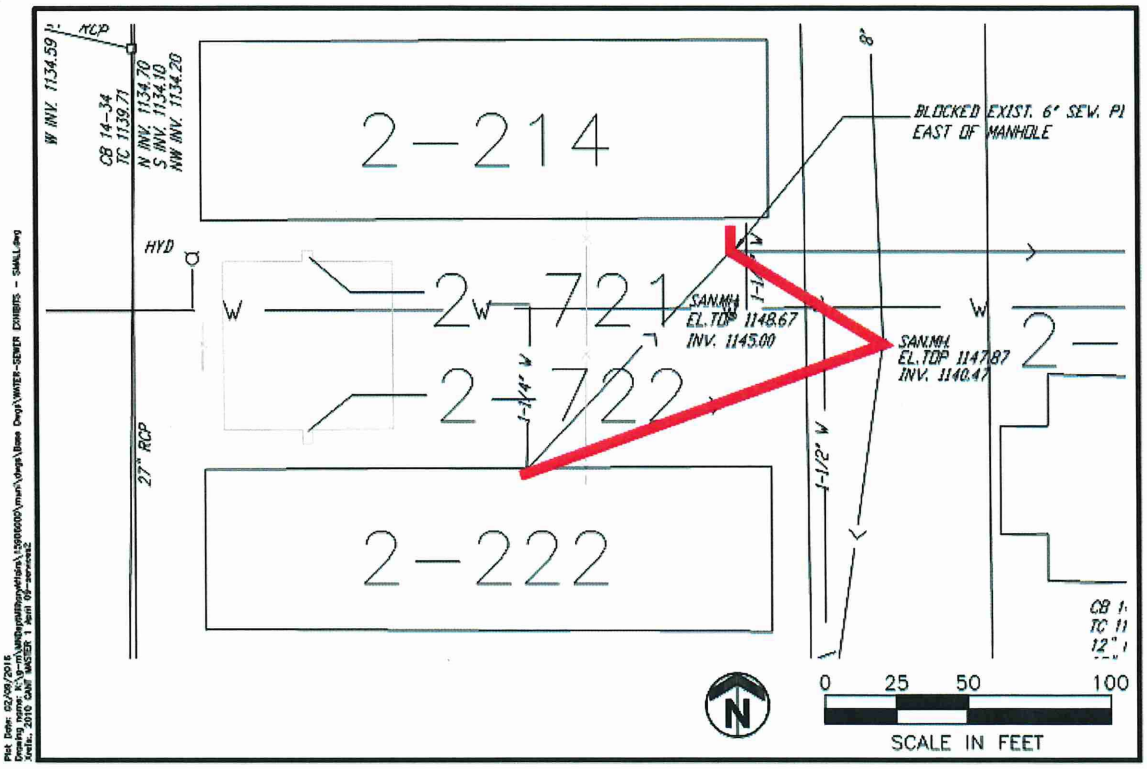
7. **Building 2-207** – Water Service & Sanitary Sewer Service – The 1" water service for Building 2-207 extends from the 4" hydrant lead located on the north side of the building. The 8" sewer service exits the building on the north side, runs east to the east side of the building and then runs south to a manhole near the southeast corner of the building. This manhole is 5.8' deep and also receives sewage flow from Building 2-211. Building 2-211 has no noted problems. Camp personnel have reported that Building 2-207's water and sanitary sewer services are "shallow".

   Recommendation – If the hydrant on the north side of the building has no known history of freezing problems, the 1" service line should be lowered between the building and the hydrant lead. The portion of the water service line that connects to the hydrant lead and the portion of the service line near the building should be insulated. The sanitary sewer service should be reduced in size to a 4" and directed north to MH 3-5 which was installed for the sanitary sewer in Bettenburg Avenue in 2010. This manhole has sufficient depth (12 feet) to provide a minimum 8' of cover over the sanitary sewer service.



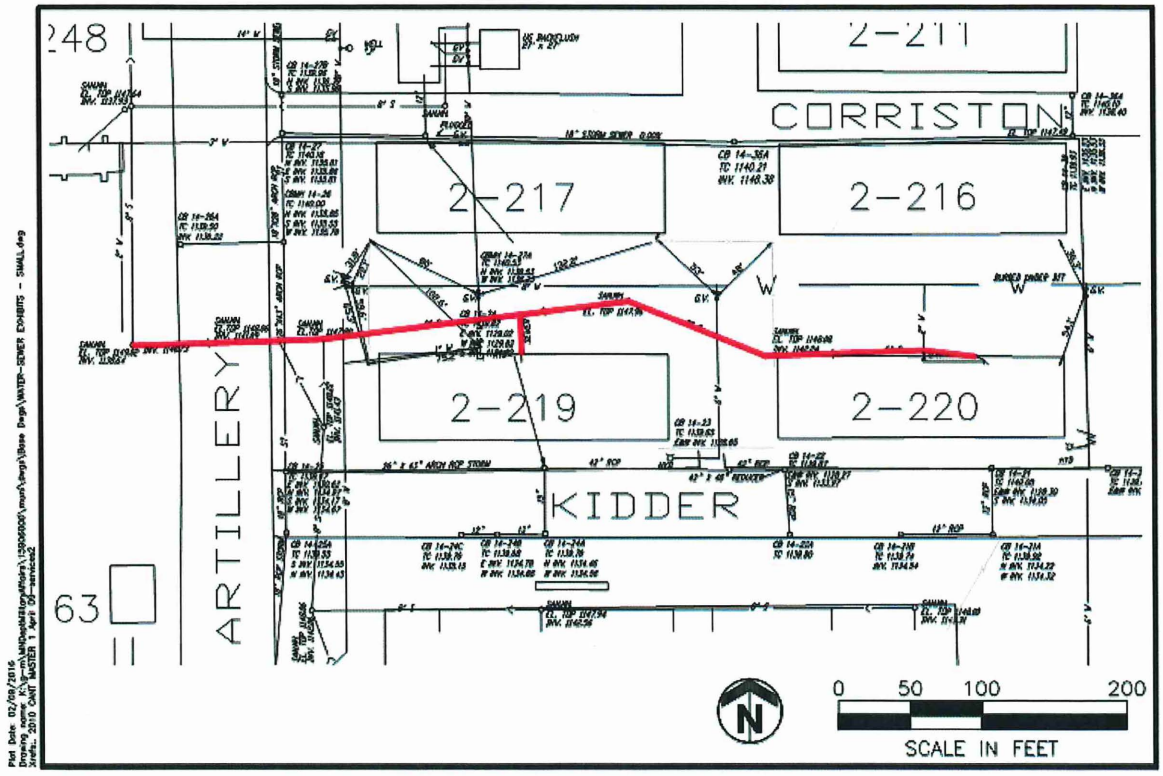
8. **Building 2-214 & Building 2-222** – Sanitary Sewer Service – The sanitary sewer services to these two buildings have been evaluated together because they are serviced by the same sewer main. Both services have been reported as "shallow" by Camp personnel. The sanitary sewer main that both services are connected to flows north and connects to the Bettenburg trunk sewer. The sanitary sewer main has sufficient depth, with manhole depths to invert vary from 8.8' to 7.4' along this line. The services for both buildings come together into the same manhole on the main. Service depths are listed as shallow as 3.6'.

   Recommendation – Lower the entire service for both buildings from the manhole on the sanitary sewer main to each building.



9. **Building 2-219 & Building 2-220** – Sanitary Sewer Service – The sanitary sewer services to these two buildings have been evaluated together because they are serviced by the same 6" sanitary sewer main. Both services have been reported as "shallow" by Camp personnel. The 6" sewer main is located on the north side of the buildings and flows west to Artillery Road. There is a 2' inside drop at the junction manhole in Artillery Road, where the flow heads north towards Bettenburg Avenue. The water service line depth was determined to be adequate with an electronic locator.

   Recommendation – Remove the existing 2' inside drop and replace the sanitary sewer main and service lines from the junction manhole in Artillery Road to Building 2-219 and Building 2-220.

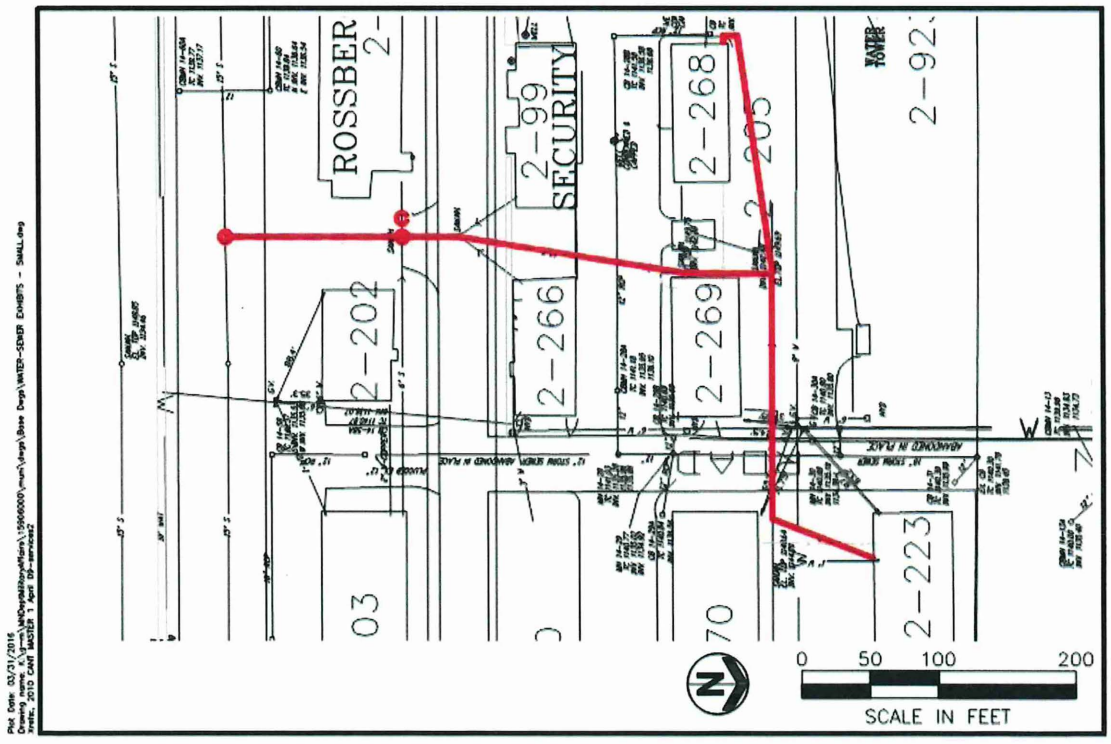


10. Building 2-223 & Building 2-268 – Sanitary Sewer Service – The sanitary sewer service lines for Building 2-223 and Building 2-268 have been listed by Camp personnel as shallow. The Building 2-223 service exits the northeast corner of the building and connects to a manhole off the southwest corner of Building 2-270. This manhole only has 4' of depth. The depth of cover over the service as it leaves Building 2-223 is unknown. Building 2-270 appears to also be served by this sewer, but Building 2-270 has no reported problems.

The Building 2-268 service leaves the building in the southeast corner and discharges to the manhole near the southeast corner of Building 2-269. The depth of cover over the service as it leaves Building 2-269 is unknown.

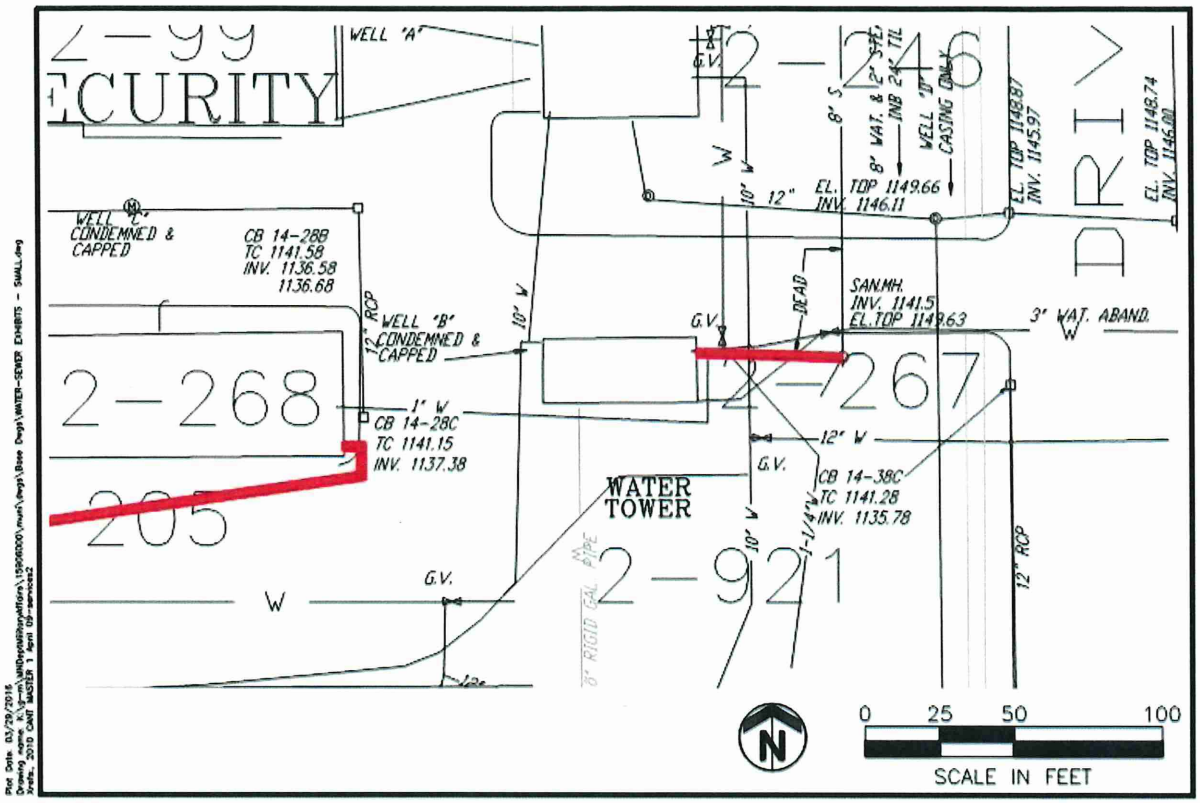
Recommendation – Replace and insulate the dist ' of 6" sewer from Building 2-223 and 215' from Building 2-269 to the existing manhole near the southeast corner of Building 2-269. If it is determined that Building 2-270 is not served by this sewer or does have problems, the replacement and insulation should be continued downstream to where either acceptable depth is reached or to where buildings without problems connect to the line.

Optional Consideration – The sewer main that serves 2-223 is a 6" line that also serves at least Buildings 2-270, 2-269, 2-268, 2-266, 2-99, 2-203, and 2-202. This sewer line passes **under** Rossberg Hall to the main in the west boulevard of Walsh Drive. Passing under Rossberg Hall is of great concern to Camp maintenance personnel. This sewer could be rerouted, starting on the west side of Rossberg Hall north to the trunk sanitary sewer in Bettenburg Avenue. A manhole should be added to the line passing under Rossberg Hall to facilitate maintenance of the line. This sewer replacement also increases the sewer size to 8" sewer line and lowers the service to provide proper cover for the entire line to Buildings 2-223 and 2-268.



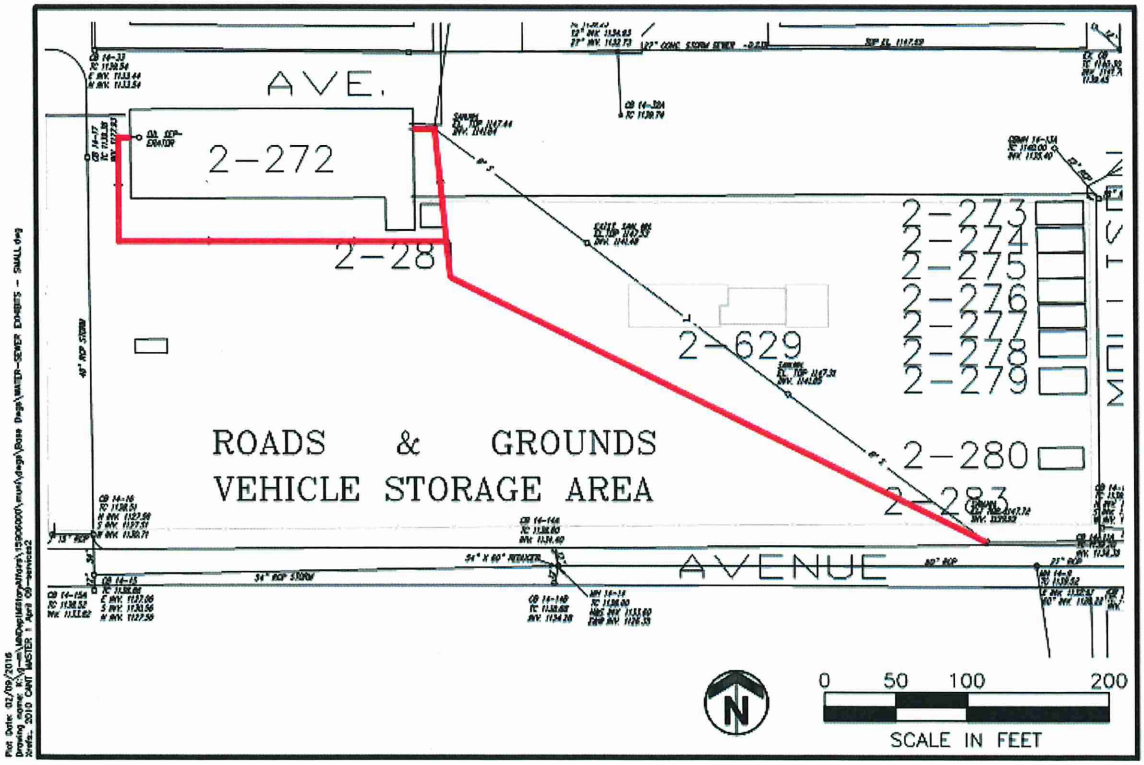
11. Building 2-267 – Sanitary Sewer Service – The sanitary sewer services to this building exits the buildings in the northeast corner and discharges into the 8" sanitary sewer main in the west boulevard of Walsh Drive. Camp Personnel have listed this building as having a shallow sewer service line. The 8" main in Walsh Drive has sufficient depth, approximately 8' deep.

<u>Recommendation</u> – Replace and insulate the sewer service lines from the Building 2-267 to the connection to the sanitary sewer main in Walsh Drive.



12. Building 2-272 – Sanitary Sewer Service – Building 2-272 has two sanitary sewer services that discharge to a main sewer line on the east side of the building. One service exits the building in the northwest corner and heads south, east, then north to the mainline on the northeast corner of the building. The other service exits the building in the northeast corner of the building and connects to the main line. It is believed that the northeast service handles sanitary waste and the northwest service handles the oil/water separator. Camp records indicate that the sanitary sewer mainline flows both north and southeast from the northeast corner of the building

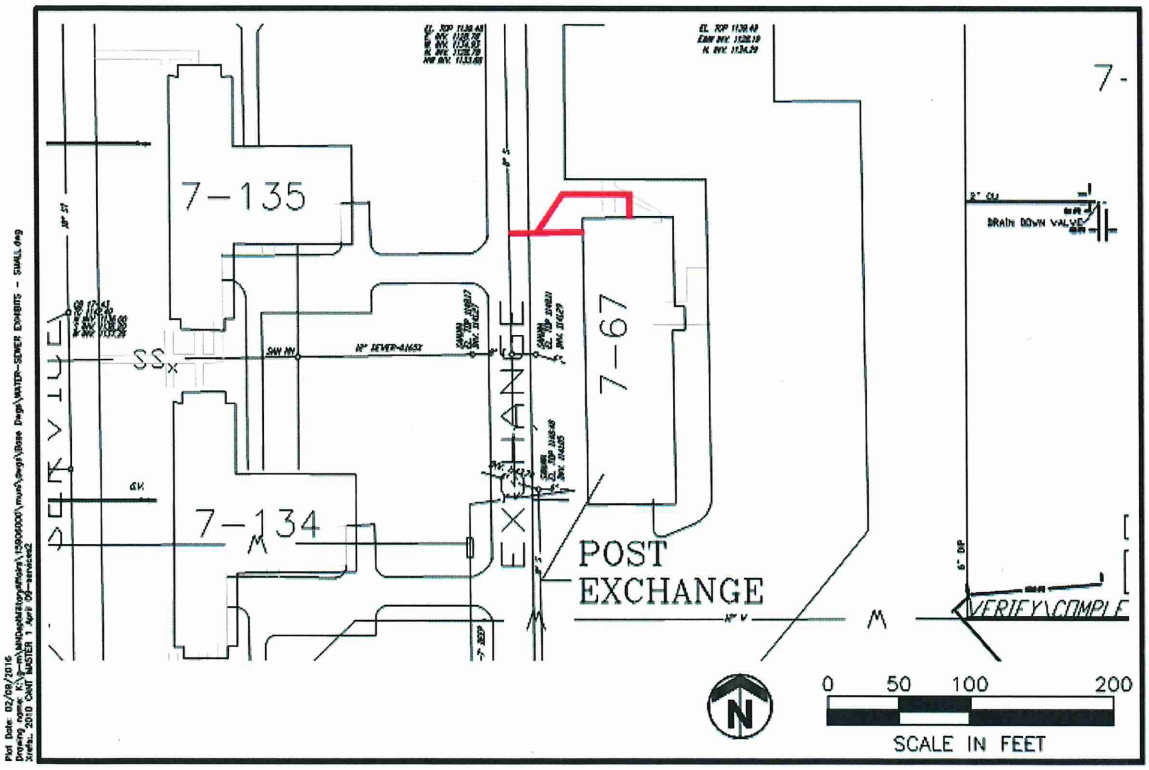
<u>Recommendation</u> – Reconstruct and insulate the service lines on the east, south, and west sides of the building. Replace and insulate the sewer main line starting at the southeast corner of Building 2-272, heading southeasterly approximately 440' to an existing manhole in Leach Avenue. The existing sanitary sewer mainline was steeper than necessary so approximately 1.0' of additional cover can be obtained by installing the new sewer at a shallower grade. Cleanouts and manholes near Building 2-272 must be protected from damage caused by large vehicle traffic especially turning movements.



13. Building 7-67 – Sanitary Sewer Service – Building 7-67 has three sanitary sewer services. Camp personnel have identified the northerly two services as shallow. One northerly service exits the northwest corner of the building and discharges to the west into the sanitary sewer main in East Exchange Road. The other northerly service exits the north side of the building and turns west then southwest and connects to the other northerly service.

The sanitary sewer main in E Exchange Road was reconstructed as part of Phase 2 & 5 Road and Utility Infrastructure Improvements in 2010. The existing 6" sewer service was connected to the deep main with a service rise and then wye'd to the two 4" services.

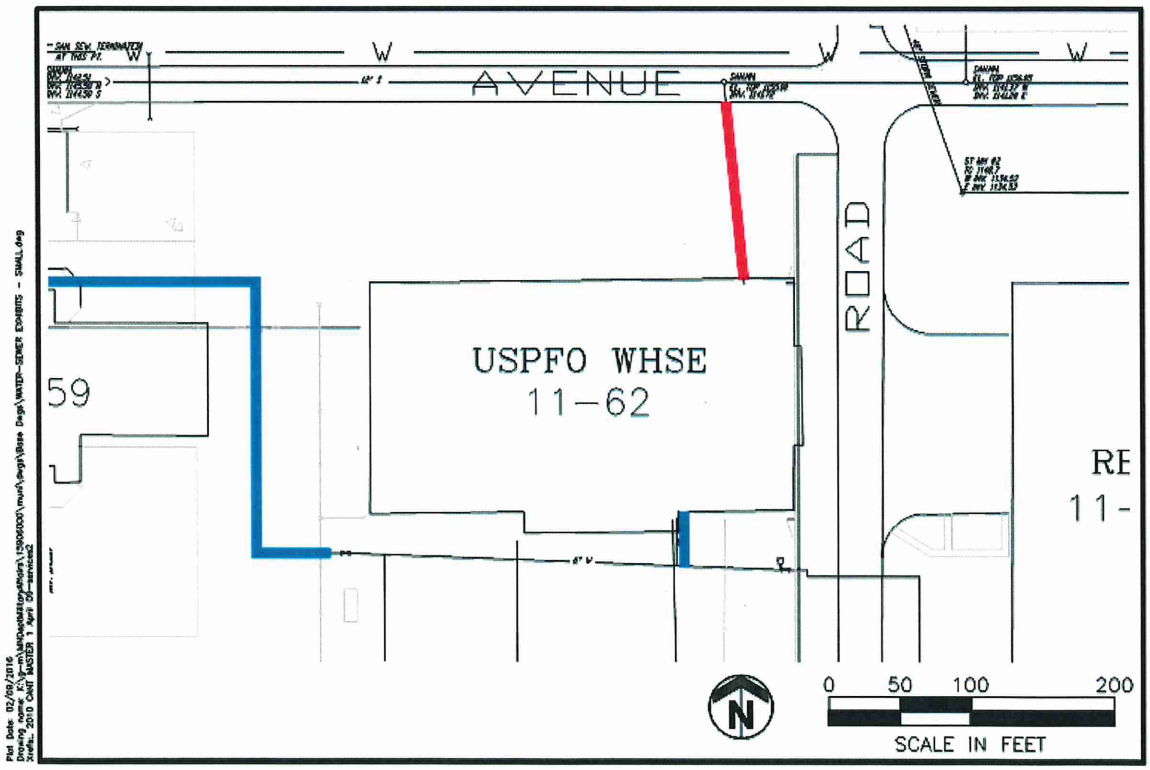
<u>Recommendation</u> – Replace and insulate new service lines at the proper depth, starting at the outside building wall and continuing into the street until the service riser is intercepted. The new service line will be reconnected to the service riser at a lower elevation.



14. Building 11-62 – Water Service & Sanitary Sewer Service – The water service for Building 11-62 is an 8" service on the south side of the building, stubbed off a 6" looped watermain that runs through the parking lot/loading dock area. Nothing is known about the depth of this service. There are no known valves on this service. Historically the water service for Building 11-62 has been left running during the winter; Camp personnel are unsure if this is necessary.

The sanitary sewer service is 6" cast iron pipe located on the north side of the building near the northeast corner. This service was reconnected to the sanitary sewer main that was replaced in Libbey Avenue in 2009 with a drop connection at a manhole. The depth of the sanitary sewer service in Libbey Avenue is about 9', but the depth of the service at the building is unknown.

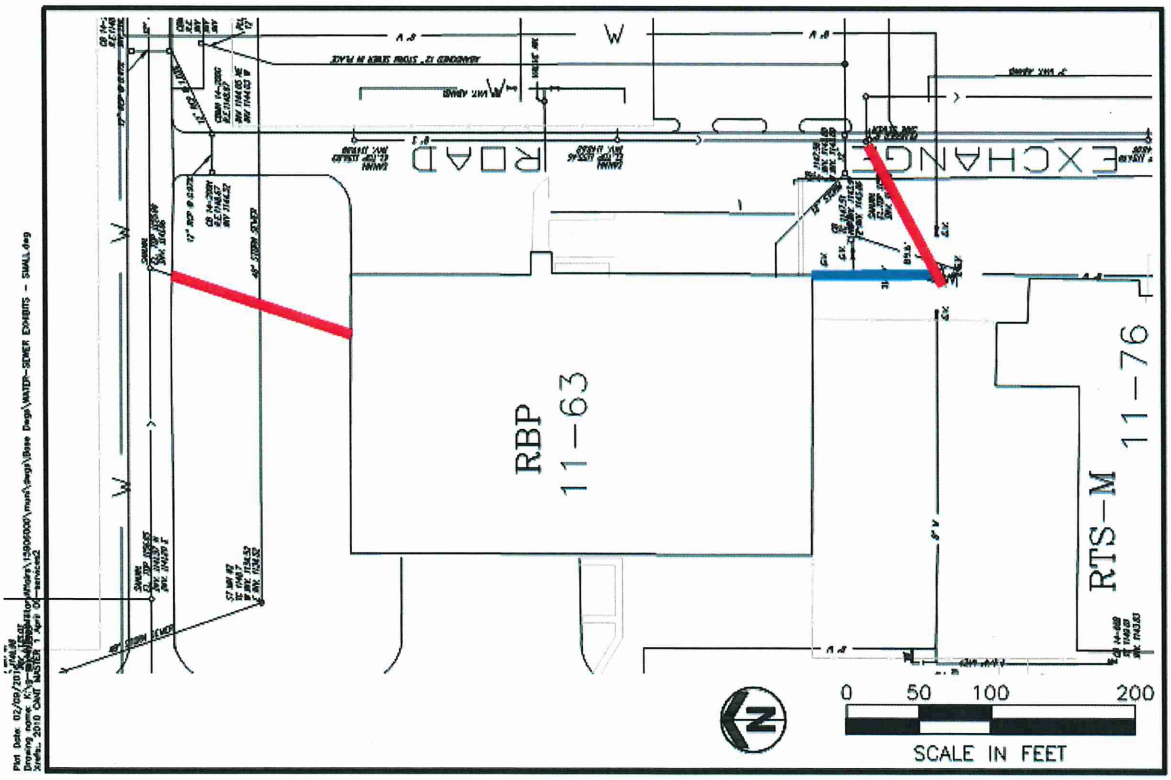
<u>Recommendation</u> – Perform exploratory excavation over the water service and the sanitary sewer service beginning near the building and progressing towards the main lines. If less than 7' of cover on the sanitary sewer service and 8' of cover on the water service is found the lines should be insulated until the recommended cover is achieved.



15. Building 11-63 – Water Service & Sanitary Sewer Service – The water service for Building 11-63 extends from the southeast corner of the building to an 8" watermain south of the building. The water service size and depth are unknown. The 8" watermain is a looped watermain in the yard area south of the building. Historically the water service for Building 11-63 has been left running during the winter. Camp personnel are unsure if this is necessary.

The sanitary sewer service is 6" diameter and exits the north side of the building near the northeast corner. The sanitary sewer service discharges to a sanitary sewer main in Libbey Avenue. The depth of the sanitary sewer service is unknown, but the depth of the sanitary sewer main in Libbey Avenue is about 14 feet.

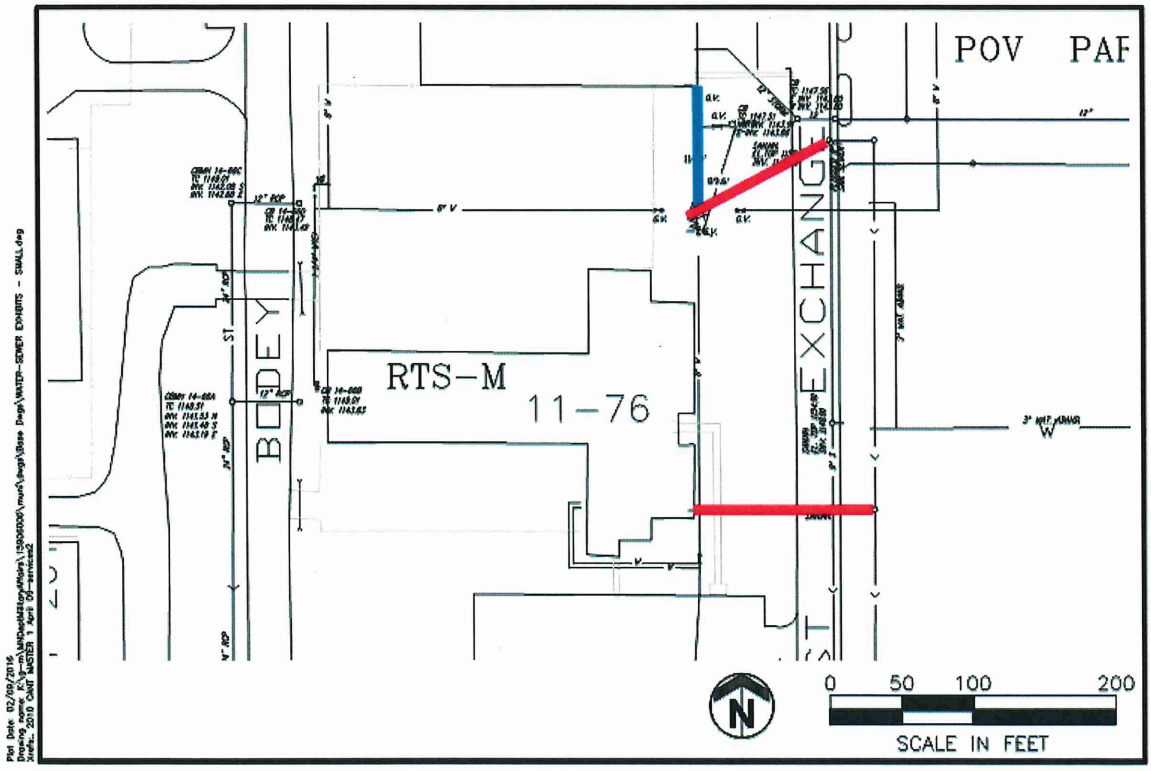
<u>Recommendation</u> – Perform exploratory excavation over the water service and the sanitary sewer service beginning near the building and progressing towards the main lines. If less than 7' of cover on the sanitary sewer service and 8' of cover on the water service is found the lines should be insulated until the recommended cover is achieved.



16. Building 11-76 –Sanitary Sewer Service – Building 11-76 has two sanitary sewer services, which Camp personnel have identified as "shallow sewer". The services exit the building at the northeast and southeast corners of the building and proceed east across W. Exchange Road to the sanitary sewer main in the east boulevard. The depth of the sanitary sewer main is 6.6' to 7.0'. The depth of the services is unknown.

Recommendation – Insulate both services from where they exit the building to the sanitary sewer main.

Optional Consideration – Lower both services and replace approximately 580' of sanitary sewer main to the northwest corner of W Exchange Road and Bettenburg Avenue where a connection to a deep drop manhole is located.



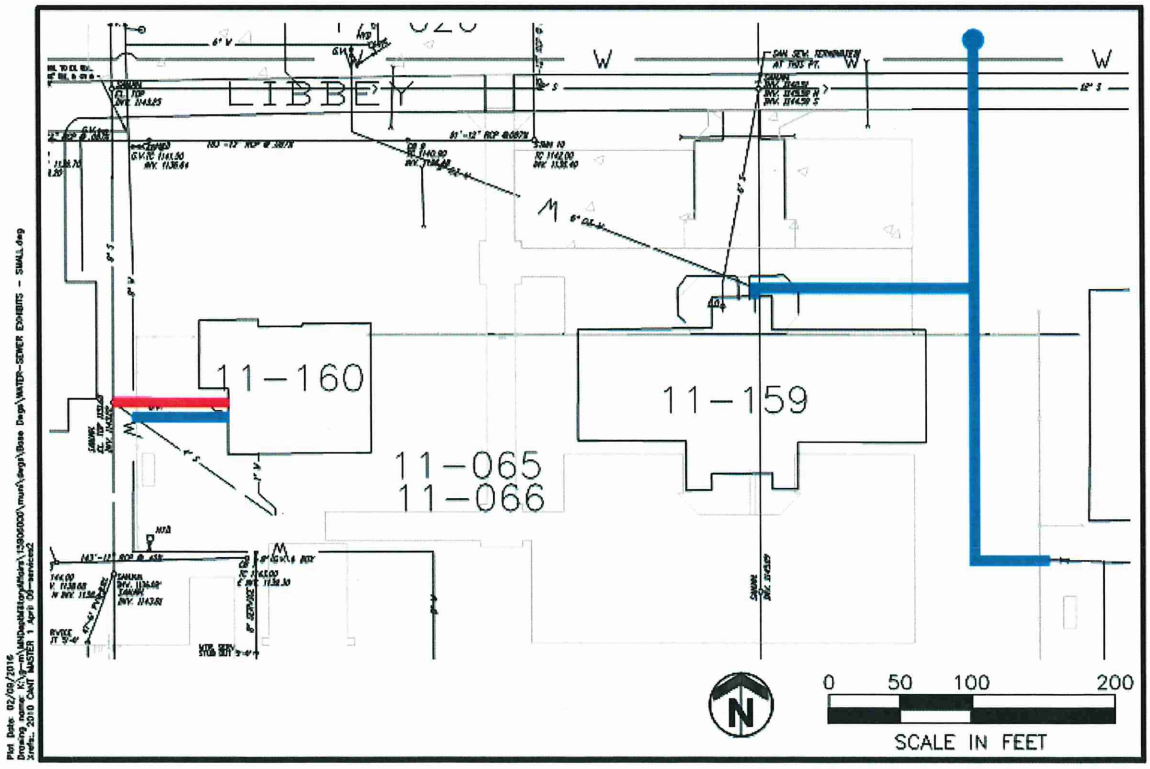
17. **Building 11-159** – Water Service – The water service is a 6" cast iron pipe extending northwesterly from the front entrance of Building 11-159 about 350' connecting to the watermain on the north side of Libbey Avenue. Record drawings indicate the water service only has 5' of cover under Libbey Avenue. The water service has been reported as "shallow" by Camp personnel. The hydrant on the north side of Libbey Avenue has been known to freeze-up as well.

    Recommendation – Remove or abandon the existing 6" cast iron water service and hydrant. Extend a new water service from the hydrant lead located at the southwest corner of Building 11-62 north along the east side of 11-159, and then east along the north side of the 11-159 to its connection point near the building entrance. Insulate the service at the building if necessary.

    Optional Consideration – If the hydrant on the north side of Libbey Avenue needs to be replaced a line can be extended from the northeast corner of 11-159 across Libbey Avenue.

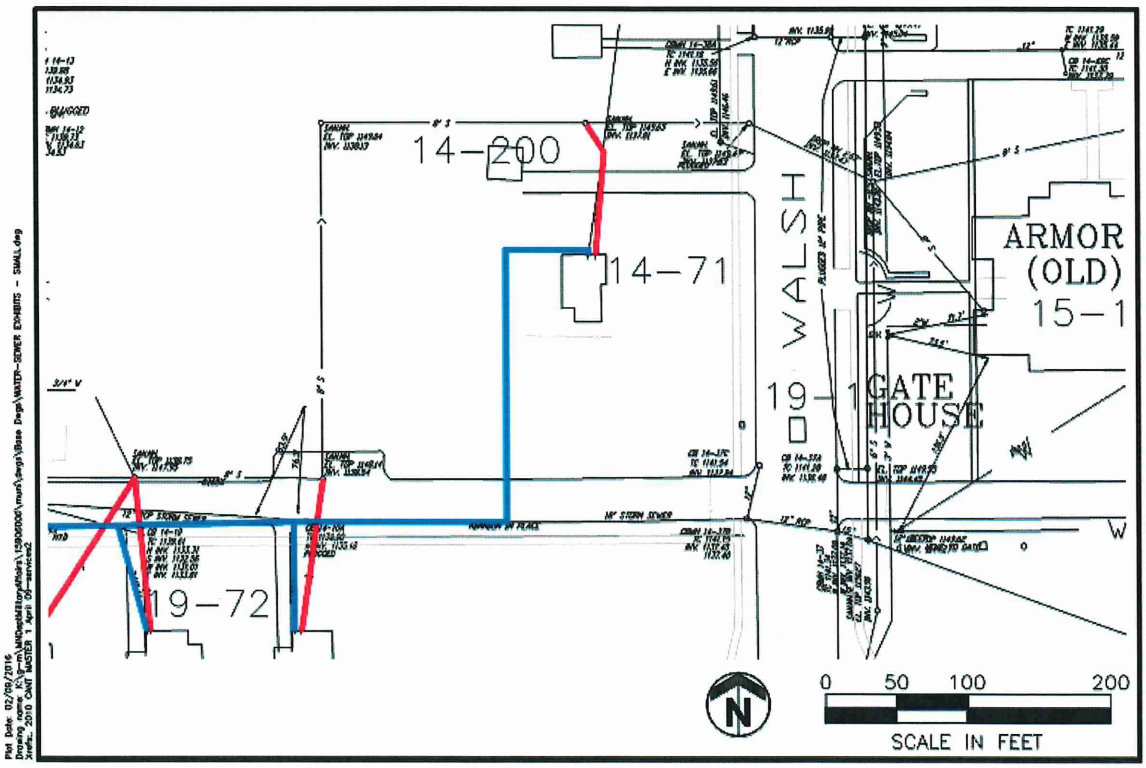
18. **Building 11-160** – Water Service & Sanitary Sewer Service – Both the water and sewer service exit the west side of the building and run west to connections with the main lines. The water service is left running through the winter, Camp personnel are unsure if this is necessary. The 2" water service was electronically located at a depth of 5'-6" for the entire 60' from the building to the main. This is insufficient cover, especially under the paved portion immediately adjacent to the building. The sanitary sewer service connection depth at the main is 8', but the depth at the building is unknown.

    Recommendation – Lower the 2" water service to a depth of 8 feet for the entire length of the service. Insulate the service at the building if necessary. Exposed and insulate the sanitary sewer service from the building heading towards the main until an appropriate depth is achieved. It should be noted that the depth of the 8" watermain west of Building 11-160 is unknown. The Camp may wish to investigate the depth of this watermain also.



19. Building 14-71 –Watermain & Sanitary Sewer Service –This building was added to the project after discussions with Camp personnel. Camp personnel listed this building as having "shallow sewer and water". The sanitary sewer service exits the north side of the building and extends approximately 115' north to a deep sanitary sewer main. The water service exits the north side of the building and extends north. The depth of the water service is unknown.

Recommendation – Replace the sanitary service along the existing alignment at an appropriate depth. Insulate at the building entrance if necessary. Replace the water service with a new service line from the watermain north of Building 19-71 on the south side of Leach Avenue. The water service would cross Leach Avenue and enter the north side of Building 14-71 at the existing water service entrance.

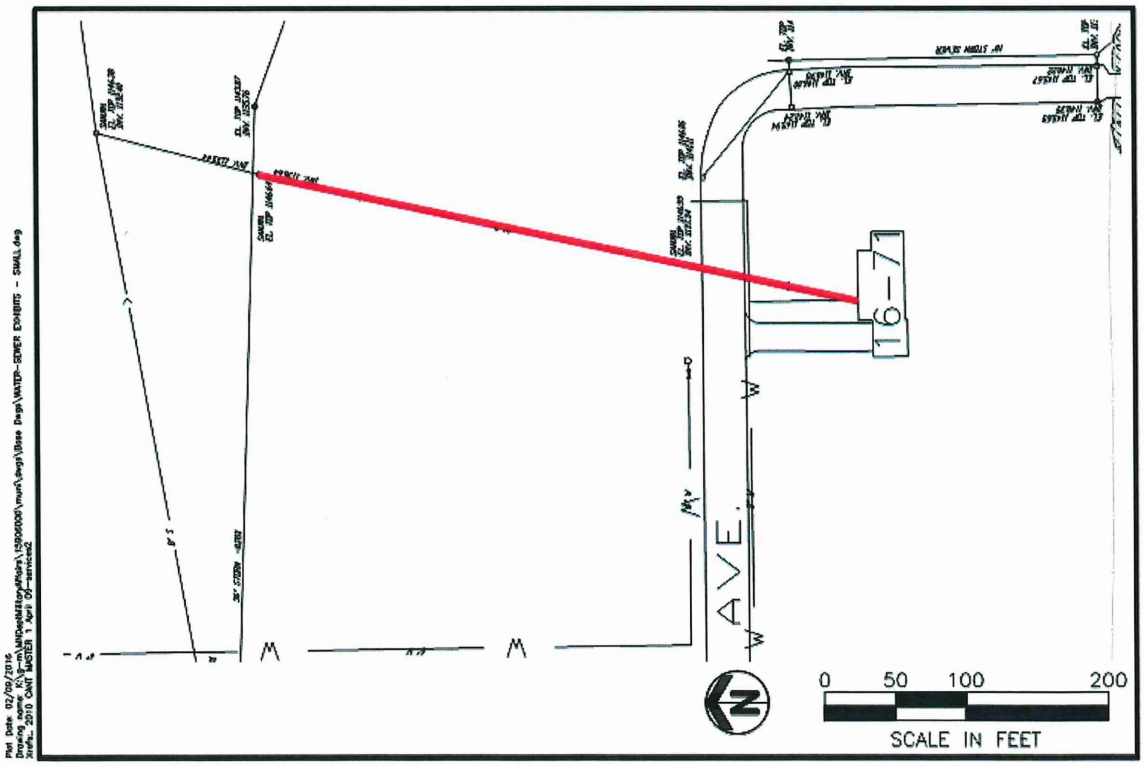


20. **Building 15-71 & Building 15-72** – According to Camp Personnel, these two buildings have not demonstrated problems in the past and should be removed from the list.

21. **Building 16-71** –Sanitary Sewer Service – The sanitary sewer service is a long 8" service that runs approximately 550' north from the north side of the Commander's House to the sanitary sewer mainline south of Bettenburg Avenue. The depth, as measured in manholes along the route varies from 9'-6" to 13'. The service is too large and too flat for the flow and Camp personnel report there is some sags in the line which accumulate solids.

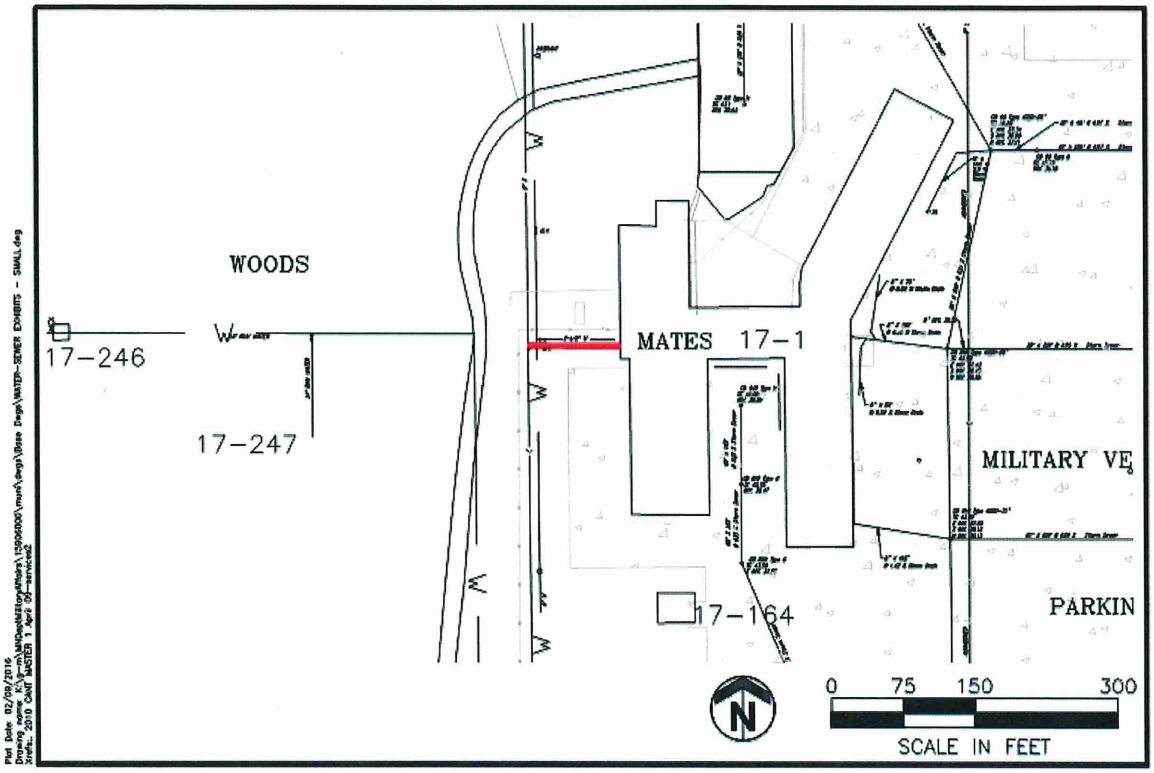
    The water service proceeds straight north from the north side of the house connecting with a 3" main in the south boulevard of Leach Avenue. The depth was electronically measured at 7'-4" to 8'-0", which is sufficient cover in a turfed area. Camp personnel question whether water needs to be left running in the winter.

    <u>Recommendation</u> – Replace the sanitary sewer service with an appropriately sized pipe for at least 430' to the drop manhole.



22. Building 17-1 –Sanitary Sewer Service – The sanitary sewer service exits the west side of the building and extends approximately 95' to a sanitary sewer main. The main appears to be about 7' deep, which is sufficient depth in a turfed area.

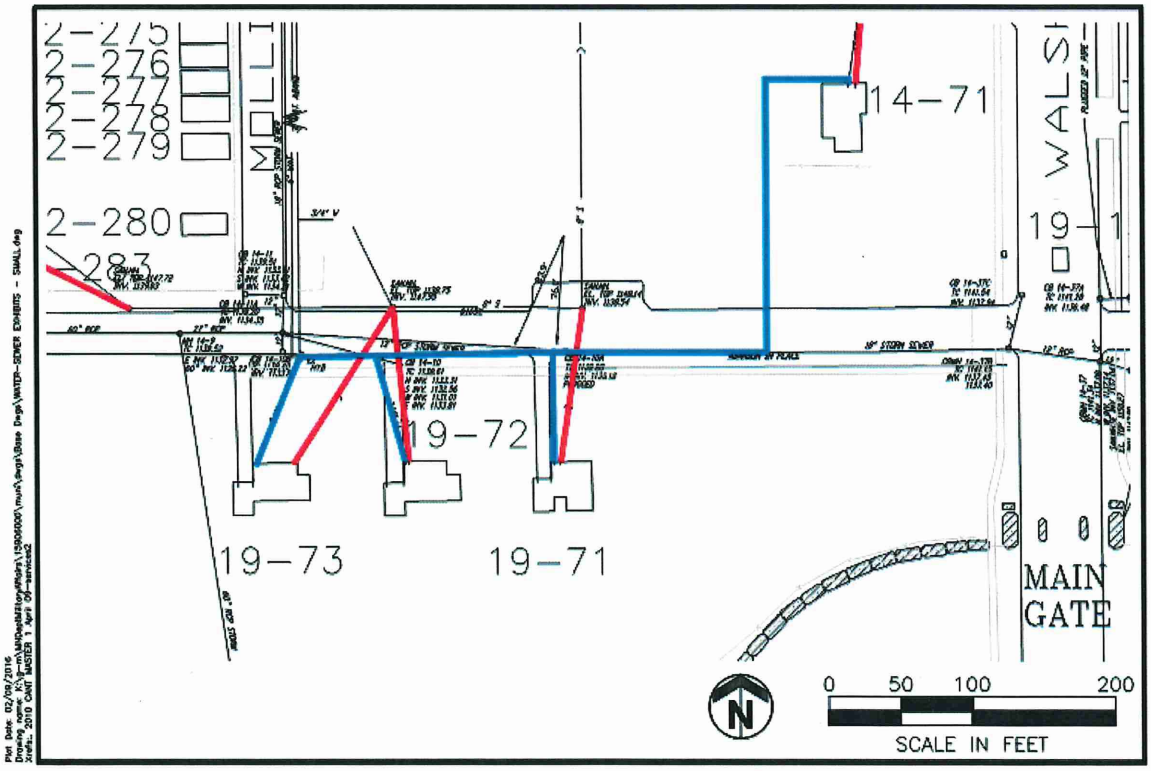
Recommendation – Expose the service as it leaves the building and replace the service or insulate between the building and the main.



23. Building 19-71, Building 19-72, Building 19-73 –Watermain & Sanitary Sewer Service – These buildings will be discussed together. Camp personnel list these buildings as having "shallow sewer". Each building has one sanitary sewer service which leaves the north side of the building and discharges into manholes on a sanitary sewer main on the north side of Leach Avenue. The services average about 115' in length. The depth of the sanitary sewer main in this location is between 8.8' to 9.5' and is therefore sufficiently deep. It appears there should be sufficient elevation drop to the main. Most of the service is in turfed area except for the Leach Avenue crossing.

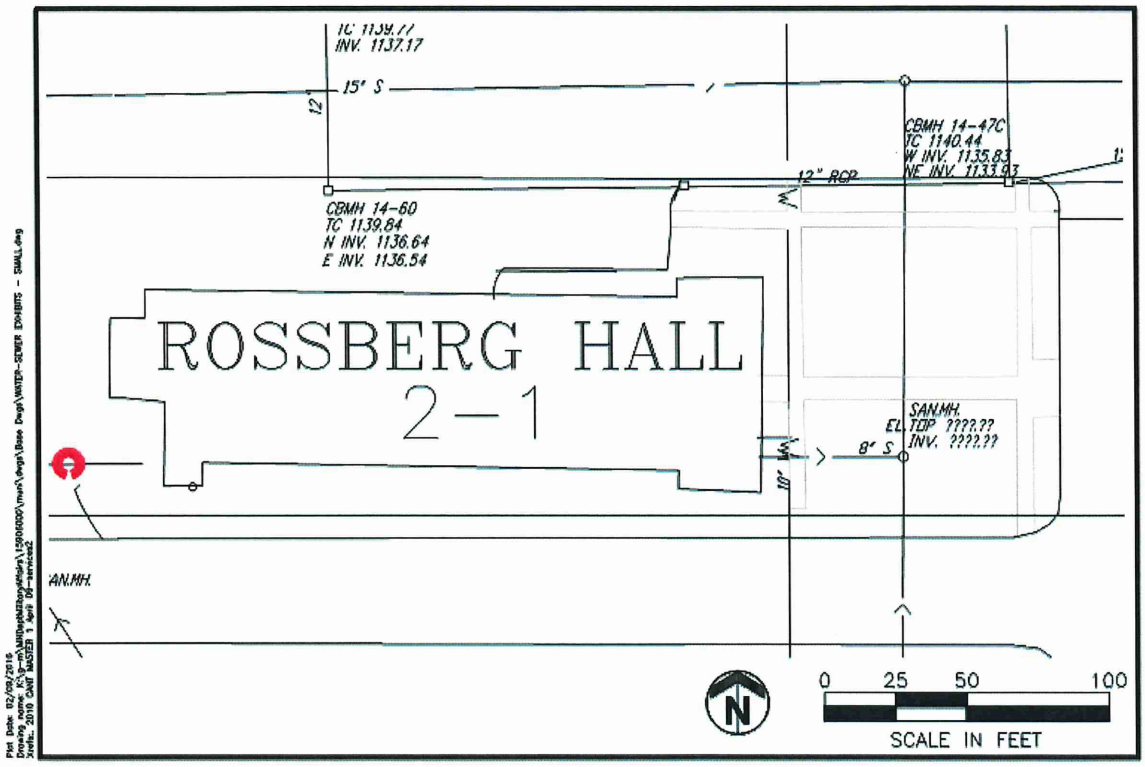
The water services were not identified as having a problem, but the electronic depth locator indicates that the water services are shallow at the main; varying from 4' to 6'. Therefore, the water services are at risk for freeze-up.

<u>Recommendation</u> – Replace both the sanitary sewer services and water services at recommended depth, adding insulation where the sewer services would cross under Leach Avenue if necessary.



24. Building 2-1 (Rossberg Hall) –Sanitary Sewer Service – There are no known freeze-up issues at Building 2-1, but as noted on Page 10 the sanitary sewer passes under the building. The location of the service is unknown and assumed to drop vertically into the sanitary sewer line. The connection of this pipe to the sanitary sewer east of Rossberg Hall has not been found so the line under the building cannot be televised.

Optional Consideration – Televise the existing sanitary sewer main to locate the sanitary sewer connection and install a manhole at the connection for future maintenance. Also televise the line under Rossberg Hall to determine the service location and condition.



Estimated Cost for Water and Sewer Service Line Recommendations

The costs estimates are 2016 dollars. Adjustments will be needed when an implementation schedule is determined. It is recommended that the improvements be implemented together or in large enough logical groupings to take advantage of scale for bidding. Parts of this work could also be added to other projects at the same location, especially if restoration can be shared.

A preliminary estimate of the cost for the improvements is:

Recommended Improvements	
Recommended Water and Sanitary Sewer Line Improvements	$776,000
Engineering and Administration (20%)	$155,000
Preliminary Cost Estimate	$931,000
Optional Improvements	
Buildings 2-223 Option	$155,000
Buildings 11-76 Option	$64,000
Building 2-1 Option	$11,000
Preliminary Estimated Construction Costs Options	$230,000
Engineering and Administration (20%)	$46,000
Preliminary Cost Estimate Options	$276,000

B. Water Meters

Of the 18 buildings listed in Table 2 of the RFP, only the Area 22 wash rack had a water meter. The other 17 buildings do not have any water meters. It is recommended to install water meters at all 17 locations and extensive plumbing will be needed to cut in meters in some of the locations. The water service lines vary in size from 3/4" up to 2". Water meters will also be required at the Area 17 and Area 22 wash racks, for water recycle lines on Area 17 wash racks, and for alternative water supply treatment (wastewater reuse or harvested rainwater) locations and for irrigation water use at the stored water locations.

Estimated Water Meter Costs

Item	Price	Quantity	Total
3/4" Meter	$ 200.00	3	$ 600.00
1" Meter	$ 275.00	5	$ 1,375.00
1 1/2" Meter	$ 500.00	2	$ 1,000.00
2" Meter	$ 650.00	9	$ 5,850.00
4" Turbine Meter	$ 1,500.00	4	$ 6,000.00
Installation and plumbing modifications	$10,000.00	lot	$10,000.00
Fixed network data transmitters	$ 800.00	23	$18,400.00
Total			$43,225.00

Costs to furnish and install the water meter are shown, and an estimated $10,000 is included for plumbing modifications to locate the new meters. For any site, some re-plumbing may be necessary to provide appropriate access and data cable.

Fixed network meter reading has been determined to best fit the needs of the facility for collecting meter data. In order of increasing cost, the meter data collection methods are as follows:

1. Manually read at each meter.
2. Touchpad reading device on the outside of the building that would be read with a handheld device.
3. Mobile drive by radio system (AMR- Automatic Meter Reading) could be done using a handheld or a laptop.
4. Fixed Network (AMI- Advanced Metering Infrastructure) where all the readings get sent automatically to a data collector and is backhauled to a central server.

Installation of meters at one time provides consistency across the Cantonment area. It is recommended to update all of the water meters in one project for the Cantonment area.

Fixed Network Monitoring System Cost Elements

Neptune is one of the water meter manufacturers and they have a transmitter called the Tricon E that produces a 4-20ma output that can be linked to a central computer for real time flow monitoring. The retail price for each unit is $800.00 added to each meter, or a total of $18,400 for the 23 meters.

C. Leak Detection

Several approaches to leak detection systems may be deployed to detect a probable leak in the distribution system. One method replaces the pumper cap on fire hydrants for leak detection. Other systems install detectors on valve stems that may be permanent or may be moved around to focus on specificareas as desired.

Mobile systems have been used to pinpoint leak locations previously. Mobile, or "lift and shift" methods involve placment of 20loggers in the field overnight or may store up to 30 days of logging information that can be read typically by drive by radio pickup. Cost are typically $850 per logger and plus the communication package for $5,500 for an estimated cost of $22,000. The disadvantage is that it requires deployment and collection of equipment, and would not be integrated into the Camp's data management system.
The other option is to use the permanently deployed leak detection data loggers with a the fixed network data collection system. The loggers send all the logging data to a repeater unit which sends it to a central data collection system. This option can be set up to automate notification of potential leaks daily to utility personnel. The estimated cost is $1,250 for each logger and they can pinpoint leaks within 1 meter. After one year there is a $1.20 per logger fee per month for data management. The loggers are recommended to be 500-750 feet apart to provide coverage for the system. For estimating the prices are shown for 60 loggers. Final placement and the logger count would be determined at the time of project implementation, with spacing closer to 500 feet in more complex areas.

Estimated Alpha Fixed Network Leak Detection Implementation Costs

	Price	Quantity	Total
Leak Logger	$ 1,250.00	60	$ 75,000.00

Estimated Alpha Fixed Network Leak Detection Annual Costs

Leak Logger Fee Per Month (Each)	$ 1.20
Annual Fee for Leak Logger (Each)	$ 14.40
Annual Fee for 40 Loggers	$ 576.00
Annual Fee for 60 Loggers	$ 864.00

D. Wells

Well H was drilled in 1960 to a depth of 80', Well L was drilled in 1988 to a depth of 101', and Well N was drilled in 1998 to a depth of 106'. All three wells have the original 75hp pumps.

Recommended Upgrades

Vertical set well pumps typically provide reliable service for a 7 to 10 year period after installation and then based upon the hours of operation the pumps are removed from service for inspection and repairs. The removal, inspection, and repairs are scheduled during low water demand periods and after inspection the worn parts of the pump and drop pipe are replaced.

In order to eliminate costly future repairs and to make sure the pumps are operating at the highest efficiency possible the Camp should rehabilitate all the well pumps. In onsite discussions with the operators, the flow meters for both Well H and L have not worked for a number of years and a timing device is used instead. Also the inspection tag from the flow meter on Well N showed that the last accuracy test was from November 1998. We recommend replacing the two flow meters and doing an accuracy test on the Well N flow meter to determine if that one should also be replaced.

The nameplate efficiency for Well H is unknown, Well L is 95% and Well N is 94.1%. Upgrading the well pump motors to premium high efficiency motors will result in efficiencies above 95% and will save electrical operating costs over the life of the pumps.

Estimated Well Rehab Costs

The preliminary estimated project costs are as follows:

Well rehab including removal, inspection, cleaning, replacing column pipe and pump shafts, replacement of bearings and stabilizing spiders, replacement of pump bowl wear rings and impellers, sand removal, reinstallation and testing)	$40,000
High Efficiency Well Pump and Motor	$10,000
Connection Piping, Flow Meter, Valves, and Air Release	$15,000
Electrical Wiring, and Controls	$25,000
VFD	$15,000
Total Preliminary Estimated Construction Costs for each well	**$105,000**
Engineering and Contingency	$25,000
Total Preliminary Cost Estimate per Well	**$130,000**

Rebates

Minnesota Power has performance rebates available for customers using NEMA high efficiency motors that lower electric demand. Details and amounts will be reviewed with Minnesota Power.

Implementation

It is recommended to rehab Well H first since it is the oldest well, and then Well L followed by Well N.

E. Stormwater System Evaluation

One goal of the study is to capture and retain on site the runoff from the 1 ½ inch rainfall event in areas with storm water outlets.

The Cantonment Area is served by storm water collection and conveyance systems that collect runoff and convey it to the Mississippi River at six separate locations. The outfall locations and approximate associated drainage areas are shown on Figure 1. The outfall locations are:

1. Northern Outfall
2. Green Avenue Outfall
3. Chickamauga Road Outfall
4. Central Outfall
5. De Parcq Woods Outfall
6. Treatment Plant Outfall

A planning level model of the Cantonment Area was created in HydroCAD (version 10.00-16) to analyze the existing stormwater drainage areas and outfalls. A runoff curve number of 98 was assumed for existing impervious areas including gravel parking areas. Runoff curve numbers of 39 (>75% grass cover, HSG A) and 49 (50-75% grass cover, HSG A) were assumed for the pervious portions of the site.

Onsite soil data is from USDA Soil Survey maps. The site consisted mainly of Psamments, and Meehan Loamy Sand. Infiltration rates in the existing basins which have Meehan Loamy Sand were assumed to be 1" per hour. This corresponds to the MSA Professional Services memorandum dated August 10, 2014. The memorandum indicates that onsite infiltration rates in the areas of outfall basins range from 0.5" to 1.63" per hour.

Refer to the Water Reuse section of this report for information on irrigation areas, treatment, and volume requirements.

Outfall Summary			
Outfall	Volume Runoff 1.5" Storm (acft)	Volume Runoff Existing Retains (acft)	Volume Runoff Needs to be Retained (acft)
Northern Outfall	3.2	0	3.2
Green Ave. Outfall	0.5	0	0.5
Chickamauga Outfall	5.1	6.0	0
Central Outfall	2.9	3.1	0
De Parcq Woods Outfall	7.5	7.5	0
Treatment Plant Outfall	3.7	4.0	0

1"/hr infiltration rate assumed

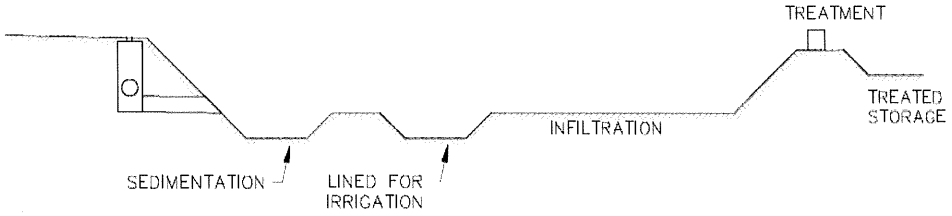
Recommended Upgrades

1. **Northern Outfall** – The Northern Outfall largely drains parts of Areas 8, 10, 21, 22, and 23. The outfall discharges directly to the Mississippi River. There is no retention for stormwater in this drainage area.

The volume of runoff from the 1.5" storm is 3.2 acre-feet. The existing system retains 0 acre-feet. 3.2 acre-feet will need to be retained to meet the study goal. The flow can be diverted from the storm sewer in an area north of Motor Pool Road and east of Robinson Road into an infiltration basin that would retain the required volume. See Figure 2 for the basin location.

The basin may be expanded to harvest stormwater to reuse for irrigation. See Water Reuse Section for additional discussion.

Recommendation – Construct an infiltration basin north of the existing pipe designed to provide irrigation water storage and provide infiltration for the 1.5" rain event. The basin will be "offline" of the existing stormwater system. Stormwater will enter the basin during rain events. When the basin has reached capacity in wet weather or large storm events, the excess stormwater will overflow to the existing storm sewer system and discharge into the Mississippi River. The basin will feature a pre-treatment sedimentation basin and may include lined storage sized for irrigation reuse. The remainder of the basin will be designed for stormwater infiltration. The basin will require 3.2 acre-feet of infiltration capacity.



Basin Schematic Diagram

2. **Green Avenue Outfall** – The Green Avenue Outfall drains a small portion of Area 9. The outfall discharges to the northeast, outletting directly to the Mississippi River. There is no retention for stormwater in this drainage area. The volume of runoff from the 1.5" storm is 0.5 acre-feet. The existing system retains 0 acre-feet. An estimated 0.5 acre-feet of runoff will need to be retained to meet the study goal.

   Recommendation – Due to the small drainage area, install local passive infiltration including rain gardens, permeable pavement, re-directing rain leaders, and disconnecting impervious surfaces.

3. **Chickamauga Outfall** – The Chickamauga Outfall drains parts of Areas 5, 6, 7, and 9. The outfall discharges to the east along Chickamauga Road into a small basin before outletting to the Mississippi River. The volume of runoff from the 1.5" storm is 5.1 acre-feet. The existing system retains 6.0 acre-feet. This outfall is currently meeting the study goals.

   Recommendation – Do nothing.

4. **Central Outfall** – The Central Outfall drains parts of Areas 3 and 5. The outfall discharges to a natural low area behind Engineer Road that provides some retention before discharging to the Mississippi River. The volume of runoff from the 1.5" storm is 2.9 acre-feet. The existing system retains 3.1 acre-feet. This outfall is currently meeting the study goals.

   Recommendation – Do nothing.

5. **De Parcq Woods Outfall** – The De Parcq Woods Outfall drains parts of Areas 1, 2, 8, 11, 13, 15 and 17 generally east along the alignment of Bettenburg Avenue and De Parcq Woods Avenue. The outfall discharges t
6. o a large constructed basin before reaching the Mississippi River. The volume of runoff from the 1.5" storm is 7.5 acre-feet. The existing system retains 7.5 acre-feet. This outfall is currently meeting the study goals.

   Recommendation – Do nothing.

7. **Treatment Plant Outfall** – The Treatment Plant Outfall drains parts of Areas 2, 14, 15, 16, and 19. It discharges southeasterly to a large constructed basin located adjacent to the Wastewater Treatment Plant before reaching the Mississippi River. The volume of runoff from the 1.5" storm is 3.7 acre-feet. The existing system retains 4.0 acre-feet. This outfall is currently meeting the study goals.

   Irrigation needs for areas identified can be supplied by the existing flows from the treatment plant. If additional areas are irrigated, the existing basin can be modified to accommodate raw water retention for irrigation.

   Recommendation – Do nothing

Optional Consideration – The Camp could install local passive infiltration including rain gardens, permeable pavement, re-directing rain leaders, and disconnecting impervious surfaces. This would increase infiltration on the site further exceeding the goal of infiltrating runoff from a 1.5 inch rainfall event. If a significant amount of local passive infiltration is installed in the Northern Outfall Area it would reduce the size needed for the infiltration basin.

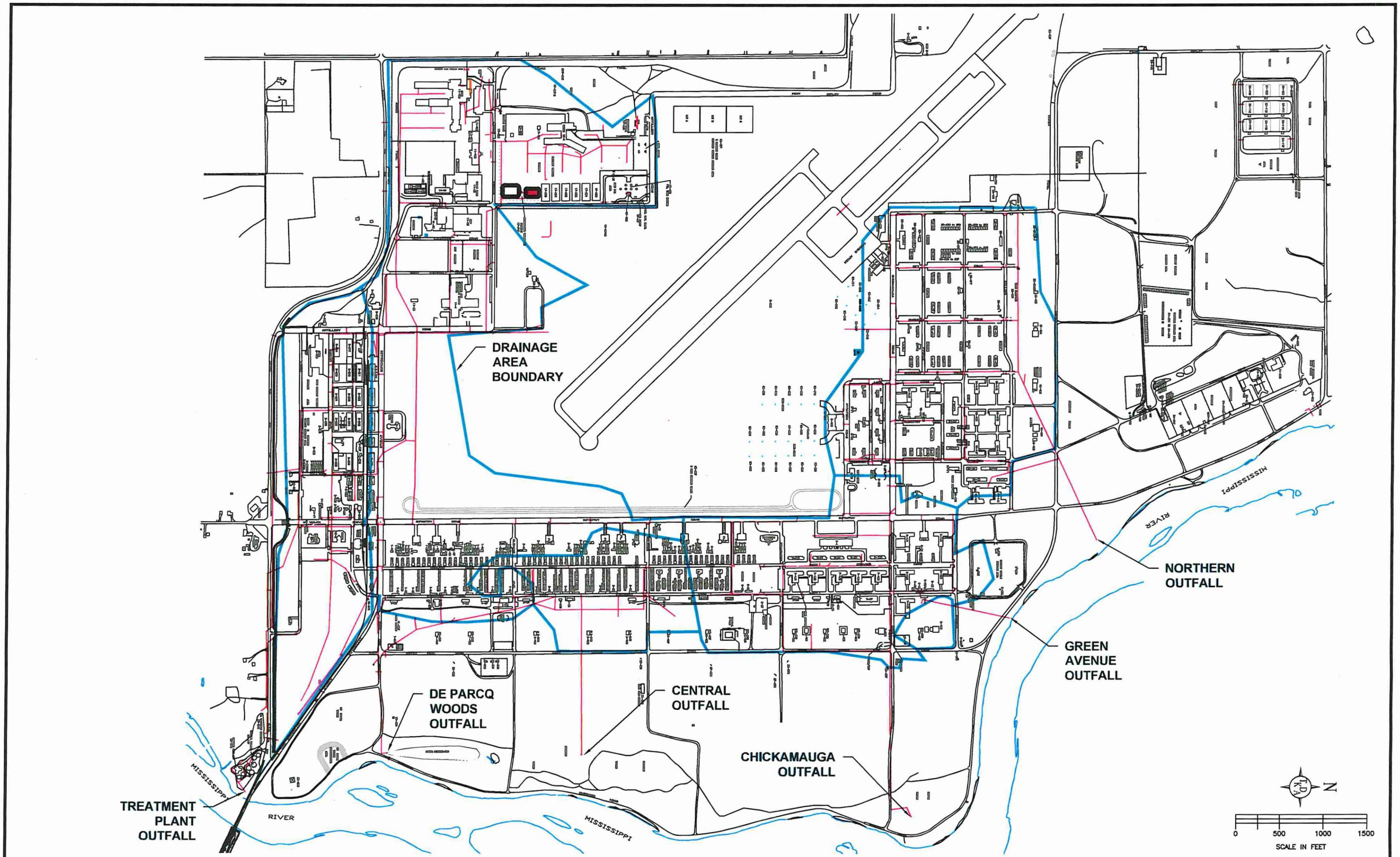
Estimated Storm Sewer Improvement Costs – Infiltration

The preliminary estimated project costs are as follows:

Northern Outfall Improvements – Infiltration Retention	$467,000
Engineering and Administration	$93,000
Total Cost Infiltration	$560,000

Improvements for the Green Avenue Outfall could be accomplished with a variety of techniques so the cost is highly variable. For this reason a cost estimate is not given.

The cost of raingardens is highly variable depending on the site and situation. A good source of cost information is the Minnesota Stormwater Manual's Cost-benefit Considerations for Bioretention section. The high permeability of the local soils is a significant consideration for design that will impact size required as well as components such as not needing underdrains. Selecting plants tolerant of both wet and dry conditions will also be challenging. Information regarding ongoing maintenance costs is also provided in the Manual.



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FEBRUARY 2016

FIGURE 1
DRAINAGE AREAS &
STORM SEWER OUTFALLS

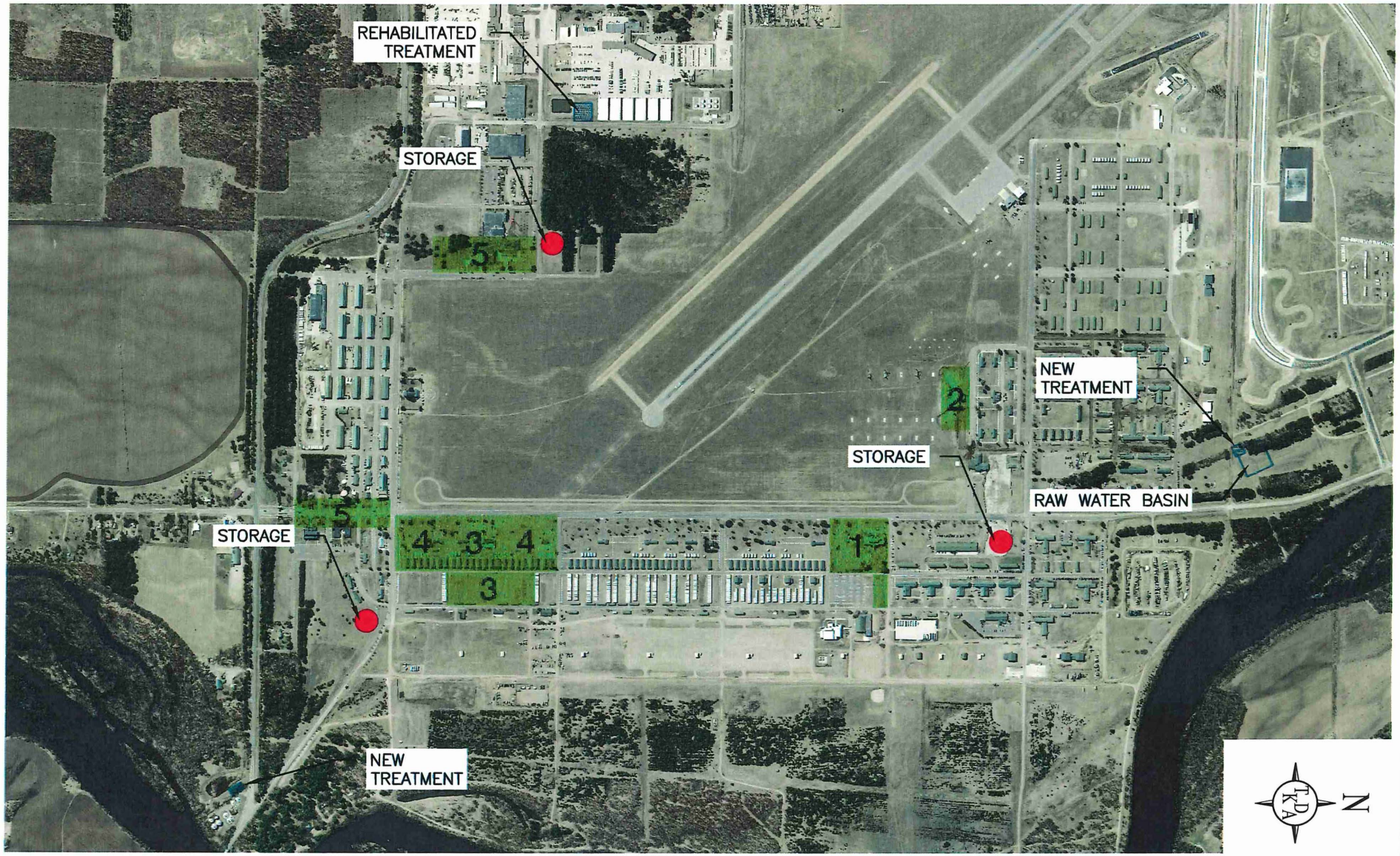

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FIGURE 2
IRRIGATION AREAS, STORAGE, TREATMENT, AND RAW WATER STORAGE

III. WATER REUSE

A. Reuse Opportunities

Reclaimed stormwater or wastewater treatment effluent may be prepared for use in landscape irrigation, aquifer recharge or vehicle washing. Regulatory requirements influence treatment requirements and specific means for application. Geographic proximity between the reclaimed water source and the point of application provide unique opportunities that will be outlined in subsequent sections.

MPCA has issued individual quality standards for stormwater reuse and for wastewater reuse. Common to both standards is to limit the amount of turbidity (residue) and the bacterial count. Based on the type of activity (irrigation and lawn watering) the wastewater reuse standard of treatment may be summarized as follows:

MPCA Municipal Wastewater Reuse

Water quality parameter	Impact of parameter	Public access area guideline
Turbidity	Irrigation system function	2/10 NTU
E. coli	Public health	2.2/23 coliform/100mL

Stormwater guidelines from MPCA similar turbidity standards (virtually residue free) and less stringent bacterial standards. However, MPCA currently has a greater number of regulated water quality parameters for stormwater. Not readily noticed is the difference in the bacterial standard - total coliform for wastewater reuse and E. coli for rainwater. The effect of these regulations is to effect two treatment objectives – the first being disinfection and the second being turbidity or residue removal.

MPCA Stormwater Reuse

Water quality parameter	Impact of parameter	Public access area guideline
Turbidity	Irrigation system function	2-3 NTU
E. coli	Public health	126 E. coli/100mL
pH	Plant health	6-9
Chloride	Plant health; corrosion of metals	500 mg/L
Copper	Plant health	0.2 mg/L (longterm use)
Zinc	Plant health	2 mg/L (longterm use)
Temperature	Public health	Future date

Treatment Technology

Cloth media disc filtration or granular media pressure filtration are recommended for removing turbidity from wastewater effluent and collected rainwater ponds. The technical effectiveness, similarity of the equipment to existing water or wastewater treatment operations, and the lower maintenance requirements are the basis for this recommendation. The following table details the estimated capital cost, filtration media replacement cost, and the labor that would typically be required for a wastewater effluent or harvested rainwater filtration application.

Turbidity Control Alternatives

Parameter	Bag	Cloth Disc	Granular	Membrane
Turbidity tolerance, NTU	<10	<50	<50	<50
Filter capital equipment cost, $	50,000	95,000	150,000	350,000
UV Equipment cost*, $	75,000	75,000	75,000	75,000
Installation, $	80,000	160,000	120,000	240,000
Pumping station, $	95,000	95,000	95,000	95,000
Engineering and administration, $	60,000	85,000	88,000	152,000
Contingency, $	60,000	102,000	105,600	182,400
Total Capital Cost, $	420,000	612,000	634,000	1,094,400
Filtration media, cost per unit, $	10	250	50	1,800
Filtration media, number of units	4	24	100	4
Media life, days	2	1,500	3,000	1,500
Cost per year, $	7,300	1,460	608	1,752
Labor cost per season**, $	15,752	3,367	2,258	6,187
Total Annual operating cost, $	23,052	4,827	2,867	7,939
Maintenance, average minutes/day	115	25	17	45
Maintenance time over season, hours	350	75	50	137

** complete disinfection assumed, may be reduced based on wastewater effluent UV system performance*
*** labor cost, burdened at $40 - $50/hour*

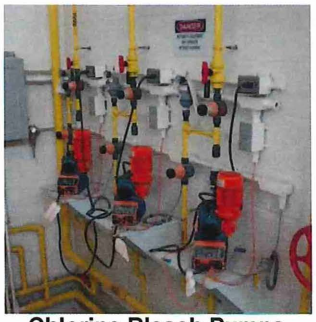
Although simple and easy to implement, the anticipated wastewater turbidity levels are higher than would be recommended for bag filters. The frequency of required bag filter change outs (perhaps daily) would be unsatisfactory from a cost and maintenance perspective, as reflected in the operating costs. Membrane filtration is considered highly effective in producing particle free water, but the capital cost, operating cost and complexity of the operation make it non-optimal. Cloth media filters are a cost-effective means of turbidity removal and should be considered further due to the lower apparent capital cost. The major disadvantage of cloth media filters is that it is a gravity system and is best located at the top of the hydraulic profile. Here, it would be located near the point of treated water storage or a pumping station would need to be added. Granular media filters, though slightly more expensive, are similar to the well water filtration system equipment and is particularly well suited to in-line installation, in this case at a pumping station at the wastewater treatment plant or adjacent to stormwater collection basins.

Disk Filter

Pressure Filter

Bag Filter

Disinfection alternatives include ultraviolet, ozone, and chlorine disinfection. Ultraviolet disinfection is currently utilized at the wastewater treatment plant and is readily accepted in other wastewater effluent reuse applications in the state. It is well suited for the hydraulic profile of the application and easily installed downstream of the filter. Ozone treatment was the most expensive, with safety and pollution control equipment being equal in cost to the ozone generator. The demand for irrigation water would correlate well with sunny weather, making the UV disinfection well matched for renewable solar energy. Ultraviolet disinfection is recommended.



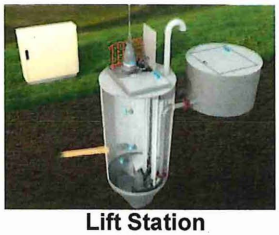
Chlorine Bleach Pumps

Ozone Generator

Ultraviolet Unit

Pumping Costs

Pumping stations will be needed to transport water from the WWTP. Recent pumping station projects of similar size in the area are estimated at $95,000 to $120,000 per pumping station, installed.



Lift Station

Recommendation

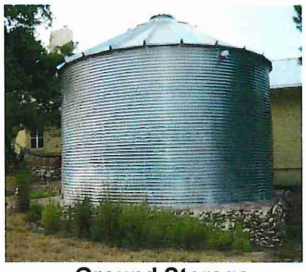
Install effluent treatment and pumping ($465,000) at the wastewater treatment plant and rainwater filtration at the (new) northern stormwater collection and infiltration basin ($440,000).

Storage and Application Costs

Maintaining water quality through storage and distribution will also be an important consideration. Bleach addition provides continuing disinfection through distribution and is accepted by state agencies, inexpensive and simple to implement. Disadvantages include the corrosion of metal parts, odors, and creation of disinfection byproducts that inhibit some plants, and some animals such as amphibians. Transport of treated water to storage units with recirculating disinfection systems using bag filters and ultraviolet disinfection would provide a chemical free alternative, and may be combined with solar arrays to reduce the carbon foot print.

For the purpose of this report, a model treated water storage unit of 20,000-30,000 gallons working capacity was selected, corresponding to 3"-5" per week of irrigation water applied to a 3 acre to 5.5 acre area in an eight-hour period. Treated water may be stored above or below grade. Above grade installation requires a concrete pad, galvanized steel tank with a water storage bladder. Below-grade installation requires excavation, and a fiberglass tank. Installed costs would be approximately $45,000 for above ground storage and $70,000 for below grade storage. For the Education center, the existing below grade cistern may be used for irrigation of priority areas 1 and 2.

Mechanical equipment for stored water harvesting includes the application pump, providing 50-60 gpm at 60 psi during water application, and intermittent recirculation at 100 gpm (depending on whether above or below grade installation is selected). A hypochlorite addition system to maintain disinfection, or an ultraviolet disinfection unit (smaller than for the wastewater reuse application) would be included to assure stored water maintains regulatory standards. With controller, valving, bag-filter, and ultraviolet unit and enclosure, the mechanical equipment housed is estimated to be another $70,000 for treated water storage and pumping system.



Ground Storage

Fiberglass Tank

B. Stormwater Filter, Area 17

The stormwater filter in Area 17 is currently unused, requiring a larger pump, new controls, and a lift station for transferring filtered water to a designated point of storage for reuse. In reviewing the design of the filter, it is a valuable asset for removing sediment from collected stormwater. With the exception of the pump sizing being insufficient to distribute flow evenly over the entire surface of the filter, the filter follows the Unified Facilities Criteria for intermittent sand filters. While it is quite possible to replace the pump with one of sufficient size for the entire filter distributor system ($75,000-$150,000), it may be prudent to substitute a pump for 50% of the filter distributor system.

If operated, the collected water could be routed to the area 17 wash rack. A lift station suitable for that purpose is estimated at $95,000 installed, plus piping to area 17.

Wash Rack 17 Upgrades

Tank and heavy vehicles carry a large sediment load into the wash rack areas. Either the addition of a prewash basin to Wash Rack 17 is recommended to accommodate the heavy sediment load, or routing all heavy vehicles through Wash Rack 22 would be recommended.

The existing water reclamation equipment is suitable for reclamation of water to a level suitable for washing vehicles with a clear-coat finish. However, the capacity of the system isn't sufficient to provide wash water for a demand equivalent to 4-6 vehicles per hour per wash rack. It would be appropriate to route the water to one of the wash racks and designate it for clear coat vehicles, and use reclaimed filtered water for the remaining wash racks.

A minimum wash water storage of 4,000 gallons is recommended based on a peak daily demand of 1,300 gallons per day, per lane. Review of the capacity of existing sedimentation, filtration and water treatment suggest that additional filtration capacity is needed in order to accommodate wash rack water recycling. A filter system similar to the wastewater effluent/stormwater reclamation filter system is recommended, $345,000 for the granular media filter and UV system. Use of the existing pump station is recommended, with a contingency of $150,000 for the storage tank and rehabilitation of the existing water reclamation and pumping system.

C. Irrigation

Camp Ripley has identified 8 areas that they wish to irrigate using reuse water. The areas were assigned priorities 1-5 which were used for naming. The areas are listed and shown below.

- 1
- 2
- 3 East
- 3 West
- 4 North
- 4 South
- 5 East
- 5 West

Irrigation Opportunities

Based on information from the University of Minnesota Extension and National Oceanic and Atmospheric Administration (NOAA) it is estimated that the watering deficit is 3" to 5" per month for turf in the Camp Ripley area for average and dry conditions respectively. This assumes amended topsoil.

Irrigation requirements for each area for both 3" and 5" per month of irrigation are shown in the table below. The information is provided in gallons per 8 hour watering cycle to illustrate needed irrigation volumes. Operationally, the turf should not be watered every day and it is expected that a schedule for watering based on zones will be developed that results in the water volumes given.

Irrigation Priority Area	Area to Irrigate (AC)	Irrigation Rate Inches/Month	Gallons Needed/8 Hour Watering Cycle (3")	Irrigation Rate Inches/Month	Gallons Needed/8 Hour Watering Cycle (5")
1*	5.25	3	14,000	5	24,000
2	3	3	8,000	5	14,000
3 East	5.5	3	15,000	5	25,000
3 West	4.5	3	12,000	5	20,000
4 North	5.5	3	15,000	5	25,000
4 South	5.5	3	15,000	5	25,000
5 East	4.25	3	12,000	5	19,000
5 West	4	3	11,000	5	18,000

*Note that Irrigation Priority Area 1 has an existing tank that may be incorporated into the system

Both stormwater and wastewater were considered as the source. Based on the location and availability a source was identified for each Irrigation Area. Areas 1 and 2 will be irrigated with water harvested from the Northern Outfall. Area 5 West will be irrigated by harvesting stormwater from the existing pond/treatment system at Libbey Avenue and Bodey Road. The remaining areas will be irrigated with wastewater from the Treatment Plant.

If additional water is needed during dry periods, the system could be configured to draw from the potable water system or a new well could be installed to provide supplemental water. The estimated costs do not include a supplemental water supply.

The incremental cost of 3 inch versus 5 inch irrigation amounts for treatment, storage, transmission and irrigation is small so cost estimates are only provided for the 5" amount.

Northern Outfall

Expansion of the infiltration area provides the opportunity to harvest stormwater for irrigation of Areas 1 and 2. As discussed earlier the infiltration basin would be expanded with a lined basin having 0.75 to 1.25 acre-feet of raw water storage, depending on the level of irrigation desired with the assumption that it will refill at least every 7 days. The treated water storage volume required for the Northern Outfall is 22,000 gallons and 38,000 gallons for the 3" and 5" irrigation rates respectively. A treatment/irrigation system would need to be constructed for Areas 1 and 2.

The estimated cost to irrigate Irrigation Priority Areas 1 and 2 with 5" per month from the Northern Outfall is:

Irrigation Priority Area	Component	Estimated Cost 5"/Month
Area 1	Harvesting	$85,000
	Ground Storage	$166,000
	Treatment	$634,000
	Transmission	$299,000
	Irrigation	$32,000
Total Area 1		$1,216,000
Area 2	Harvesting	$49,000
	Storage	$0
	Treatment	$0
	Transmission	$0
	Irrigation	$18,000
Total Area 2		$67,000
Total Northern Outfall		**$1,283,000**

The Harvesting cost is for expansion of the infiltration basin and would need to be increased if done separately. The Harvesting cost can be reduced to $80,000 for 3" per month. The Storage, Treatment and Transmission costs listed for Area 1 include capacity for Area 2 also. The costs include 20% for Engineering and Administration.

Treatment Plant

The treatment plant discharge has sufficient capacity to irrigate Areas 3 East and West, 4 North and South, and 5 East. The 75 gpm provided by the treatment system to provide irrigation water is approximately the Treatment Plant's average daily flow and corresponds to about 4.7" per month for the irrigation areas. The system could be adjusted to supply the additional 5 gpm needed for 5" per month if desired, but this is basically the maximum flow that could be reliably supplied by the wastewater stream. Additional areas could be irrigated if a lower application rate is used or if the flow is supplemented during low flow periods.

The treated water storage volume required for the Treatment Plant is 69,000 gallons and 114,000 gallons for the 3" and 5" irrigation rates respectively. Unfortunately, it is not practical to irrigate the subject areas with the existing 2" line due to headloss. Two 4 inch supply pipes are projected to be required.

The estimated cost to irrigate Priority Areas 3 East and West, 4 North and South, and 5 East with 5" per month from the Treatment Plant is:

Irrigation Priority Area	Component	Estimated Cost 5"/Month
3 East	Buried Storage	$202,000
	Treatment	$634,000
	Transmission	$245,000
	Irrigation	$33,000
Total Area 3 East		$1,114,000
3 West	Storage	$0
	Treatment	$0
	Transmission	$0
	Irrigation	$27,000
Total Area 3 West		$27,000
4 North	Storage	$0
	Treatment	$0
	Transmission	$0
	Irrigation	$33,000
Total Area 4 North		$33,000
4 South	Storage	$0
	Treatment	$0
	Transmission	$0
	Irrigation	$33,000
Total Area 4 South		$33,000
5 East	Storage	$0
	Treatment	$0
	Transmission	$0
	Irrigation	$25,500
Total Area 5 East		$25,500
Total Treatment Plant		**$1,232,500**

The Storage, Treatment and Transmission costs listed for Area 3 East include capacity for Areas 3 West, 4 North and South, and 5 East also. The costs include 20% for Engineering and Administration.

Libbey Avenue Basin

Rehabilitation of the basin and filter in the northwest corner of Libbey Avenue and Bodey Road provides a reused water source for irrigation of Area 5 West.

The estimated cost to irrigate Priority Areas 5 West, with 5" per month from the Libbey Avenue Basin is:

Irrigation Priority Area	Component	Estimated Cost 5"/Month
5 West	Ground Storage	$166,000
	Treatment (Rehab)	$353,000
	Transmission	$92,000
	Irrigation	$24,000
Total Area 5 West		**$635,000**

The costs include 20% for Engineering and Administration.