Grand Canyon Railway Boiler Wastewater Treatment and Storage

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CENE 476–001

04/26/2018

Client: Grand Canyon Railway

- Steam Saturdays and special events: March – October
- Coal-fired to recycled vegetable oil [1]
- Eric Hadder, Chief Mechanical Officer
- Mike Gallegos, Environmental Health and Safety Technician

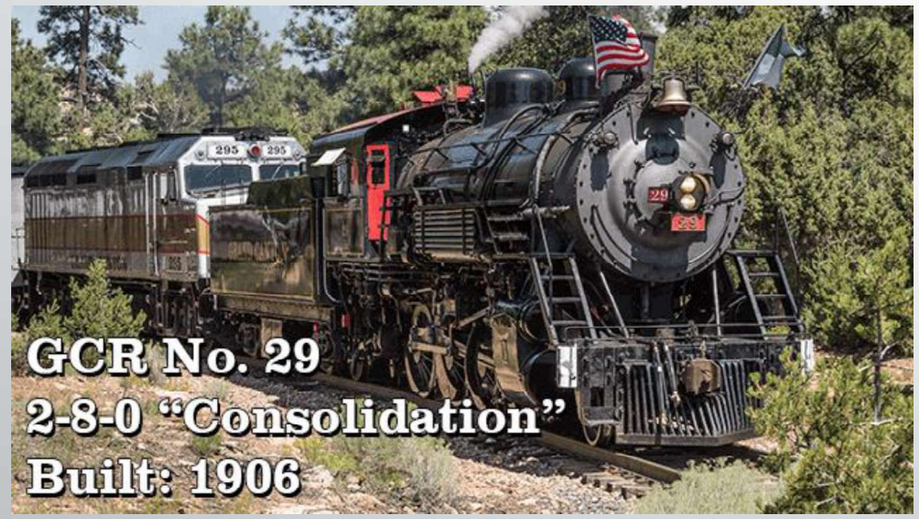


Figure 1: GCR train named "Consolidation" [1].

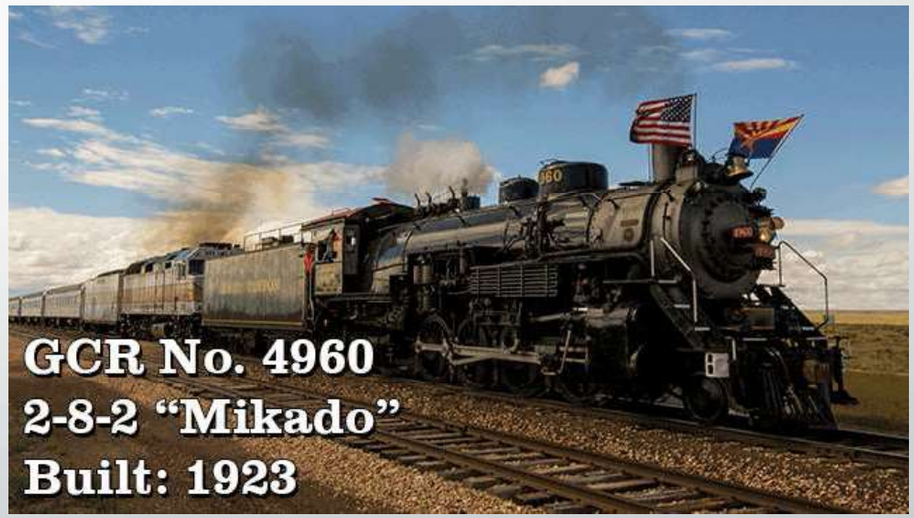


Figure 2: GCR train named "Mikado" [1].

Project Location

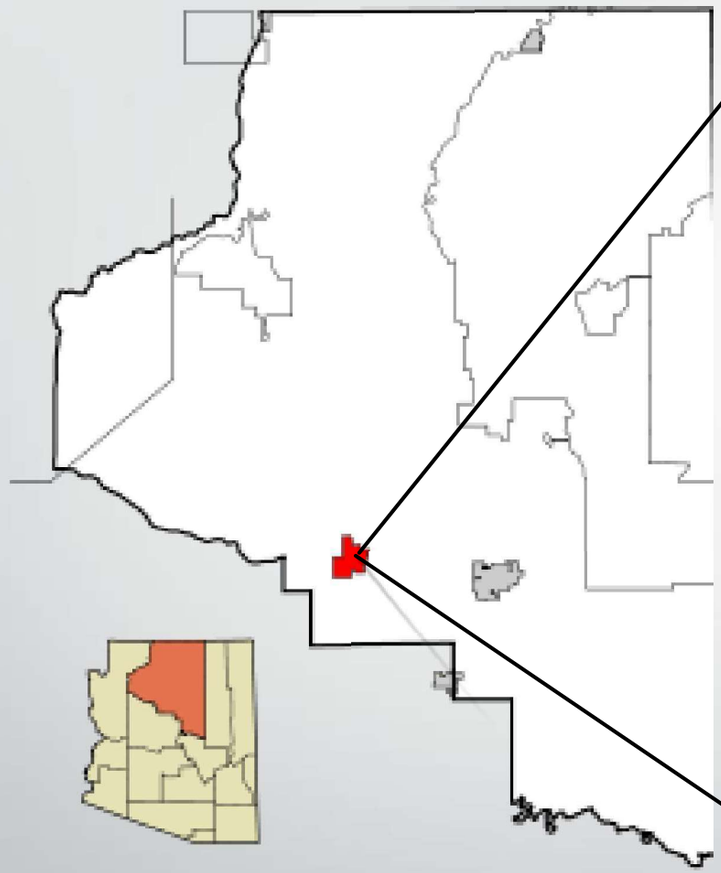


Figure 3: Location of Williams in Coconino County, Arizona. Census Bureau Tiger GIS. 22 April 2018

Figure 4: Aerial View Grand Canyon Railway created in ArcGIS. 22 April 2018.

1.0 Project Understanding

Figure 5: Picture of the GCR trains taken onsite [1].

Wastewater produced in blowdown process - sediment builds and sludge deposits in the base of the water tank

	pH	TDS (mg/L)
GCR Wastewater Analysis	11.4	1540
Williams WWTP	5.5-9	350

Table 1: Current GCR wastewater statistics compared to William's Wastewater Treatment Plant's minimum influent standards.

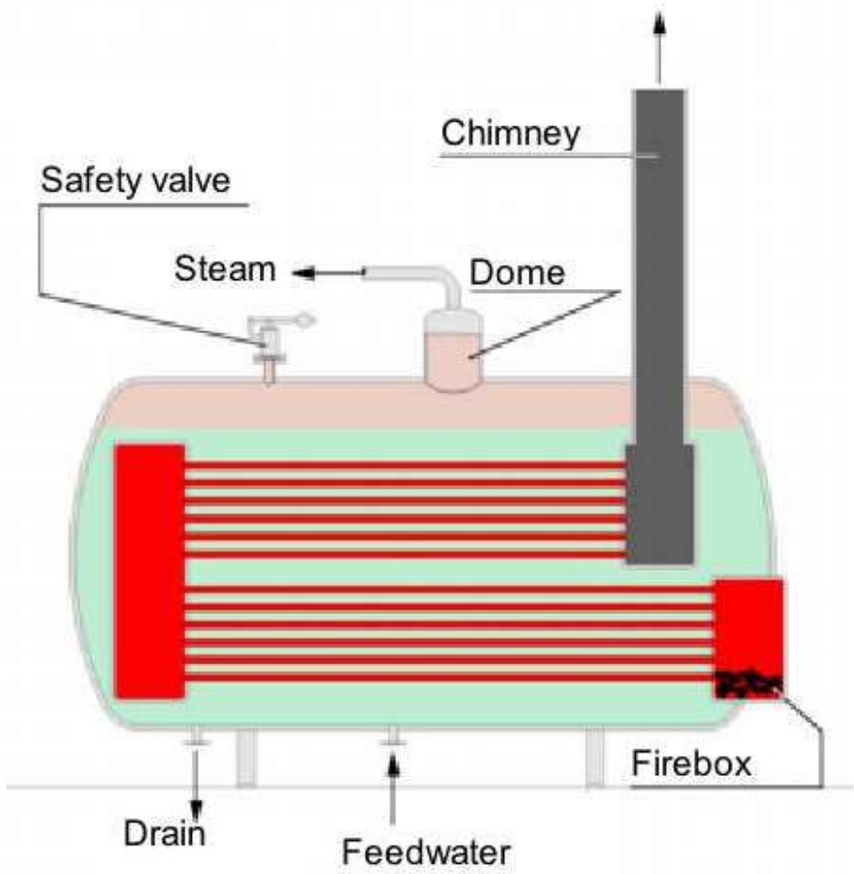


Figure 6: Schematic of inner boiler mechanics [2].

2.1 Field Work

2.1.1 Site Map

- ArcGIS map of existing site conditions

2.1.2 Sampling Plan

2.1.2.1 Boiler Blowdown Water

- 3 samples
- ASTM D 3370-10 Practice A

2.1.2.2 Rainwater Reservoir

- 3 samples
- ASTM D 3370-10 Practice A

2.2 Pretreatment Alternatives

2.2.1 Wastewater testing methods

2.2.1.1 pH Testing

- ASTM D 1293-58: pH of Industrial Water and Industrial Wastewater

2.2.1.2 TDS Testing

- Colorado Plateau Analytical Lab - total inorganics
- $100/Sample

2.2.2 Choose Treatment Options

- Decision matrix
- Biological/Chemical/Physical

Matthews 7

2.3.1 Storage Tank Design Alternatives: Tank Design

2.3.1.1 Choose Premade Holding Tank

- Material resistant to high pH – Min. 11.2 pH
- Material resistant to high temperatures – Min. 300°F

2.3.1.1.2 Ensure Volume Requirements – > 8,000 gallons

2.3.1.1.3 Cost - Price premade tank options to determine installation costs

2.3.1.1.4 Choose Tank Options– Decision Matrix

2.3.1.2 ArcGIS Site Map – Tank installation site

2.3.2 Storage Tank Design Alternatives: Transport to Grinder Pump

2.3.2.1 AutoCAD Design – Design pipe network to connect tank to grinder pump

2.3.2.2 Choose Pipe

- **2.3.2.2.1 Research Pipe Options** – Manufacturers and Materials
- **2.3.2.2.2 Cost -** Price pipe options to determine installation costs
- **2.3.2.2.3 Choose Pipe Options**– Decision matrix

2.4 Project Management

Meeting Type	Frequency	Duration (hrs)
Group	Weekly	1-2
Technical Advisor	Bi-Weekly	1-2
Client	Monthly	1-2

Table 2: Breakdown of group, technical advisor, and client meetings based on frequency duration.

2.4.4 Transport Forms

- Prior to field work
- NAU travel form, travel reimbursement

2.4.5 Coordination

- Colorado Plateau Analytical Lab

2.5 Deliverables

2.5.1 30% Report

- Report initial progress towards the completion of the project

2.5.1 60% Report

- Summary of work to date

2.5.2 Final Report

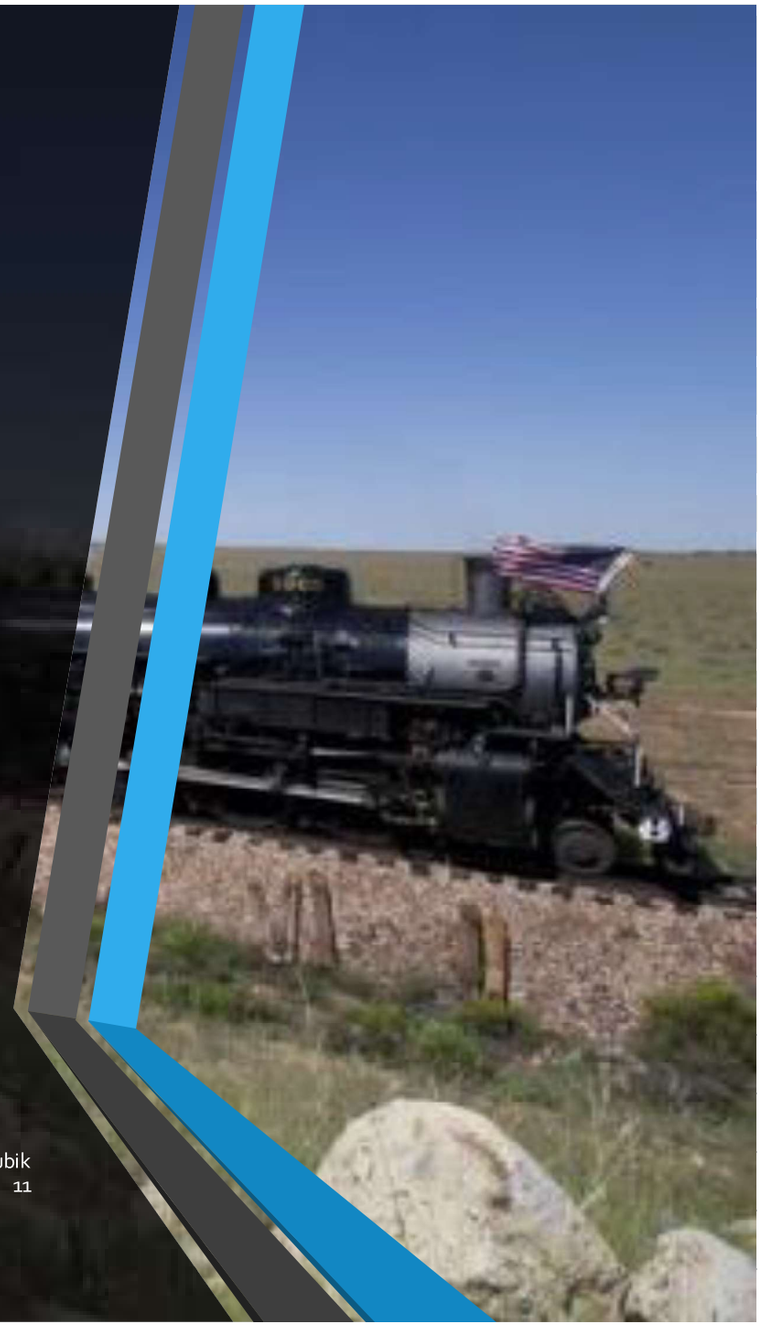
- Summary of analysis, results, and final suite of solutions

2.5.3 Website

- Advertise the project, results, and impacts

2.5.4 Presentation

- Present the project, analysis, and final suite of solutions
- UGRADS



2.6 Impacts

2.6.1 Economic Impacts

Total cost analysis of different treatment/tank options

- Life-cycle costs
- Start-up costs

2.6.2 Environmental Impacts

- Potential risks
- Water quality impact

2.7 Project Limitations

Challenge	Description
Sampling	GCR washes the steam engine out after the winter season
Testing	Resources not available to us

Table 3: GCR project challenges including sampling and testing.

Exclusion	Description
Site Survey	Unnecessary for project completion
Fully Concentrated Wastewater Analysis	Scheduling restrictions
Analysis limited to TDS and pH	Focus on client concerns
Tank Foundation Design	Outside the scope of work for this project

Table 4: GCR project exclusions.

3.0 Schedule

Task No.	Task	Start Date	End Date	Duration (days)
1.0	Field Work	9/10/2018	9/16/2018	6
1.1	Site Map	9/10/2018	9/14/2018	4
1.2	Transport Forms	9/10/2018	9/14/2018	4
1.3	Sampling Plan	9/15/2018	9/16/2018	1
1.3.1	Boiler Blowdown Water	9/15/2018	9/16/2018	1
1.3.2	Rainwater Reservoir	9/15/2018	9/16/2018	1
2.0	Pretreatment	9/17/2018	10/14/2018	27
2.1	Testing the Wastewater	9/17/2018	9/30/2018	13
2.1.1	pH Measurement	9/17/2018	9/23/2018	6
2.1.2	Dissolved Solids Identification	9/24/2018	9/30/2018	6
2.2	Treatment Options	9/30/2018	10/14/2018	14
3.0	Design Wastewater Holding Tank	10/15/2018	11/11/2018	27
3.1	Holding Tank Design	10/15/2018	10/29/2018	14
3.1.1	Choose Premade Holding Tank	10/15/2018	10/21/2018	6
3.1.3	ArcGIS Site Map	10/22/2018	10/29/2018	7
3.2	Transport to Grinder Pump	10/30/2018	11/11/2018	12
3.2.1	AutoCAD Design	10/30/2018	11/4/2018	5
3.2.2	Choose Pipe	11/5/2018	11/11/2018	6
4.0	Project Management	9/10/2018	11/26/2018	77
4.1	Group Meetings	9/10/2018	11/25/2018	76
4.2	Technical Advisory Meetings	9/17/2018	11/23/2018	67
4.3	Client Meetings	10/1/2018	11/26/2018	56
5.0	Deliverables	11/12/2018	11/26/2018	14

Table 5: GCR project table of tasks and subtasks.

3.0 Schedule – Gantt Chart

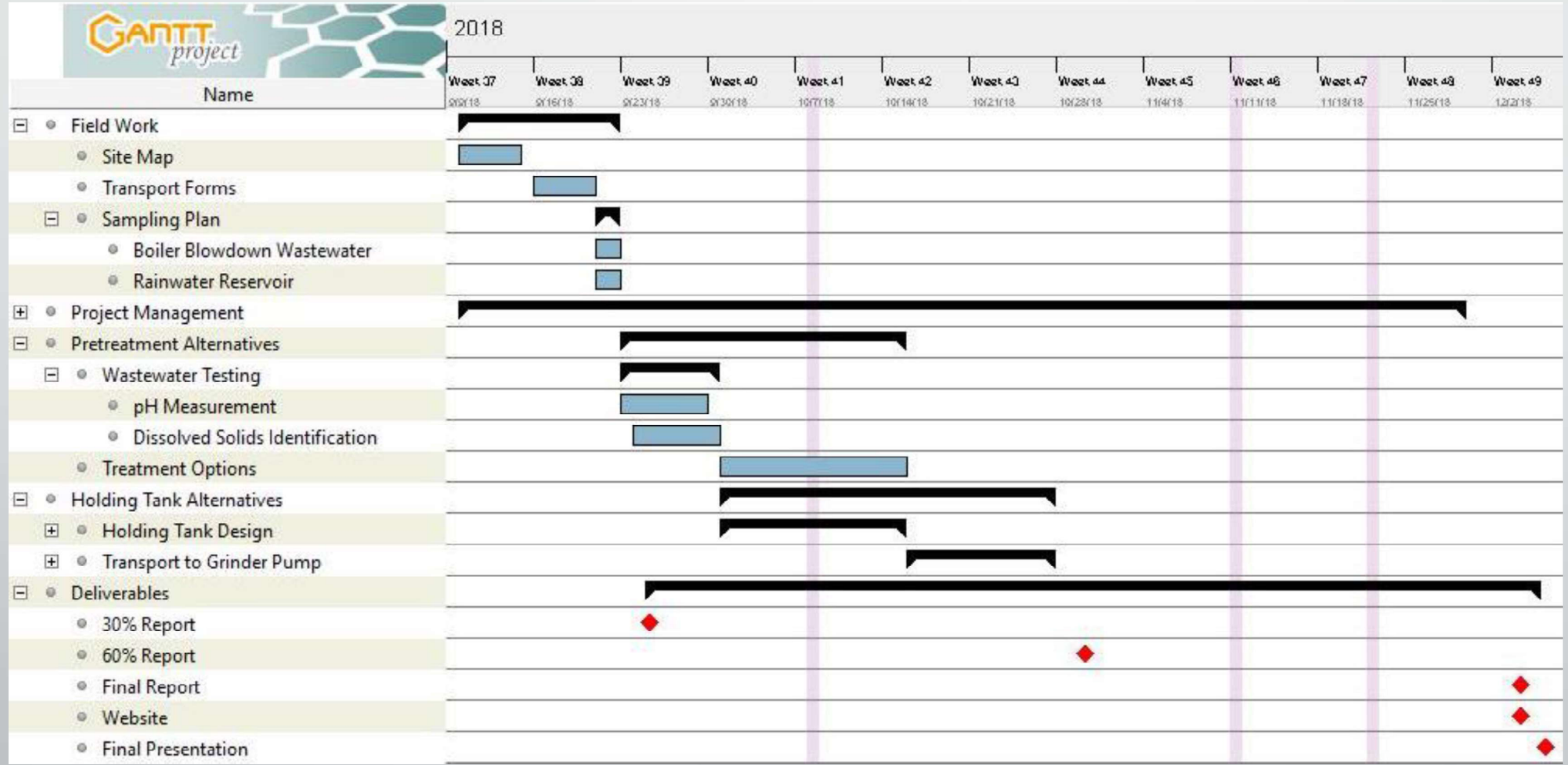


Figure 7: Full Gantt chart outlining GCR project.

Critical Path

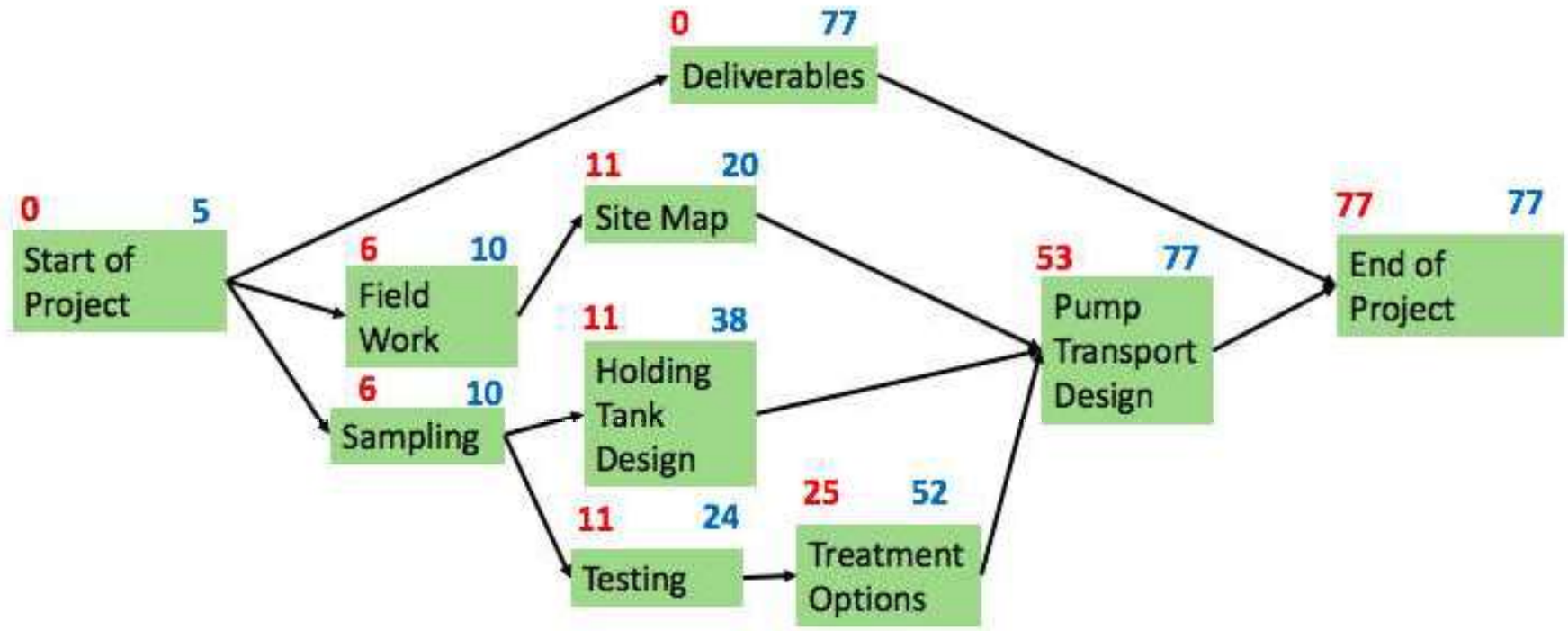


Figure 8: GCR critical path based on start and finish of the project's total business days.

4.0 Staffing

Position	Billing Rate ($/hr)
Senior Engineer	176.00
Junior Engineer	65.00
Intern	21.00
Administrator	33.00

Table 6: GCR project positions and billing rates.

4.3 Summary Table

Staff Position	Total Hours	Justification of Hours
Senior Engineer	182	The Senior Engineer has reduced hours as they are mainly approving work and are much more expensive than the other engineering positions.
Junior Engineer	213	Most of the work is done by the Junior Engineer.
Intern	212	The Intern will do most of the menial work and is the least expensive staff position.
Administrator	140	The Administrator will have minimal work but it will occur throughout the project.

Table 7: Engineering positions and responsibility description/workloads.

4.4 Task/Subtask Matrix

Task	Staff Hours				Total Hours
	SE	JE	IN	AD	
1.0 Field Work	**30**	**18**	**37**	**20**	**105**
1.1 Site Map	10	10	20	15	55
1.2 Transport Forms	5	5	5	5	20
1.3 Sampling Plan	15	3	12	0	30
2.0 Pretreatment Alternatives	**39**	**37**	**45**	**40**	**161**
2.1 Testing Wastewater	14	17	15	20	66
2.2 Treatment Options	25	20	30	20	95

Table 8: Breakdown of billable hours spent on field work and its respective subtasks.

4.4 Task/Subtask Matrix Cont.

Task	Staff Hours				Total Hours
	SE	JE	IN	AD	
3.0 Design Wastewater Holding Tank	**35**	**65**	**32**	**22**	**154**
3.1 Holding Tank Design	15	25	17	10	67
3.2 Transport to Grinder Pump	20	40	15	12	85
4.0 Project Management	**28**	**28**	**28**	**28**	**112**
4.1 Group Meetings	16	16	16	16	64
4.2 Technical Advisor Meetings	8	8	8	8	32
4.3 Client Meetings	4	4	4	4	16
5.0 Deliverables	**50**	**65**	**70**	**30**	**215**
Total Billable Hours	**182**	**213**	**212**	**140**	**747**

Table 9: Breakdown of engineering services billable hours and its respective subtasks.

5.0 Cost

Subcontracting Costs						
	# of Samples	Units (test type)	Cost ($/sample)	Multiplier (%)	Cost ($)	Billing Cost ($)
Wastewater Testing	3	1	100	15	300	345

Table 10: Subcontracting cost of TDS inorganic testing from a third party certified laboratory.

Travel Costs						
	# of Trips	Distance (miles)	Cost ($/mile)	Multiplier (%)	Cost ($)	Billing Cost ($)
Travel to WIlliams	4	6	0.25	15	68	78.2

Table 11: Cost of travel for a total of four trips to Williams, AZ.

5.0 Cost

GCR Engineering Services Cost					
Personnel	Base Pay ($/hr)	Billing Rate ($/hr)	Hours (hr)	Multiplier	Cost ($)
Senior Engineer	80	176	182	3.2	$ 102,502.40
Junior Engineer	35	65	213	2.5	$ 34,612.50
Intern	15	21	212	1.5	$ 6,678.00
Administrator	20	33	140	3	$ 13,860.00
				Total Cost	**$ 157,652.90**

Table 12: Total billing cost of engineering services for the Grand Canyon Railway Project.

References

[1] Grand Canyon Railway, "History of Our Trains," 1 September 2010. [Online]. Available:https://www.thetrain.com/the-train/history-of-the-train/. [Accessed 20 April 2018].

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