Running Head: SUSTAINABLE HOME PROJECT MANAGEMENT PLAN

Project Management Plan

From PMGT501

by

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WBS 8.7

Sustainable Home Construction Project: Week 8 Final Deliverables

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Table of Contents

Introduction

This document represents Group 3's several final deliverables for PMGT 501, which are due at the end of week 8 for WBS 8.7. This document includes the Project Scope Statement, Communication Plan, Responsibility Matrix, Budget Approach, Quality Management, Change Control, and Risk Management Plans for the group's sustainable home construction project. Two other separate documents complete this week's deliverables and include the Network diagram with forward and backward pass, slack, and critical path, as well as the MS Project plan with Work Breakdown Structure (WBS), durations, costs, and resources.

Project Scope Statement

Project Objective

The objective of this project is to build a high-quality, LEED-certified, single family house in Colorado within 9 months. This initial estimate is based on a modification to the average timeframes derived from the 2012 Survey of Construction as reported by the National Association of Home Builders (Siniavskaia, 2013, para. 3). The home will be built from sustainably sourced material wherever possible and include features in the deliverable list to reduce the occupants' long-term carbon footprint. While the average construction price of a new home is approximately $400,000 (Taylor, 2014, p. 1), the home specification for this project calls for a larger finished area and significant sourcing of advanced materials and systems. Therefore, the initial top-down estimate provided for a budget not to exceed $1,000,000.

Additionally, the specifications of the number of rooms, and other structural attributes for this home are based on a report from the National Association of Home Builders, which describe "what home buyers really want" (Quint, 2013). In keeping with the sustainability objectives, the home will not have luxury amenities such as elevators, wine cooler, wet bar, or game room.

Deliverables

1. A 3,500 square-foot finished home, with 4 bedrooms and 4 bathrooms.
2. Exterior finish in accordance with environmentally preferable products.
3. Energy independence systems, including rooftop solar energy installation in accordance with the California Energy commission, with renewable energy battery support building/room attached to back of the garage, and a geothermal heat pump.
4. A 2-car, detached, finished garage, insulated and sheet rocked with an attic storage area and with built-in connection for electrical vehicle recharging.
5. Energy Star, or higher, rated all-electric Stainless steel kitchen appliances, to include induction cooktop, dual ovens, built-in microwave and dishwasher.
6. Interior finish using environmentally preferable materials according to ASID Sustainable Design Council (ASID, 2014).
7. Integrated, intelligent control systems for lighting, heating, ventilation and air conditioning (HVAC), high speed internet, and entertainment.
8. Leadership in Energy and Environmental Design certification (LEED, 2014).

Baseline Milestones

1. Contract signed……6 Jan 15
2. Architectural design started……8 Jan 15
3. 30% design review……..... 9 Feb 15
4. 60% design review……2 Mar 15
5. 90% design review…….……...16 Mar 15
6. Design complete…….……..16 Mar 15
7. Permits approved, construction begins …….…..……..17 Mar 15

8. Excavation complete..……...……23 Mar 15
9. Foundation complete……..……...15 Apr 15
10. Framing complete……..……8 May 15
11. Roofing complete…….....7 May 15
12. HVAC system installed……..……..28 May15
13. Plumbing, electrical, and mechanical installed ……...……...5 Jun 15
14. Plumbing, mechanical, electrical inspections passed ……..…...8 Jun 15
15. Exterior finish……..8 Jun 15
16. Landscaping complete……15 Jul 15
17. Interior finish……...……..24 Sep 15
18. Final inspection and acceptance by owners …….29 Sep 15

Technical Requirements

The renewable energy sources must initially provide for approximately 2,000 KWH per month from a Grid-tile rooftop solar installation with Micro-grid AC Coupling (Wholesale Solar, 2014), upgradable to full energy independence (i.e. wind generation) with additional home owner investment at a later date. The design must facilitate the use of natural lighting as much as possible, using skylights and energy efficient windows and doors. Each room must have security, high speed internet, cable TV, and motion sensing to indicate room occupation to be used with HVAC zoning and automated lighting options for more efficient energy use. All appliances shall be at least Energy Star compliant. The structure will be built with a minimum of 2 X 6 inch sustainably sourced framing to allow for increased insulation and structural stability. Communications system will be designed with the most recently available consumer technology.

A geothermal heat pump system will provide heating and air conditioning to allow solar panels to be used primarily for direct electrical power generation.

Limits and Exclusions

Limitations of the project scope exclude:

1) Providing electrical power, sewage, natural gas, and water services to the site,
2) Development of driveways beyond 500 feet from the building site,
3) Maintenance contracts and inspections (e.g. septic system)

Customer Review and Approval

This scope statement serves to establish an understanding and agreement that the deliverables of this project outlined above are in accordance with customer expectations. Interim approvals for these deliverables will be sought to ensure your ongoing satisfaction with our progress. Modifications to the scope may be submitted during the planning and execution phases of this project. However, these will constitute Change Orders, potentially requiring changes to cost or schedule.

If, during the project, there are any issues or concerns please alert our organization as soon as possible. We look forward to serving you in this effort and look forward to our ongoing collaboration. Please sign and date two copies of this letter; one for your records, and the other for our records.

X_____	X_____
(Signature of Customer)	(Signature of Contractor)
Date_____	Date_____

Communication Plan

Stakeholder Analysis

Stakeholder analysis is intended to identify the groups that are involved in the project in order to ensure their communication needs are known by the project tem. Larson and Gray stated these stakeholders need "project information to make decisions and/or contribute to project progress" (2014, p. 120). The analysis of the stakeholders for this project show there are three main groups, the customer, the contractor, and the county (permitting and inspection). The list of stakeholders is included in Table 1 and is identified as audience or provider.

Information Needs

The homeowner, project manager, and general contractor will update one another as each subtask is completed, and if any activity will cause a delay, increased cost, or affect project inspection or completion milestones as soon as they are identified. The goal of this analysis is to ensure the project defines "what information is pertinent to stakeholders who contribute to the project's progress" (Larson & Gray, 2014, p. 121).

As defined in Table 1, the project manager will be kept apprised of aspects of the project from the project team, general contractor, and county Inspector in order to make adjustments in time, cost, or supplies. The project team will be responsive to all levels of the project to resolve issues as soon as practical. The county Inspector will provide written copies of each inspection milestone as it is accomplished to document the construction phases.

Sources of Information

The sources of information to be provided are in the communication plan provided in Table 1. This element of the plan defines 'where…the information resides" (Larson & Gray, 2014, p. 121).

Milestone reports provided by the project team to the homeowner and project manager will include progress status for each milestone. Project status reports are provided by the project manager and will include an updated risk register highlighting any risks that have become issues, along with the proposed remediation plan, primary point of contact for resolution, and project budget status. The General Contractor and sub-contractor status reports are provided by the respective entity and will include, at a minimum, actual and projected percent of completion of the task, status of known risks, and emerging risks. Issue reports will be updated by the responsible party per the schedule given in the below matrix. New issues affecting scope, schedule, or budget will be reported to the project manager by the responsible party immediately. All escalation reports are the responsibility of the project team and will be updated and briefed to the project manager as required. Approved change requests are the sole responsibility of the project manager. Change requests should be formulated and submitted by the project team to the project manager and will include recommended corrective or preventative actions to remedy or avoid potential shortfalls or undesirable conditions.

Dissemination Modes

Coordinating communication through predetermined modes will ensure clear concise answers to issues, questions and approvals. This element of the plan defines "how will [the information] be communicated" (Larson & Gray, 2014, p. 120).

Email and signed or certified mail hardcopies will be the preferred method of communication. In-person and hardcopy communication will be required for any escalation of reports that affect scope, cost, and time. The preferred methods of the communication will be by email and certified delivery of hardcopies for documentation as specified in the matrix. In

person and signed hardcopies will be required for any escalation of reports. All change requests will require email and hard copies once approved.

Responsibility and Timing

It is the responsibility of the party that cannot meet their respective task on time, within budget, or within scope, to notify the required audience in writing within 24 hours of the issue being identified, in accordance with Table 1. It is the audience's requirement to reply with their response or solution in writing within 24 hours of being notified. The exception to this is if the approval from the homeowner is required. Any approval costing more than $5,000 or delaying the primary project by more than one week must have the homeowner's signed approval.

Table 1: Project Communication Plan Summary

Project Communication Plan				
Deliverable	**Audience**	**Frequency**	**Method**	**Provider**
Milestone reports	Project Manager, Homeowner	Bi-monthly	Email and hardcopy	Project Team
Project status reports	Homeowner	Weekly	Email and hardcopy	Project Manager
General Contractor status reports	Project Manager, Project Team	Bi-weekly	Email	General Contractor Lead
Subcontractor status reports	Project Manager, Project Team, General Contractor Lead	Bi-weekly	Email	Sub-contractor Lead
Issues reports	Project Team	Weekly	Email	Sub- / General-Contractor Lead
Escalation reports	Project Manager	As applicable	In-person and hardcopy	Project Team
Approved change requests	Homeowner	As applicable	Email and hardcopy	Project Manager
Change requests	Project Manager	Weekly	Email and hardcopy	Project Team

Responsibility Matrix

Since this project is not considered large in scope a simple responsibility matrix would be preferred over an elaborate Work Breakdown Structure (WBS) or an Organization Breakdown Structure (OBS) (Larson & Gray, 2014, p. 113). The following responsibility matrix will identify who is responsible for which specific tasks on the project, who they will report to, and the appropriate approving authority. It will also outline a time line for reporting and the required response. (Larson & Gray, 2014, p.121).

Summary

The following responsibility matrix lists top-level deliverables and each stakeholder's role in completion of the respective deliverable. The roles are defined as follows:

1. Responsible: stakeholder is the primary producer/executor of the respective deliverable
2. Support: stakeholder supports the responsible party as required or defined by contract
3. Consult: stakeholder provides information or guidance to the responsible party
4. Notification: stakeholder will be notified of finalization or changes to the deliverable
5. Approval: stakeholder is the approval authority for completion of deliverable

Deliverables

The following matrix, Table 2, includes only top-level tasks. Sub-deliverables are not listed, but are ultimately the obligation of the responsible stakeholder. The deliverables are contracting, design, permitting, procurement, staffing, construction, inspection, and approval.

Stakeholders

The stakeholders listed in Table 2 each have varying degrees of involvement and responsibility. The Project Team is selected by the project manager to work the project and is responsible for consulting, expert professional analysis and quality control during the project.

The homeowner, referred to as the customer, is the primary stakeholder of the project. The architect will act as the project manager. The general contractor is the director of the sub-contractors working on the project and is responsible for control of all aspects of sub-contract performance. The County is the government agency responsible for tasking and documenting construction inspections to ensure all aspects of the tasks meet building codes, county and state requirements. They will also be responsible for documenting any and all non-compliance standards when reviewing.

Table 2: Responsibility Matrix

	Responsibility Matrix			
	Stakeholder			
Deliverable	Project Team	Customer	Contractor	County
Contracting	1	5	2	4
Design	3	3, 5	1	5
Permitting	3	5	1	5
Procurement	2	5	1	4
Staffing	1	5	2, 3	4
Construction	2	5	1	4
Inspection	2	5	1	1
Approval	2	5	1	4

1) Responsible
2) Support
3) Consult
4) Notification
5) Approval

Budget Approach

Determining an Accurate Budget

The Sustainable Home construction project is based on a budget not to exceed $1,000,000. This budget was derived from an initial top-down estimate by the corporate managers. While this top-down method was the main input in developing the budget other key elements were utilized creating the budget for this construction project. Since the design was not yet finalized it was logical to utilize a top-down approach to determine the estimated project cost. (Larson & Gray, 2014, p. 135) Table 3 below is an example of the top-down estimate for the Sustainable Home Construction project.

Once the initial project plan was developed and key requirements determined then research from the National Association of Home Builders (NAHB) provided accurate cost estimates as the project developed. The cost estimate for a single family home in 2013 was just under $250,000; while others averaged construction prices for a new home at approximately $400,000 (Taylor, 2014, p. 1). We were also able to obtain detailed pricing of a high-end 3500 square foot home with geothermal heat pump unit, built by Prindle and Prindle Inc. of Boise Idaho. (personal communication, November 2, 2014)

The U.S. Green Building Council defined a LEED house, “Leadership in Energy & Environmental Design” (USGBC, n.d.). LEED provides specific building criteria that allows for the estimate to be modified in order to meet the project objectives. The budget would become more accurate as the project progressed. (Larson & Gray, 2014, p. 274)

The time-phased work report in Table 4 is a break down by primary tasks from the project plan and shows Name of key task, remaining cost, actual cost, cost or (estimated cost) with Actual Cost of Work Performed (ACWP), Budgeted Cost of Work Performed (BCWP), and

Budgeted Cost of Work Scheduled (BCWS) to provide for accurate tracking of each deliverable and if it is under cost or over cost as compared to the project estimate. This tracking takes into account cost of resources paid. The information in Table 4 would provide accurate budget tracking as the project progressed allowing for adjustments and changes when each high level task was reported.

When utilizing Microsoft Project 2013 the team can also track the variance over time utilizing the report option. The variance over time in Microsoft Project 2013 allows for viewing "Cost and schedule variances for the project based on status date. If CV is negative, then the project is over budget. If SV is positive value then the project is behind schedule."

Table 3 Sustainable Home Construction Project Cost Estimate

WBS	Task Name	Duration	Resource Names	Cost
1	Sustainable Home Construction Project	180 days		$681,157.52
1.1	Project Initiation	2 days		$78,040.00
1.2	Project planning	47 days		$72,680.00
1.2.1	Design	47 days		$67,680.00
1.2.2	Permitting	30 days	County Government, Permit Fees[1]	$5,000.00
1.2.3	Design complete	0 days		$0.00
1.3	Executing	127 days		$524,037.52
1.3.1	Foundation	22 days	Foundation Materials[1]	$17,120.00
1.3.2	Geothermal Heat pump ground unit	11 days	Geothermal Materials[1]	$53,900.00
1.3.3	Framing	17 days	Framing Materials[1],Roofing Materials[1],Trusses[1]	$139,476.40

1.3.4	HVAC system	13 days	HVAC Materials[1]	$14,160.00
1.3.5	Electrical	9 days	Electrical Materials[1]	$21,455.20
1.3.6	Plumbing	11 days	Plumbing Materials[1]	$22,191.20
1.3.7	Communication systems wiring	10 days	Communication System Materials[1]	$23,000.00
1.3.8	Interior structure ready for drywall	0 days		$0.00
1.3.9	Solar system	4 days	Solar Panel Materials[1]	$25,600.00
1.3.10	Exterior finish	30 days		$57,800.56
1.3.11	Interior	69 days		$119,454.16
1.3.11.1	Drywall	18 days	Drywall Materials[1]	$19,040.00
1.3.11.2	Interior finish carpentry	18 days	Interior Finish Materials[1]	$16,400.00
1.3.11.3	Interior painting	11 days	Paint (Int)[1]	$12,200.00
1.3.11.4	Kitchen and bathroom cabinetry	14 days	Cabinets[1]	$20,380.00
1.3.11.5	Appliances and fixtures	22 days		$23,574.16
1.3.11.6	Finish flooring	7 days		$27,860.00
1.3.11.7	Interior complete	0 days		$0.00
1.3.12	Structure complete (Interior and Exterior)	0 days		$0.00
1.3.13	Landscaping	26 days	Landscaping Materials[1]	$29,880.00
1.4	Monitoring and control	129 days		$4,480.00
1.5	Closing	3 days		$1,920.00
1.5.1	Final inspection and acceptance by owners	3 days	Customer, PM	$1,920.00

Table 4: Cost of Top Level Tasks

Name	Remaining Cost	Actual Cost	Cost	ACWP	BCWP	BCWS
Lot purchased	$75,000.00	$0.00	$75,000.00	$0.00	$0.00	$0.00
Contract signed, Project started	$3,040.00	$0.00	$3,040.00	$0.00	$0.00	$0.00
Design	$67,680.00	$0.00	$67,680.00	$0.00	$0.00	$0.00
Permitting	$5,000.00	$0.00	$5,000.00	$0.00	$0.00	$0.00
Design complete	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Foundation	$17,120.00	$0.00	$17,120.00	$0.00	$0.00	$0.00
Geothermal Heat pump ground unit	$53,900.00	$0.00	$53,900.00	$0.00	$0.00	$0.00
Framing	$139,476.40	$0.00	$139,476.40	$0.00	$0.00	$0.00
HVAC system	$14,160.00	$0.00	$14,160.00	$0.00	$0.00	$0.00
Electrical	$21,455.20	$0.00	$21,455.20	$0.00	$0.00	$0.00
Plumbing	$22,191.20	$0.00	$22,191.20	$0.00	$0.00	$0.00
Communication systems wiring	$23,000.00	$0.00	$23,000.00	$0.00	$0.00	$0.00
Interior structure ready for drywall	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Solar system	$25,600.00	$0.00	$25,600.00	$0.00	$0.00	$0.00
Exterior finish	$57,800.56	$0.00	$57,800.56	$0.00	$0.00	$0.00
Interior	$119,454.16	$0.00	$119,454.16	$0.00	$0.00	$0.00
Structure complete (Interior and Exterior)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Landscaping	$29,880.00	$0.00	$29,880.00	$0.00	$0.00	$0.00
Final inspection and acceptance by owners	$1,920.00	$0.00	$1,920.00	$0.00	$0.00	$0.00

Time-Phased Budget

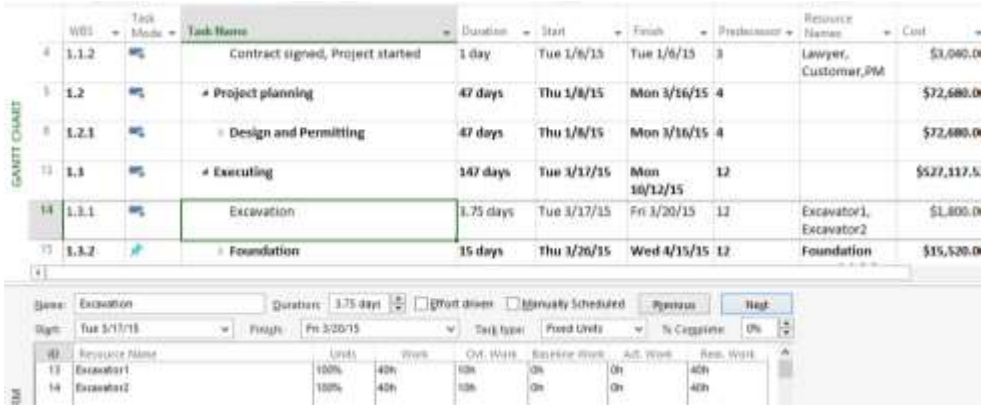
A time-phased budget for this project was established to assist in determining progress payments to the service providers and to help in conducting schedule compression analysis. In addition, project performance measures such as Earned Value, Cost Performance Index (CPI), and Schedule Performance Index (SPI). CPI measures the "cost efficiency of the work accomplished to date" (Larson and Gray, 2014, p. 473). When the value of CPI is greater than 1.0, the project or task is better than planned through that period. When looking at the Schedule Performance Index (SPI), like CPI, when it is less than 1.0 can be considered 'worse than planned.' The time-phased budget can be found in Appendix 2.

Reducing the Schedule Length and Impact on Budget

The current project plan has a duration of 201 days, with project completion on 16 October 2015. There is a possibility that the homeowners will need to move in earlier than they are currently planning, because they will be selling their existing home. As a result, the project team assessed an alternate course of action to determine the feasibility of an earlier move-in date. By crashing some of the critical tasks, the team could bring the project time from 201 days down to 188.25 days for a 30 September completion. Further crashing could be done to determine additional time savings, although that would come with a price. This approach assumed that material costs would not change and so the crash could be achieved through paying overtime at a rate of 1.5 times the normal rate.

To figure out which task should be crashed, and knowing we were attempting to meet the schedule by adding overtime work for select workers, we looked at the lowest pay-rate employees first. Since that was the excavators, the first task to be crashed was WBS 1.3.1 – Excavation. By adding 2 hours of overtime per day to each of their schedules, one can see in the Table 5 that the resulting completion time was reduced from 5 to 3.75 days, at a cost of $200.

Table 5 – Example of Crashed Task



	WBS	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost
4	1.1.2		Contract signed, Project started	1 day	Tue 1/6/15	Tue 1/6/15	3	Lawyer, Customer,PM	$3,040.0
5	1.2		Project planning	47 days	Thu 1/8/15	Mon 3/16/15	4		$72,680.0
6	1.2.1		Design and Permitting	47 days	Thu 1/8/15	Mon 3/16/15	4		$72,680.0
13	1.3		Executing	147 days	Tue 1/17/15	Mon 10/12/15	12		$527,117.5
14	1.3.1		Excavation	1.75 days	Tue 1/17/15	Fri 1/20/15	12	Excavator1, Excavator2	$1,800.0
15	1.3.2		Foundation	15 days	Thu 1/26/15	Wed 4/15/15	12	Foundation	$15,520.0

ID	Resource Name	Units	Work	Ovt. Work	Baseline Work	Act. Work	Rem. Work
13	Excavator1	100%	40h	10h	0h	0h	40h
14	Excavator2	100%	40h	10h	0h	0h	40h

Continuing to follow that methodology, we then crashed the following activities:

1.3.2 – Foundation (Concrete workers)

1.3.4.14 – Pour sidewalks and driveways (Concrete workers)

Bumping the concrete workers up to 2 hours per day of overtime resulted in a net time savings for the overall project of 5 1/2 days, at a cost increase of only approximately $1200. With just these few inexpensive crashes, the project saved almost 7 days in the overall schedule.

Further crashing, looking now at the roofing task saved another 3.5 days following the same methodology. Then by adding overtime to the siding installers and also the drywall team, we were able to reduce the project completion date to 30 September. With this addition, as can be seen in table 6 below from the project plan that reflects these crashed activities, we now could meet a 1 October move-in date for the customers at an additional cost of only $2700.

Table 6 – Final Cost and Time for Crashed Project Plan

	WBS	Task Mode	Task Name	Duration	Start	Finish	Cost	P
1	**1**		**Sustainable Home Construction Project**	**188.25 days**	**Mon 1/5/15**	**Wed 9/30/15**	**$687,737.52**	
2	**1.1**		**Project Initiation**	**2 days**	**Mon 1/5/15**	**Tue 1/6/15**	**$78,040.00**	
5	**1.2**		**Project planning**	**47 days**	**Thu 1/8/15**	**Mon 3/16/15**	**$72,680.00**	**4**
13	**1.3**		**Executing**	**135.25 days**	**Tue 3/17/15**	**Fri 9/25/15**	**$530,617.52**	**1**
121	**1.4**		**Monitoring and control**	**129 days**	**Mon 2/2/15**	**Mon 8/3/15**	**$4,480.00**	
129	**1.5**		**Closing**	**3 days**	**Fri 9/25/15**	**Wed 9/30/15**	**$1,920.00**	**1**

Outsourcing Strategy

The Sustainable Home Project is an entirely outsourced project, making it difficult to demonstrate an advantage for additional outsourcing. However, the framing contractor, Hammer and Nail Construction Inc. has been offered another job which will start near the half-way point of their contracted work on our project. Both have the potential for being very lucrative prospects and they don't wish to lose out on either opportunity.

Hammer and Nail is a high-end rough framing company with an excellent reputation of in for quality and timeliness of work. They usually contract out at a higher price per job than most other companies, but are in demand with high quality home builders because of the quality of work they are known for. They typically complete all the framing and roofing work on the job site to ensure that the building is straight, level, and built to their high professional standards.

The Challenge

The Sustainable Home Construction job needs to start framing on the April 16, 2015, and is scheduled for completion and inspection on the June 9, 2015. The other job site is scheduled to begin construction on the May 5th and is also a quality home build with potential for follow-on contracts. Hammer and Nail has a large enough of a construction crew to handle only one job site at a time with three part-time workers who can handle minor jobs under supervision. In order to meet the requirements of both job sites Hammer and Nail will have to outsource a portion of the work. They will need someone who is reliable enough to maintain their high construction standards and timeliness of work. Spiffy Topper Roofing Company is based in the area and is known for quality services. The owner is a former employee of Hammer and Nail

Construction. Both respect each other's workmanship and have referred customers to each other for the last several years.

Jim Purvis, the owner of Hammer and Nail, approached Johnny Rickenbacker of Spiffy Topper at the town Christmas parade with a plan to join forces. Johnny's construction crews had a busy year, the year before but, due to the economy, most people were holding off on major home repair. For the most part Spiffy Topper was doing patch and fix work instead of roof replacements, which pays the bills but doesn't sit well with Johnny. "It's hard to guarantee a patch in an old roof, the rest of the roof may fail then I look bad for fixing it even though my part is quality." Johnny was eager to start putting his guys to work on complete jobs again.

The Solution

Spiffy Toppers crews were made up of experienced construction people with the same attitude towards "doing a job right" as Johnny and they, too, earned a premium wage. During their conversation Johnny told Jim that his crews could get the roofing work done in two thirds of the time Jim had planned for his crew. This meant shortening the scheduled roofing time from three weeks to two; and Hammer and Nail would be able to use the people they would have had roofing to complete the framing work even earlier. All in all they would be able to cut the entire job requirement time by 20 days, allowing Hammer and Nail to send two thirds of their workers and a foreman to start on the next project on time.

Since the original job bid for the Sustainable Home project was already accepted, reducing the schedule would not affect Hammer and Nail's net profit, as long as the outsourcing costs didn't exceed their expected organic cost. Knowing this, Johnny agreed to accept the rate Hammer and Nail had bid on the roofing job even though it was slightly lower than what he

would have bid; but only, if he were given an opportunity to bid on future Sustainable Home project roofing jobs whenever Jim became aware them.

The two companies agreed and began to draw up the contract. One minor contention was who would bear overall responsibility on the job site for the work being done. Jim demanded that his foreman, a tough, no-nonsense sort who he has trusted for years, take the lead. But Johnny having worked for the man was unwilling to put his employees under his supervision. Johnny normally acted as a foreman on his roofing crews; he liked to work with the guys but decided working alongside a prior supervisor would put him at a disadvantage. The two agreed that Jim's foreman would have decision making power at the site but had to work through Johnny's assistant on roofing issues and if an unresolvable disagreement were to arise, both Johnny and Jim would be available to work it out. With the line of communication, the compensation, and time frames agreed upon. It seemed that all they need to do is get their respective legal counsel to draft the papers.

Conclusion

By outsourcing the roofing portion of the Sustainable Home Construction Project to Spiffy Topper Roofing, Jim was able to complete the contracted task in less time enabling him to start the new project on its proposed start date. Although Spiffy Topper would receive the profits for the roofing portion of the Sustainable Home job, having Johnny's company finish the roofing allowed Jim to move his foreman and most of his crew to the next job without delay. This enabled Johnny to accept concurrent projects and created greater profit in the long run.

Quality Management Plan

The following Quality Management Plan will describe how quality control will be planned, managed, and measured throughout the project and will serve to establish a common understanding of quality management for all project stakeholders (Piscopo, 2014). This plan is organized to establish:

- quality management approach
- quality standards
- quality assurance activities
- quality control activities

Quality Management Approach

While the project manager retains ultimate responsibility for quality management, every member of the project team must ensure quality is a top priority. The quality management approach will be to plan, execute, measure, verify and document compliance for all deliverables in accordance with applicable industry standards, Colorado state building codes, and the 2012 edition of the International Residential Code, except where specifically amended by state, county, or city code (Colorado, 2013) (International Code Council, 2012).

All stakeholders must fully understand the expectations of the project manager, and ultimately the customer, before any work is to begin. Each party responsible for a deliverable will be well acquainted with the standards and regulations governing their respective trade and will have internal processes to ensure compliance with the same. Project team members assigned as quality representatives will support and advise contractors in establishing a robust

quality assurance system as well as verify validity of and adherence to the processes. Quality control measures will be in place prior to production of the respective deliverable.

Adherence to the industry standards and building code will be verified by the producing party, project team quality representatives, state/county officials, and ultimately the customer. Thorough documentation of meeting or exceeding the quality standards throughout the building process will be accomplished by producing parties as well as the project team. Final verification and documentation will be provided by the state/county inspection official.

Through effective planning, execution, monitoring, and thorough documentation, the project team will ensure the highest quality product is delivered to its customer.

Quality Standards

Colorado State approved state building code, chapter 1; section 101.2 indicates the International Residential Code will be used for establishing quality standards for residential construction of single-family dwellings (Colorado, 2013, p. 3). As such, this document, and parent standards reference therein, will form the basis of quality standard minimal for this project. It remains the goal of the project team to exceed these standards wherever feasible and prudent, however, deliverables meeting the standards outlined in this code are acceptable.

Proof of adherence to the standards in both product and process will be incumbent on the producing party and will be verified by the project team quality representative. Open communication and transparency among all stakeholders is vital to ensuring all parties are executing in accordance with the appropriate regulations and standards. In cases where process quality becomes less than that called for in the governing regulation, or where the project team quality representative deems necessary, the processes in question will cease until a resolution is reached. This will ensure all work is done at or above standards to avoid rework where possible.

Quality Assurance

Quality assurance for the project will be based on the overall quality management strategy plan of: execute, measure, verify and document. An assigned project team quality representative will advise the producing party on establishing a quality management plan before any work begins. This will include establishing valid and meaningful metrics for the job at hand. Due to the wide range of tasks encompassed in this project, this Quality Management Plan will not delve into specific metrics, but will require that quality representatives define these metrics for efforts they oversee. Quality assurance metrics should be process-focused instead of product-focused. Key metrics will be reported to the project manager on a weekly basis via defined methods in the project communications plan. Known quality shortfalls or negative quality trends may require more frequent reporting and will be directed by the project manager.

In addition to reporting quality metrics to the project manager, quality representatives will perform regular, recurring process and documentation audits to ensure continued adherence to standards. The project manager may supervise audits on occasion to ensure objectivity.

Quality representatives will function on site as integrated team members required to verify processes, enforce standards and encourage process and product improvement.

Quality Control

Unlike quality assurance, quality control is product-focused. Project team quality representatives will establish periodic inspection points as a part of the planning phase of their respective effort. These inspection points can be chronologically based, but will more likely be based on individual task milestones. The quality representative, accompanied by the producing party, and the project manager for key milestones, will perform physical inspections and/or testing as applicable. Again, due to the diversity of tasks this Quality Management Plan will not

dictate specific inspections or tests, but quality representatives will establish inspection points before commencement of their respective effort. Producing parties may be required to provide documentation of more frequent inspections and/or tests as determined in the quality planning phase.

All inspections and tests will be thoroughly documented and reported to the quality representative. Key milestone inspections, as identified by the project manager, will be reported in the bi-weekly sub-contractor status reports. Known quality shortfalls or high-risk activities may require more frequent reporting and will be directed by the project manager.

Any failed or marginal inspections and/or tests will be reported immediately to the quality representative. All similar work in process will cease until resolution is reached. This is to ensure all deliverable are produced at or above the standard and to avoid rework to the max extent possible.

Stakeholder Acceptance

Customer:_____ Date:_____

Project Manager:_____ Date:_____

Quality Representative:_____ Date:_____

General Contractor:_____ Date:_____

Change Control Process

The following Change Control Process will describe how the project team will manage the change control process. It will spell out the project team's approach to change, the process for requesting a change, the approval process for requested changes, and implementation of approved changes. All parties responsible for producing deliverables will be familiar with the process and philosophy governing change control for this project.

Approach to Change

Controlling change is critical to maintaining project schedule, budget, and scope. The project team will aim to minimize change through robust planning, effective resource management, and proactive risk management.

Planning is the first and most effective tool to minimizing change. Each producing party will have a plan established to guide them from conception to completion of their respective deliverable before work is to begin. A project team quality representative will be assigned to advise the producing party and approve the plan for each deliverable. Any change to the plan once work begins will be routed through the quality representative per the change control process spelled out below.

After the plan is developed and execution has begun, team leaders must manage and allocate resources effectively in order to accomplish their task within schedule and budget. Smart organization will enable teams to meet or even exceed their performance goals. Resource management will be a key risk management tool throughout the project. General and sub-contractors will be primarily responsible for managing the resources necessary to produce their

respective deliverable, while project team members will provide oversight and guidance as required.

Along with smart resource management, the project team will utilize proactive measures to manage risk. A proactive approach to addressing risk items as they begin to be realized will preserve options to mitigate or avoid the risk altogether. Change requests to avoid negative outcomes, rather than repair them will circumvent rework and minimize wasted effort. Timely identification of risk item realization and implementation of necessary change will be critical to overcoming adversity which is sure to occur.

Process for Requesting a Change

Any stakeholder wishing to make a change to a deliverable or a process will generate a Change Request found in Figure 1: Change Request Form. The form will be filled out completely and submitted through the assigned project team quality representative. The project team member will review the request and verify the necessity for change before forwarding the request to the project manager via hardcopy or e-mail per the communication plan. Emergency change requests will be submitted as soon as it is prepared and will require direct contact with the project manager. Emergency changes will be made on rare occasions and only in response to undesired products or process results.

Before a change request is submitted to the project manager the quality representative will ensure alternative measures have been considered. Alternative solutions considered should include: coping with the issue through resource reallocation, organizational restructure or manning changes, additional or different training for employees, etc. Change requestors will

also coordinate with any parties responsible for deliverables which are dependent on the product requesting to be changed to ensure there is no degradation to interoperability.

The change request form differentiates between process changes and product changes, however, the process to request the change will be the same. Certain changes will affect both the process and the product. The requestor need not submit separate requests. If the change is driven by a previously identified risk or issue, ensure the form indicates which risk or issue is being remedied. Once the change request is reviewed and approved for submission by the project team quality representative, the project team member becomes the sponsor of the request. The sponsor will be primarily responsible for the implementation of the change. They will ensure the change is documented and update the master schedule and budget as required.

While change is generally discouraged, continuous process and product improvement are highly encouraged. Project team members must always consider the potential cost and benefit of proposed changes and pursue change when prudent.

Approval Process

All change requests will be submitted by project team members per the communication plan, with exceptions as described above. The project manager will review change requests weekly, unless more urgent action is required. In which case, the requesting project team member will contact the project manager directly.

The project manager will consult with subject matter experts and relevant stakeholders, to include the customer when final products are affected, as required when considering change requests. If denied, the project manager will provide rationale for their decision. The project team sponsor will be able to amend and resubmit the change request. If the change request is

approved, the project team sponsor becomes the primary party responsible for implementing the change.

Implementation of Change

Implementation of the change will be the responsibility of the project team sponsor. They will ensure all interested parties are aware of the change and develop a plan for its implementation. The project team sponsor will also ensure the schedule and budget of the WBS task and any other affected by the change are updated. While authority to implement the change can be delegated to prime or sub-contractors, responsibility for its implementation cannot.

The project team sponsor will provide weekly updates on the implementation and result of changes until the project manager directs otherwise. This step must not be overlooked or its importance underestimated. Project team sponsors will be responsible for reporting if the change resulted in the desired outcome, and if not, determining if additional change is required.

The project manager will provide change reports to the customer as directed in the communication plan. Generally, only changes affecting the end-deliverable, overall cost, or schedule will be reported to the customer. Internal changes which are transparent to the customer will only be provided when requested by the customer.

Figure 1: Change Request Form

Change Request Form			
WBS Task:		**Date:**	
Change Requestor:		**Change Request No:**	
Project Team Sponsor:		**Known Risk/Issue No:**	
Change category (check all that apply): □ Product Change □ Process Change □ Corrective Action □ Preventative Action □ Defect Repair □ Updates □ Other:_____			
Does this change affect (check all that apply): □ Schedule □ Cost □ Scope □ Deliverables □ Testing/Quality □ Resources □ Other:_____			
Describe the change being requested:			
Describe the reason for the change:			
List expected impacts to schedule and/or budget:			
Describe potential impacts to subsequent WBS:			
Describe risks to be considered for this change:			
Estimate resources needed to implement this change:			
Coordinated with downstream product producers: □ Yes – no impact □ Yes – impact mitigated □ N/A			
Disposition: □ Approve as submitted □ Approve with comment □ Denied			
Justification of Approval, Comment, or Rejection:			
Change Board Approval:			
Name	**Signature**	**Date**	

Risk Management Plan and PERT Analysis

Purpose

This document defines the processes for conducting risk management activities for development of the project. The risk management plan establishes policy, disseminate guidance and communicates procedures to ensure the most effective use of risk management techniques with in the project. A project's own people, process, and technologies can be contributors to increased risk. Economics, as well as environmental, social and political issues are sources of external risk. Risk management requires proactive risk identification, analysis, mitigation and documentation procedures and must incorporate the project team, subcontractors and key stakeholders to meet project objectives. This plan is guided by the project scope statement, cost management plan, schedule management plan, and communications plan.

Scope

The scope of this document provides risk focus for the project team on project activities including schedule, cost, and technical project aspects; and identifies parties for which some risk responsibilities will contractually be transferred. This effort involves identification, analysis, mitigation, and management of internal and external threats.

Objectives

1. The total cost of the project, including management reserve, will not exceed the $1M.
2. The total duration of the project, including management reserve, will not exceed 9 mos.
3. Quality and scope requirements will be met, unless changes are approved through formal change order process.

Supporting Products

The project's management plan and scope provides general guidance related to the project team's management approach, quality and budgetary goals as well as scheduling guidance. The International Building Code and minimal quality requirements as referenced in the quality management plan for this project. Stakeholders and subcontractors provide input on risk assessment continually which will be documented and become part of the project support.

Referenced Products

Referenced documents include:

1) Project Management Plan and Budget
2) Project Work Breakdown Structure (WBS)
3) ICC IBC (2012): International Building Code
4) A Guide to the Project Management Body of Knowledge

Roles and responsibilities

Risk Originator:

Risk originators are any project team member, subcontractor, stakeholder and customer involved in this projects activities who identify a risk which could affect the outcome of the project scope.

Risk Owner:

Person or entity responsible to control, mitigate, or avoid risks, as well as execute responses. The risk owner must develop and document a risk resolution action, meet resource and timeline requirements as established in project documents, immediately communicate any deviations from documented requirements to the PMO and update the risk management tracking sheet status of risks resolution.

Functional Teams/Subcontractors:

Any group performing work within the project. Functional teams and subcontractors will analysis risks, determine addressable cause, determine impact on implementation activities, and communicate the result of this analysis to the PMO within established timelines. Teams and subcontractors are responsible to effectively manage all risks inherent in the task for which they were obligated, and if unable to do so, must report to the PMO as soon as possible.

Project Management Office:

The PMO includes the administrative staff, project management team members and the project manager. These individuals are responsible to review and validate risk analysis and qualification as well as develop proposed mitigation solutions and closure criteria. They provide assistance to establish mitigation action, assign risk owner, and communicate time requirements for risk mitigation. The PMO reviews all activity documentation to ensure accuracy and completeness. The PMO reviews project risk activity weekly and disseminates risk assessment changes. The PMO also determines primary target severity levels, and the alternate methods and resources required to mitigate the risks

Project Manager:

The project manager (PM) or designated representative is responsible to coordinate with the stakeholder, customers and any outside organization to facilitate the project. They also approve the mitigation activities of high level risks and ensure communication of the status of these activities to appropriate offices. The PM is overall responsible for the project risk mitigation and management plan.

Support Tools

Project tools to manage risk include the risk register which will be used to communicate identified risks to the project team (see appendix). This document will be provided to

stakeholders identified by the PM. The information from the risk register will be used to manage status of qualifying risk, maintain historical records and provide for post project review data. Risk process review will be accomplished on a monthly basis by functional team leads who will communicate status of new and previously identified issues documented in the risk register.

Budgeting

Funding for this project will be in accordance with the project cost estimate established in the Budget Approach. Funding for mitigation for risks owned under contract by subcontractors will be the responsibility of the subcontractor. In the event subcontractors are unable to mitigate risks at their level they shall notify the project management team as soon as possible and not later than two weeks prior to the activity deadline. A budgetary management reserve has been established based on 25% of the established estimated cost, and will be available for distribution under the authority of the project manager following coordination with stakeholders and the customer. The management reserve may also be used to mitigate or avoid the effects of external risk with approval as listed previously.

Risk Management Methodology and Processes

The plan intentions are to mitigate or reduce the negative risks ("risks"). Exploiting the possibilities positive risks ("opportunities") within the project will not be handled under this plan. Opportunities to reduce schedule or cost will be identified and handled under the Change Order process. Within this document the term "risk" will mean only negative risk. Risk management is an iterative process of addressing threats to the realization of project cost, schedule, quality, and other key performance objectives.

Risk management procedures include identification, analysis, assignment of responsibility, mitigation, and tracking of potential risks and emerging issues. Risks are adverse

threats that have not yet materialized, while issues are risks that have materialized and begun to impact the project. The main risk management procedures are:

1) Identify risks and issues in a timely manner
2) Analyze severity and probability of risk factors
3) Plan mitigations to minimize impact on objectives
4) Implement risk and issue mitigations
5) Accept risk
6) Monitor and document risk / issue

Figure 2: Risk Management Process Steps

This section identifies the step-by-step risk management process utilized in this project. The iterative nature of the risk management process means that every activity should be reviewed for potential risks. Following identification, analysis and actions must be taken to resolve emerging issues. Risk management processes are integral to our project strategy and implementation. Figure 2 outlines the steps for risk management.

Identify Risks

Utilizing a Risk Breakdown Structure, the team will brainstorm risk ideas and submitted them to the PMO three weeks prior to the proposed project start date. Two weeks prior to project start the project management team, stakeholders, subcontractors, and customer will meet to discuss, evaluate and categorize identified risks. The PMO will forward the risk register to all team members not later than one week prior to the project start date.

All members of the project team are responsibility to identify and communicate potential risks. This process requires constant attentiveness to ensure accuracy. Proactive risk management relies on identification of potential risks prior to the risk materialization including evaluation of all project activities, internal and external which may impact the project cost,

schedule and/or performance objectives. The risk register will be updated and forward as a report to the appropriate team lead and PMO (see appendix). Initial risk assessment can be accomplished by the team member using this sheet. Final assessment of the risk shall be accomplished by the PMO. If necessary the PMO will coordinate with risk owners to categorize identified risks. As defined in the communication plan, weekly reports will be sent to the PMO on all issues that arise. This will include mitigation of risks and completion of tasks.

If new risks are identified, the PM or PMO will forward information to the team and make an initial evaluation as to whether there is a need to meet to revise the risk mitigation plan. As risks are mitigated and tasks completed there will be no further need to report or evaluate the identified risks. Documentation of the results of the risk elevation shall be forward to the PMO upon completion of risk owner responsibilities and not later than two weeks prior to the established project complete date.

Analyze Risk

Two effective ways to establish the result of risk on a project are to evaluate the likelihood or the probability, of risk occurrence, and the impact, or the severity, of the negative effect if the risk occurs. Upon identification of a possible risk an initial analysis must be made and the risk register accomplished and forwarded. The PMO will evaluate and may decide to collaborate with the rest of the team to validate and create an execution plan for the risk. The weekly project team meeting serves as forum for disseminating risk information. During this meeting the impact of the risk across all functional areas will be discussed. The PMO then designates the risk owner. This process allows for multiple inputs on each activity and provides a broad level of review. This process not only aides in risk identification and qualification but also

prioritizing risk resolution activities. The tools are used to assess qualitative and quantitative analyze risk are demonstrated in the following tables.

Table 3 provides guidelines to determine the probability of occurrence of the risk.

Table 3: Probability of Occurrence

Likelihood	Estimated Probability	Effect
Remote	5%	Negative outcome is almost non-existent
Unlikely	15%	Negative outcome is not likely
Even Chance	50%	Negative outcome is likely
Highly Likely	85%	Negative outcome is very likely
Near Certain	95%	Negative outcome is almost certain

Table 4 provides guidelines to assess impact on the project if the event occurs.

Table 4: Significance of Impact

Impact	Cost	Schedule	Quality
Low	Resolution expected to cost less than 5% of project budget	Minimal or no impact	No reduction in performance or structural integrity
Minor	Resolution expected to cost between 5% and 12% of project budget	Chance of missing checkpoints. No impact to project complete date	No reduction in performance to **critical** system or component functions
Moderate	Resolution expected to cost between 12% and 15% of project budget	checkpoints will not be met, Minor schedule slip of no more than 1 weeks to critical path activities	Does not meet LEED code objectives; may not pass initial inspection without minor resolution
Significant	Resolution expected to cost between 15% and 20% of project budget	Critical path affected by 2 week schedule slip. Will not meet checkpoints or milestones	Does not meet Project criteria or pass building code without Major redress
High	Resolution expected to cost 25% or more than of project budget	Will not meet activity delivery by1 month schedule slip to critical path required	Does not pass building code or meet Scope requirements as documented

Once the risk is factored for the probability of occurrence and significance of impact from the tables above, it is plotted on the risk matrix, shown in Figure 3. Not only does this

process help to prioritize risks, but it allows the team to understand which level of the organization can accept risk. Using this matrix we can place different risks into one priority listing for attention, mitigations, or funds allocation.

Impact	Remote	Unlikely	Even Chance	Highly Likely	Near Certain
High	*5*	*6*	*7*	*8*	*9*
Significant	*4*	*5*	*6*	*7*	*8*
Moderate	*3*	*4*	*5*	*6*	*7*
Minor	*2*	*3*	*4*	*5*	*6*
Low	*1*	*2*	*3*	*4*	*5*

Figure 3: Risk Matrix

Plan Response

Upon completion of the risk analysis, a response will be determined by the PMO with input from subject matter experts, documented, and communicated to the risk owner. The PMO shall assign a risk owner who will report on risk activities in accordance with previously established guidelines. Risk activities mitigation strategy and status are a priority topic during the weekly project team meeting.

Table 5: Strategies for Mitigating Risk

ACTION	DESCRIPTION
Mitigate	Reduces likelihood or impact of a risk possibly to elimination. Mitigation can occur at any point within the project.
Avoid	Changes of the project management plan to eliminate the threat. To find an alternative method of accomplish task to do away with the risk
Transfer	Place responsibility of the risk on another organization, example: using contractual agreements, subcontractors assume the risk and provide warranties or the customer to assume some of the risk.
Accept	Tolerate the risk while attempting to elude its consequences

Risk Acceptance

Once an issue has been mitigated and all actions have been taken to control, the PM will review the results and determine if the residual risk is acceptable to continue. Residual risk is the risk that the issue, once resolved will remain mitigated or re-emerge as an issue. Only the PM can accept closure of the action items associated with a medium of high risk issue.

One month prior to project complete date, the PMO will organize risk management documents for archiving. Final evaluations and acceptance of all issues and risks shall be forwarded to the PMO two weeks prior to project complete date. One week prior to project completed date the PMO, stakeholders, subcontractors, and customer will convene to review and suggest risk management strategies for future projects. From this meeting a final risk management report will be generated and submitted to the project archive.

Tracking

Using the risk register allow the project team to identify document and monitor risks. The risk register shall have an assigned risk number and each element of the register will be completed. The risk originator has the responsibility to ensure notification is made to the PM that a new entry has been made on the risk register. The PMO will ensure that all unresolved risks are part of the weekly project team meeting. The PM will identify the risk owner and provide a copy of the risk register line item for remediation and monitoring. The risk owner is will mitigate the risk following guidance and follow upon on status at least weekly one day prior to the weekly project team meeting. Upon completion of the risk mitigation, the risk owner will notify the PM and complete the remainder of the documentation and forward the data sheet to the PMO for archiving.

Program Evaluation and Review Technique (PERT)

The focus of this home construction project is an industry leading, beautiful, and environmentally efficient home, a high degree of planning is required to ensure projects are on time and within budget. The use of the Program Evaluation and Review Technique (PERT) is statistical technique used to review activities, cost, and "assessing projected risk" (Larson & Gray, 2014, p. 213). PERT analysis "assumes a statistical distribution (range between optimistic and pessimistic) for each activity duration…[to produce a] relative probability…of an activity becoming critical…" (p. 213). This analysis allows the project manager to evaluate the potential of an activity becoming a schedule risk. Armed with this knowledge, the project manager can identify potential risk factors and develop mitigation strategies that will increase the assurance that the project can be completed as planned.

The three time estimates used in the PERT analysis are shown in Table 1: Duration Distribution Table below. The first is the Optimistic time the best case scenario that all things will come together with no issues and the identified task or activity will be completed by this time. Larson and Gray, 2014 define optimistic in the PERT analysis as "a 1 chance in 100 of completing the activity earlier under normal conditions" (p. 240). The next estimate is the Most Likely time in which the activity may be completed based on professional experience and past project data. The final time estimate is Pessimistic and is based on the possibility that some issues might arise and cause a slowdown of the activity. Larson and Gray also define Pessimistic in the PERT analysis "a 1 chance in 100 of completing the activity later under normal conditions" (p. 240).

Expert opinion provided the basis for the estimated values defined in Table 6 and were used to determine the most reliable duration of each project task using the following PERT formula below.

Equation 1: PERT Formula

$$\frac{a + 4m + b}{6}$$

The results of the PERT analysis will provide the project manager a weighted average (rounded) for each project task which will be used in performing forward and backward pass activities to define the project's duration and identify the critical path.

Table 6: Duration Distribution Table

Task	Optimistic (a)	Most Likely (m)	Pessimistic (b)	Weighted Task Duration
Initiation	1	2	3	2
Design	30	47	60	46
Permitting	15	30	45	30
Foundation	20	22	25	22
Geothermal Heat pump	8	11	15	11
Framing	15	17	25	18
HVAC system	10	13	16	13
Electrical	6	9	12	9
Plumbing	8	11	15	11
Communication system	5	10	15	10
Solar system	3	4	6	4
Exterior finish	25	30	40	31
Interior	60	69	80	69
Landscaping	20	26	35	27
Closing	1	3	5	3

When the project's information is reviewed utilizing PERT as in Table 7, we determined the project duration to be 246 days. (Larson & Gray, 2014 Table 1) The use of PERT also provides the probability for each project primary activity which is not shown. A great advantage to being able to utilize PERT and the information it provides also allows for identifying specific risks and being able to mitigate those risks. (Larson & Gray, 2014, p. 213)

Table 7: Forward and Backward Pass Analysis

Sustainable Home Construction Project Solution								
Activity	Start node	End node	Activity time	Early Start	Early Finish	Late Start	Late Finish	Slack
Project			246					
Project planning	0	1	47	0	47	199	246	199
Design	2	3	47	0	47	0	47	0
Permitting	3	4	30	47	77	89	119	42
Executing	4	5	127	77	204	119	246	42
Foundation	3	6	22	47	69	47	69	0
Geothermal Heat pump Ground Unit	6	7	11	69	80	69	80	0
Framing	7	8	17	80	97	80	97	0
HVAC system	8	9	13	97	110	97	110	0
Electrical	9	10	9	110	119	110	119	0
Plumbing	10	11	11	119	130	119	130	0
Communication system wiring	11	12	10	130	140	130	140	0
Solar system	12	13	4	140	144	140	144	0
Exterior finish	13	14	30	144	174	144	174	0
Interior	14	15	69	174	243	174	243	0
Landscaping	14	16	26	174	200	220	246	46
Closing	15	16	3	243	246	243	246	0

Comment [JLR1]: The numbers in this table need to be reevaluated using the pert task durations

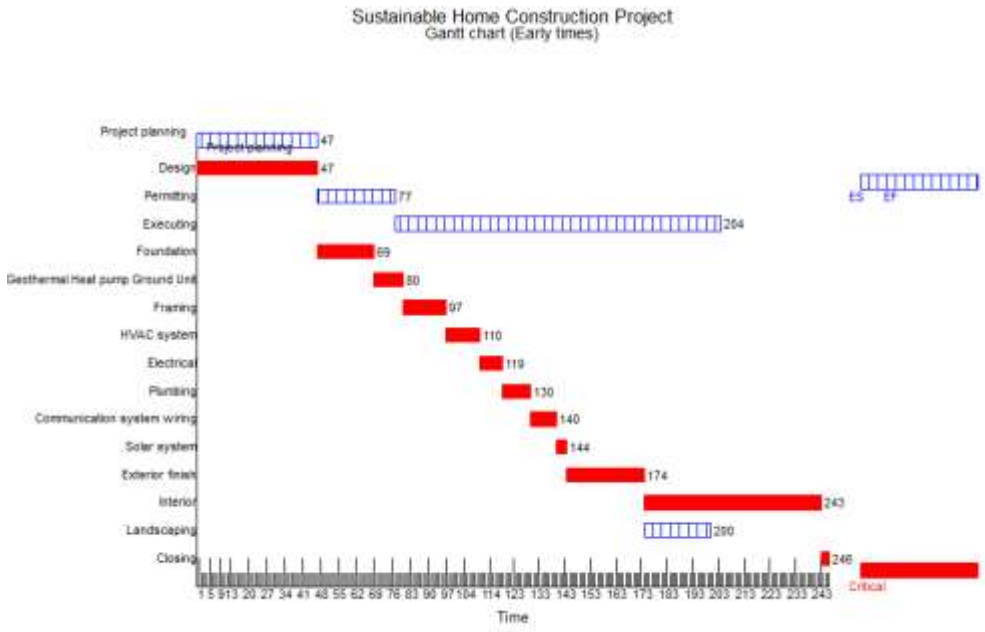


Figure 4: PERT Analysis Graph

Human Resources Plan

Human Resource Management serves an extremely important purpose in the overall project plan. It ensures the project team is properly organized, trained, and equipped to perform their respective jobs and enables success. The following Human Resource Management Plan will serve to establish project team organization, roles and responsibilities, and staffing management plan. This plan will ensure the project team consists of people with the right mix of skills and abilities, and that each member of the team is keenly aware of their responsibilities.

Project Team Organization

The project team is built on a matrix style organization chart, wherein team members are organized according to their functional specialty, with the Project Manager serving as the supervisor of the individual team leads. Project members will be assigned to certain task teams for operational control, but will remain under the administrative control of their respective functional manager. Prime and sub-contractors are encouraged, but not required, to mirror the project team organization structure to the maximum extent practical to ensure ease of counterpart pairing. Functional team leads will be responsible for all aspects of management for the members of their team. This includes hiring, firing, initial and continuous training, welfare, and discipline of the members of their team. Team members will fall under the operational control of the individual responsible for the task assigned. This includes day-to-day work assignments as required to complete the task at hand.

The project team will be organized as depicted in the chart below:

Project Team Roles and Responsibilities

Project Manager: The Project Manager (PM) is responsible for the overall effort. The PM prepares the project management plan, oversees project planning activities, and manages resource allocation. The PM is ultimately responsible for contract adherence including cost, schedule, performance, and quality.

Architect Manager: The Architect Manager is responsible for oversight of all architectural planning, development, and design. The structural and design team leads will report to the Architect Manager. The Architect Manager will be the primary point of contact for the Project Manager for all architectural issues. He/she will also lead the staffing effort for the architectural team.

- Structural Lead- The structural team leader is responsible for managing all structural development, planning, drawings, and code compliance.
- Design Lead-The design lead is responsible for the exterior and interior design development, planning, drawings, and code compliance.

Quality Manager: The Quality Manager is responsible for oversight of all quality efforts. These efforts include both quality assurance and quality control. The Quality Manager will be

the primary point of contact for the Project Manager for quality related issues. Quality team leads will report directly to the Quality Manager.

- Quality Assurance Lead-The quality assurance team lead will ensure the prime and sub-contractor processes meet or exceed all quality assurance metrics as developed in the quality planning phase. He/she will also perform regular process and documentation audits to ensure contractor adherence respective to industry standards.
- Quality Control Lead-The quality control lead will ensure prime and sub-contractor deliverable meet or exceed design specifications and applicable county/state code and/or industry standards. He/she will perform physical inspection/testing as determined by the quality planning phase.

Human Resources Manager: The Human Resources Manager is responsible for overseeing all HR related efforts. He/she will work with the Project Manager and the individual effort managers to determine manning levels for each team. Both the staffing lead and training lead will report directly to the HR Manager.

- Training Lead-the Training Lead is responsible for ensuring members of the team are adequately trained to perform their respective tasks. Due to the relatively short life of the project, every reasonable effort will be made to hire fully trained individuals. The training lead will work closely with the staffing lead to identify and ensure a positive handoff of skills gaps for inbound employees.
- Staffing Lead-the Staffing Led is responsible for all employee gain and loss actions. He/she will work closely with the Project Manager and manager of the team hiring. They will post job openings both internally and externally, will organize applications,

coordinate interviews, and process all paperwork involved in gaining or losing employees.

Administrative Support Manager: The Administrative Support Manager is responsible for overseeing all administrative efforts including accounting, administrative assistants, and contracting. Each team lead will report directly to the Administrative Support Manager.

- Accounting Lead-the Accounting Lead is responsible for overall management of the project budget and will provide reports to the Project Manager no less frequently than weekly. He/she will work closely with team leads and prime/sub-contractors to ensure adherence to the budget.
- Administrative Assistant Lead-the Admin Assistant Lead is responsible for hiring, and managing all administrative assistants for the project team. The Project Manager and each manager underneath him/her will be assigned an administrative assistant, who will be responsible for compiling all documentation for the efforts overseen by their manager.
- Contracting Lead-the Contracting Lead is responsible for developing, awarding, executing, and monitoring the contract. He/she will work closely with team leads to ensure their respective efforts are executed in accordance with the contract. The contracting lead will coordinate all contact changes and will be the signature authority for obligating the project team to legally binding contracts.

Staffing Management Plan

Required manning levels will vary by team and project phase. Functional managers will work with their team leads to determine appropriate manning levels. Ultimately the Project Manager, working with functional managers and the HR team, will determine how many people

to hire for each functional specialty. Training and education levels will be determined by the functional manager and team lead. Any required training will be coordinated with the Training Lead.

Prime and sub-contractors will be required to have their team intact before commencing their respective effort. Training and Staffing team members will work closely with prime and sub-contractors to ensure employees are adequately trained and licensed as applicable. Staffing issues will be reported to the Project Manager in the weekly issue report as directed by the Project Communication Plan. Critical position manning issues may require immediate reporting and more frequent updates as directed by the Project Manager.

Project Closeout Checklist

One key factor of a project is that it ends. (Larson & Gray, 2014) While there are several causes a project may be ended some of the more common reasons include a project finishes as planned, the project was cancelled, or the project was abandoned. (Larson & Gray, 2014) Projects that are abandoned can be over budget, ongoing for too long, or the priorities of the corporation may have changed. (Larson & Gray, 2014) Long term projects often fall prey to changes in corporate leadership and corporate redirection or restructuring. What was a priority for the last leadership is no longer a priority for the new leadership or board of directors.

The following are sample closeout checklists for our Sustainable Home Construction Project. The first section is a closeout checklist for the subcontractors to confirm all deliverables are complete. In addition, any system that will have a warranty or be under a continuing service contract, such as the HVAC system or the solar system, have their documentation provided. The PM will confirm that all of the entries made by the subcontractors is accurate.

The next closeout checklist will be completed by the PM and the homeowners during a final walk through of the home. This will also serve as an inspection and handover of the home to the new owners.

Subcontractor Closeout Checklist

Item	Complete (Y/N)	Subcontractor Initials
Foundation Inspection		
Plumbing Inspection		
Electrical Inspection		
Roofing Inspection / Warranty		
HVAC Inspection		
HVAC Warranty / Service Contract		
Geothermal System Inspection		
Geothermal System Warranty / Service Contract		
Solar Installation Inspection		
Solar Installation Warranty / Service Contract		
Vehicle Charging Station Inspection		
Vehicle Charging Station Warranty / Service Contract		
Interior Inspection		
Appliances/Electronics Warranty		
Security System Inspection		
Security System Warranty / Service Contract		
Landscaping Inspection		

Project Manager Signature Date:

Project Manager and Homeowner Closeout Checklist

Item	Warranty	Service Contract	Initials
Exterior	No	No	
Interior	No	No	
Appliances/Electronics	Yes	Yes	
Security System	Yes	Yes	
HVAC	Yes	Yes	
Geothermal System	Yes	Yes	
Solar System	Yes	Yes	
Vehicle Charging System	Yes	Yes	
Landscaping	Yes	Yes	

Homeowner Signature_____ Date: _____

Project Manager Signature_____ Date: _____

Bank Signature_____ Date: _____

County Clerk Stamp / Seal_____ Date: _____

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Appendix 1

Fixed Price Construction Contract

This Construction contract, valid April 24, 2015 between Hammer and Nail Construction of 9874 Framers Dr., Boulder Colorado 80301, and Spiffy Topper Roofing Inc. of 12345 Roofing Ln, Boulder Colorado 80301. Spiffy Topper Roofing Inc. desires to provide construction services to Hammer and Nail Construction and Hammer and Nail Construction desires to obtain such services from Spiffy Topper Roofing Inc.

1. DESCRIPTION OF SERVICES. Beginning April 24, 2015, Spiffy Topper Roofing Inc. will afford Hammer and Nail construction the following services, to be completed on or near May 14, 2015, and not later than June 7, 2015 without risk of penalty as specified in paragraph 7 PAYMENTS:

Install roof framing to include trusses and fasciae

Install roof sheeting as specified in the blue print

Install roofing vapor barrier in accordance with applicable code

Install roof shingles as specified by the customer

2. SCOPE OF WORK. Spiffy Topper Roofing Inc. will afford all labor, tools, and equipment required to complete services previously described for a single-family residential home with detached two car garage at 4569 Green Building Rd. Boulder Colorado, 80301 here after referred to as the "worksite".

3. PLANS, SPECIFICATION AND CONSTRUCTION DOCUMENTS. Hammer and Nail will make available to Spiffy Topper Roofing Inc. all plans, specifications, drawings, blueprints,

and any other required construction documents for Spiffy Topper Roofing Inc. to provide the services described herein. Any such material will remain the property of Hammer and Nail Construction and will be returned upon completion of said services.

4. COMPLIANCE WITH LAWS. All contracted services will be incompliance with all applicable federal, state, and local laws, and regulations including, but not limited to, all requirements of the Fair Labor Standards Act, the Americans with Disabilities Act, and Federal Family and Medical Leave Act.

5. WORK SITE. Hammer and Nail Construction declares it has been contracted to provide construction services on the worksite property and is authorized to contract services within their agreed upon scope based upon agreement with Sustainable Home Construction Company.

6. MATERIALS AND LABOR PROVIDED. All materials for the contracted labor at the worksite will be provided to the worksite by the general contractor, Sustainable Home Construction Company. Any labor required prerequisite to services provided by Spiffy Topper Roofing Inc. will be accomplished prior to the contractual start time contained herein.

7. PAYMENT. An agreed upon payment of $8750.40 will be dispersed to Spiffy Topper Roofing by Hammer and Nail Construction upon completion of said services. No other agreed upon monetary amount will be dispersed for early completion. However, a 5% per week penalty will be assessed for past due work if Spiffy Topper fails to meet the inspection deadline of June 7, 2015.

8. TERMS Spiffy Topper Roofing will have 24 hour access to the worksite contingent on them providing power, compressed air, and lighting as needed after 1700 hours Mountain Time.

Electrical power and air compression will be provided on site by Hammer and Nail Construction Company between 0600 and 1700 Monday thru Friday.

9. CHANGE ORDER. Changes to the scope of services provided by Spiffy Topper Roofing may be dictated by natural weather phenomena, customer needs, regulatory compliance needs and as negotiated between Hammer and Nail Construction Company, Spiffy Topper Roofing Inc., Sustainable Home Construction Company, and the customer. Any delay to the contractual start date for any reason by any party must be communicated to all remaining parties as soon as possible and not later than one week prior to contracted service start date. Any delay which cannot be coordinated shall be renegotiated with the appropriate parties and may negate predetermined completion dates.

10. PERMITS. All permits will be secured and maintained by the Sustainable Home Construction Company. Said permits will be available at their worksite construction office for reference by all interested parties.

12. INSURANCE. Spiffy Topper Roofing Inc. shall be responsible to insure their employee, and worksite activities, vehicles, and equipment in accordance with federal, state, and local law. It is the sole responsibility of Spiffy Topper Roofing Inc. to provide replacement for loss of labors on the contracted worksite to complete the services herein contracted if needed.

13. CONFIDENTIALITY. Any copyright applicable material, real property, intellectual property, design and construction techniques used on the worksite remain the property of Sustainable Home Construction Company and may only be used on contracted projects under their contractual obligation. Individual techniques used by any other subcontractors to include Hammer and Nail Construction, and Spiffy Topper Roofing outside of those employed

specifically by the Sustainable Home Construction Company for the building of the sustainable home remains the prerogative of the initiating organization to share or retain at their desire.

14. WARRENTY. Spiffy Topper Roofing Inc. shall provide workmanship applicable to the desired outcome agreed upon by Hammer and Nail Construction, Spiffy Topper Roofing, Sustainable Home Construction Company, the customer, government inspectors, and building codes of the state of Colorado. Any lapse in quality for the contracted services shall be corrected at the expense of Spiffy Topper Roofing Inc.

15. AMENDMENT. Any amendments to the agreements herein must be agreed upon by all parties in order to be of force. To include but not limited to, change in contractual scope, additional services, change in dates, change in materials, or change in time requirements.

16. GOVERNING LAW. All federal, state and county codes as dictated by regulations, laws and standards set by the inspector shall be adhered to, as well as the international and LEED building codes to ensure LEED certification requirements. Spiffy Topper Roofing is responsible to know and understand these standards and abide by them while providing services herein.

22. NOTICE. Upon notification by inspectors, the customer, Hammer and Nail Construction and/or Sustainable Home Construction Company that work quality, code requirements, blue print, or structural requirements have not been met, Spiffy Topper Roofing shall make the required corrections within two days. If said corrections exceed the not later than completion date agreed to herein, penalties listed in paragraph 7 PAYMENTS may be invoked.

23. SIGNATORIES. The signatures below are legal representatives for their respective companies. Jim Purvis, owner of Hammer and Nail Construction, and Johnny Rickenbacker,

owner of Spiffy Topper Roofing Inc. The representatives herein agree to all the provisions stated in this document and shall be legally bound to the agreements herein.

X_____,

Jim Purvis

Owner, Hammer and Nail Construction

(Contractor license:plmn698532)

X_____,

Johnny Rickenbacker

Owner, Spiffy Topper Roofing Inc.

(Contractor license: rfgn852369)

X_____,

Tobin James

CEO, Sustainable Home Construction Company

WBS 8.7 - GROUP 3
FINAL DELIVERABLES: SUSTAINABLE HOME CONSTRUCTION PROJECT

Appendix 2

Sustainable Home Construction Project Time Phased Budget and Cost

		Month	1	2	3	4	5	6	7	8	9	10
WBS ID	**WBS Task**	**Budget**										
1.1.1	Lot Purchase	$ 75,000.00	$ 75,000.00									
1.1.2	Contract Signed, Project Started	$ 3,040.00	$ 3,040.00									
1.2.1.1	Initial Concept Draft for Permitting	$ 10,080.00	$ 10,080.00									
1.2.1.2	30% Design Review	$ 21,600.00		$ 21,600.00								
1.2.1.3	60% Design Review	$ 21,600.00			$ 21,600.00							
1.2.1.4	90% Design Review	$ 14,400.00			$ 14,400.00							
1.2.2	Permitting	$ 5,000.00			$ 5,000.00							
1.3.1	**Foundation**	$ 17,120.00										
	Foundation Material	$ 8,800.00			$ 4,400.00	$ 4,400.00						
1.3.1.1	Excavation	$ 1,600.00			$ 1,600.00							
1.3.1.2	Form and pour footing	$ 1,440.00			$ 1,440.00							
1.3.1.3	Form and pour stem walls	$ 2,880.00				$ 2,880.00						
1.3.1.4	Pour and finish flat work	$ 2,400.00				$ 2,400.00						
1.3.2	**Geothermal Heat Pump Ground Unit**	$ 53,900.00										
	Geothermal Materials	$ 47,900.00			$ 26,127.00	$ 21,773.00						
1.3.2.1	Prepare ground for heat exchanger	$ 1,680.00			$ 1,680.00							
1.3.2.2	Plumb heat exchanger system	$ 2,800.00			$ 2,800.00							
1.3.2.3	Bury heat exchanger and level ground	$ 1,120.00			$ 1,120.00							
1.3.2.4	Complete exterior heat pump component	$ 400.00			$ 400.00							
1.3.3	**Framing**	$ 142,356.40										
	Framing Material	$ 56,000.00				$ 16,211.00	$ 29,474.00	$ 10,315.00				
	Trusses	$ 17,890.00				$ 5,179.00	$ 9,416.00	$ 3,295.00				
	Roofing Material	$ 50,000.00				$ 14,474.00	$ 26,316.00	$ 9,210.00				
1.3.3.1	Exterior and support wall framing	$ 4,338.00				$ 4,338.00						
1.3.3.2	Roof framing	$ 4,270.40				$ 4,270.40						
1.3.3.3	Interior wall and floor framing	$ 4,338.00					$ 4,338.00					
1.3.3.4	Roofing	$ 4,480.00					$ 2,880.00	$ 1,600.00				
1.3.3.5	Framining Inspection	$ 1,040.00					$ 1,040.00					
1.3.4	**Plumbing**	$ 22,191.20										
	Plumbing Material	$ 15,900.00						$ 15,900.00				
1.3.4.1	Install main plumbing lines and vents	$ 1,895.04					$ 1,895.04					
1.3.4.2	Install room water lines and drain terminations	$ 1,895.04					$ 1,895.04					
1.3.4.3	Plumbing inspection	$ 2,501.12					$ 2,501.12					
1.3.5	**Electrical**	$ 21,455.20										
	Electrical Material	$ 13,900.00						$ 13,900.00				
1.3.5.1	Install main electrical bus, terminations	$ 1,221.60						$ 1,221.60				
1.3.5.2	Run wiring, install sockets , switches and wire breaker box	$ 5,090.00						$ 5,090.00				
1.3.5.3	Electrical inspection	$ 1,243.60						$ 1,243.60				
1.3.6	**Communication systems wiring**	$ 23,000.00										
	Communication System Material	$ 15,000.00						$ 9,000.00	$ 6,000.00			
1.3.6.1	Run conduit for communication lines	$ 3,200.00					$ 3,200.00					
1.3.6.2	Install communications wiring and termination boxes	$ 2,400.00						$ 2,400.00				
1.3.6.3	Configure and test communications system	$ 2,400.00						$ 2,400.00				
1.3.7	**HVAC system**	$ 14,160.00										
	HVAC Material	$ 10,000.00						$ 10,000.00				
1.3.7.1	Install main components	$ 1,440.00						$ 1,440.00				
1.3.7.2	Ducting and wiring	$ 1,440.00						$ 1,440.00				
1.3.7.3	HVAC inspections	$ 1,280.00						$ 1,280.00				
1.3.8	**Solar system**	$ 25,600.00										
	Solar Panel Material	$ 20,000.00						$ 20,000.00				
1.3.8.1	Install solar panels on roof	$ 2,400.00						$ 2,400.00				
1.3.8.2	Build battery storage compartment	$ 1,600.00						$ 1,600.00				
1.3.8.3	Intergrate wiring	$ 800.00						$ 800.00				
1.3.8.4	Place batterys, connect and test system	$ 800.00						$ 800.00				

1.3.9	**Exterior finish**	$ 57,800.56										
	Siding Materials	$ 10,000.00						$ 10,000.00				
1.3.9.1	Exterior sheeting and moisture barrier	$ 2,400.00						$ 2,400.00				
1.3.9.2	Windows	$ 14,500.00						$ 14,500.00				
1.3.9.3	Exterior doors	$ 17,900.00						$ 17,900.00				
1.3.9.4	Exterior door and window trim	$ 1,720.56						$ 1,720.56				
1.3.9.5	Siding installed	$ 2,400.00						$ 960.00	$ 1,440.00			
1.3.9.6	Siding trim installed	$ 2,400.00							$ 2,400.00			
1.3.9.7	Exterior paint	$ 4,400.00							$ 4,400.00			
1.3.9.8	Final county inspection	$ 2,080.00							$ 2,080.00			
1.3.10.1	**Drywall**	$ 19,040.00										
	Drywall Material	$ 5,600.00							$ 5,600.00			
1.3.10.1.1	Wall insulation	$ 6,240.00							$ 6,240.00			
1.3.10.1.2	Hang sheetrock	$ 2,400.00							$ 2,400.00			
1.3.10.1.3	Tape	$ 2,400.00							$ 2,400.00			
1.3.10.1.4	Fill holes and finish sand	$ 1,440.00							$ 1,440.00			
1.3.10.1.5	Apply wall and ceiling texture	$ 960.00							$ 960.00			
1.3.10.2	**Interior finish carpentry**	$ 16,400.00										
	Interior Finish Material	$ 5,000.00								$ 5,000.00		
1.3.10.2.1	Install window sills	$ 2,400.00								$ 2,400.00		
1.3.10.2.2	Install interior doors	$ 4,000.00								$ 4,000.00		
1.3.10.2.3	Install base boards	$ 3,000.00								$ 3,000.00		
1.3.10.2.4	Install closet shelving and components	$ 2,000.00								$ 2,000.00		
1.3.10.3	**Interior painting**	$ 12,200.00										
	Paint	$ 2,800.00								$ 764.00	$ 2,036.00	
1.3.10.3.1	Paint ceilings	$ 1,200.00								$ 1,200.00		
1.3.10.3.2	Caulk base boards and trim	$ 800.00								$ 800.00		
1.3.10.3.3	Paint interior walls	$ 5,000.00									$ 5,000.00	
1.3.10.3.4	Paint interior trim	$ 2,400.00									$ 2,400.00	
1.3.10.4	**Kitchen and bathroom cabinetry**	$ 20,380.00										
	Cabinets	$ 10,300.00									$ 9,564.00	$ 736.00
1.3.10.4.2	Install base cabinets	$ 2,880.00									$ 2,880.00	
1.3.10.4.3	Install counter tops	$ 2,160.00									$ 2,160.00	
1.3.10.4.4	Install wall cabinets	$ 2,880.00									$ 2,880.00	
1.3.10.4.5	Finish cabinets/hardware installation	$ 2,160.00									$ 1,440.00	$ 720.00
1.3.10.5	**Appliances and fixtures**	$ 23,574.16										
1.3.10.5.1	Install kitchen appliances	$ 9,800.00										$ 9,800.00
1.3.10.5.2	Install bathroom fixtures	$ 3,663.36										$ 3,663.36
1.3.10.5.3	Install light fixtures	$ 5,110.80									$ 5,110.80	
1.3.10.5.4	Appliance and fixture final work	$ 5,000.00										$ 5,000.00
1.3.10.6	**Finish flooring**	$ 27,860.00										
1.3.10.6.1	Install tile bathrooms	$ 3,940.00										$ 3,940.00
1.3.10.6.2	Install tile in kitchen and entry area	$ 960.00										$ 960.00
1.3.10.6.3	Install hardwood floor	$ 11,920.00										$ 11,920.00
1.3.10.6.4	Install carpet	$ 11,040.00										$ 11,040.00
1.3.12	**Landscaping**	$ 34,360.00										
	Landscaping Material	$ 10,000.00							$ 2,259.00	$ 7,741.00		
1.3.12.1	Level ground	$ 2,160.00							$ 2,160.00			
1.3.12.2	Form side walk and driveway	$ 2,160.00							$ 2,160.00			
1.3.12.3	Pour sidewalks and driveway	$ 960.00							$ 480.00	$ 480.00		
1.3.12.4	Install main sprinkler lines	$ 1,200.00							$ 1,200.00			
1.3.12.5	Complete sprinkler system installation	$ 2,000.00							$ 666.70	$ 1,333.30		
1.3.12.6	Install curbing	$ 1,600.00								$ 1,600.00		
1.3.12.7	Plant trees and shrubs	$ 5,000.00								$ 5,000.00		
1.3.12.8	Install decorative rock	$ 1,800.00								$ 1,800.00		
1.3.12.9	Lay sod	$ 3,000.00								$ 3,000.00		
1.4	**Monthly status review**	$ 4,480.00		$ 640.00	$ 640.00	$ 640.00	$ 640.00	$ 640.00	$ 640.00	$ 640.00		
1.5.1	**Final inspection and acceptance by owners**	$ 1,920.00										$ 1,920.00
	Monthly Cost		$ 88,120.00	$ 22,240.00	$ 81,207.00	$ 76,565.40	$ 83,595.20	$ 163,455.76	$ 44,925.70	$ 40,758.30	$ 33,470.80	$ 49,699.36
	Running Total		**$ 88,120.00**	**$ 110,360.00**	**$ 191,567.00**	**$ 268,132.40**	**$ 351,727.60**	**$ 515,183.36**	**$ 560,109.06**	**$ 600,867.36**	**$ 634,338.16**	**$ 684,037.52**