



DUAL PLUMBING STUDY

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1

Executive
Summary

EXECUTIVE SUMMARY

Project Overview

In 2018, Austin City Council adopted a 100-year integrated water resource plan, Water Forward, which includes the development of new water supplies and an emphasis on water conservation and reuse. To meet the goals developed in this plan, Austin Water will adopt ordinances and incentives for new development to include dual plumbing systems that deliver non-potable reuse water to buildings for toilet/urinal flushing, clothes washing, cooling and irrigation.

In the near-term, ordinances are being developed for new large commercial and multi-family development projects (250,000 square feet or greater gross floor area). At a minimum, these projects will be required to either collect and treat onsite water sources (rainwater, air-conditioning condensate, or graywater) for non-potable use in the buildings, or to connect to the City's reclaimed water pipe network for non-potable use in the buildings. In the long-term, new reuse ordinances and incentives will be considered for smaller commercial and multifamily developments, and single-family residences.

Development projects implementing non-potable water reuse require dual plumbing distribution systems to deliver non-potable water to non-potable fixtures and uses such as toilets/urinals, clothes washers, cooling towers and irrigation systems. To collect and treat graywater (water from bath, shower, and lavatory drains) for non-potable water reuse, development projects will require additional dual plumbing drainage systems to collect the graywater for treatment.

In support of the Water Forward Plan implementation, FGM Architects Inc. (FGMA) and its consultants, RGM Engineering (Plumbing Engineer) and CCS International, Inc. (Cost Estimator) were engaged to perform a dual plumbing cost study to determine the additional plumbing costs that projects implementing non-potable water reuse would incur. The study involved 22 building typologies, selected by Austin Water, to ensure a wide range of building sizes and uses. Typologies included single-family homes, a mixed-use retail/restaurant facility, a high-rise apartment building, a car wash/gas station, a data center, and a movie theater.

For all 22 building typologies, the conventional plumbing system (single distribution/single drainage) was evaluated and a construction cost estimate prepared. This provided a baseline cost estimate.

For all typologies a schematic dual distribution system was then designed to allow for the supply of non-potable water to applicable fixtures (i.e. toilets, urinals, and clothes washers). For nine (9) of the typologies a schematic dual drainage system was also designed to allow for the separation of graywater and blackwater. Irrigation systems and cooling tower makeup systems already have dedicated supply lines so there is no additional plumbing cost to supply these systems with non-potable water other than the required backflow prevention assembly to protect the municipal potable water supply.

Construction cost estimates were prepared for the dual distribution and dual drainage systems, providing the opportunity to identify anticipated premium costs beyond the baseline cost estimate for each typology.

Methodology

DRAWINGS:

Austin Water provided architectural and engineering drawings for each of the typologies to the FGMA team. The team reviewed the available drawings and determined that plumbing drawings for Typologies 1 – 6 were either not provided or otherwise incomplete and inadequate. For these typologies, RGM Engineering prepared a schematic plumbing design for a conventional system (single distribution/single drainage) to serve as the baseline system.

For Typology 19, an assembly occupancy building, Austin Water had provided drawings for the Zach Theater. RGM noted that the plumbing drawings provided were not very detailed and proposed to use one of its own projects, the Circle C Alamo Drafthouse, instead. Austin Water reviewed the Alamo Drafthouse drawings and agreed that the project was an appropriate substitute for the desired Assembly typology.

SCHEMATIC DUAL PLUMBING SYSTEM DESIGN:

To reflect the dual plumbing scenario, RGM added color-coded, dual distribution and dual drainage lines, with pipe sizes identified, to the existing drawings to allow CCS, the Cost Estimator, to do quantity take-offs. Design also included non-potable water supply booster pumps (single, twin or tri plex) with associated electrical connections where required. Onsite water source holding or transfer tanks were not included.

The schematic dual plumbing system design, and corresponding estimate, also addressed details such as the need for a Reduced Pressure Zone (RPZ) valve at the potable hot water supply to the clothes washer to isolate it from the non-potable cold water supply. Another configuration for protecting the potable water supply while supplying non-potable water to clothes washers, is through the use of a small on-demand water heater plumbed to supply only the washing machine. This configuration was not costed out as a part of this study, but it is likely a lower cost option, and eliminates the need for an RPZ at each clothes washer. An RPZ is required to be tested annually so long-term inspection costs are also eliminated.

Similarly, since the use of a second plumbing system conveying non-potable water to toilets and the clothes washers would reduce the size and quantity of potable water piping, these changes were indicated to allow for the proper quantity take-off by the Estimator. See Figures 1 (plan) and 2 (riser diagrams) below.

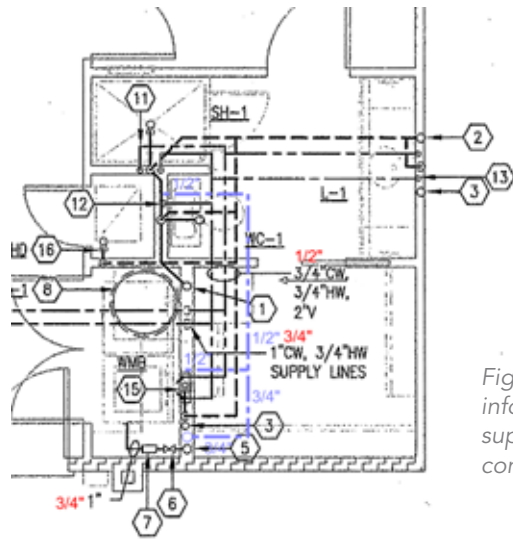
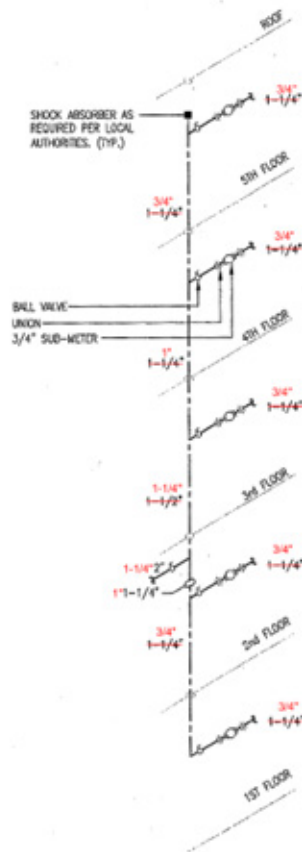


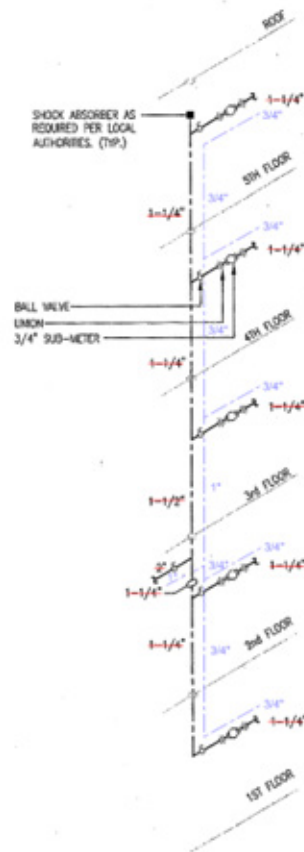
Figure 1: Black indicates original drawing information; blue indicates non-potable supply; red indicates size reduction for conventional potable domestic water line.



TYPICAL WATER RISER

REF: ALL UNITS

BASELINE PIPE SIZES REVISED
IN RED DUE TO GRAY WATER SUPPLY



GRAY
TYPICAL WATER RISER

REF: ALL UNITS

GRAY WATER SYSTEM BESIDE
BASELINE SYSTEM

Figure 2: Black indicates original drawing information; blue indicates non-potable supply; red indicates size reduction for conventional potable domestic water line.

CONCEPTUAL CONSTRUCTION COST ESTIMATE:

The estimate was prepared in current dollars and limited to plumbing system “hard” costs within the building enclosure. General Contractor’s mark-ups (General Conditions, Overhead, and Fee) have been included at 15% and Contingencies (5% Design and 10% Construction) were also included to cover the likelihood of additional costs that would be identified with more detailed design drawings and complete specifications, as well as potential construction phase-related changes.

Figure 3 below indicates the typical level of cost estimating detail prepared for each building typology. Line items indicate the quantity take-offs and the associated unit cost (in current dollars).

Description - <u>DUAL DISTRIBUTION SYSTEM</u>	Quantity	U/M	Unit Price	Unit Price Ext
A03 - Dual Distribution System **** 09 - Suburban Apartment **** 08 - Mechanical **** 0810 - Plumbing				
Domestic Cold Water Piping - 1/2"	1,566 LNFT		\$15.94	\$24,962.04
Domestic Cold Water Piping - 3/4"	1,144 LNFT		\$18.41	\$21,061.04
Domestic Cold Water Piping - 1"	315 LNFT		\$22.77	\$7,172.55
Domestic Cold Water Piping - 1-1/4"	232 LNFT		\$31.00	\$7,192.00
Domestic Cold Water Piping - 2"	36 LNFT		\$49.25	\$1,773.00
Domestic Cold Water Piping Insulation - 1/2"	1,566 LNFT		\$7.20	\$11,275.20
Domestic Cold Water Piping Insulation - 3/4"	1,144 LNFT		\$9.00	\$10,296.00
Domestic Cold Water Piping Insulation - 1"	315 LNFT		\$11.47	\$3,613.05
Domestic Cold Water Piping Insulation - 1-1/4"	232 LNFT		\$13.60	\$3,155.20
Domestic Cold Water Piping Insulation - 2"	36 LNFT		\$17.86	\$642.96
Domestic Water Fixture Connections	126 EACH		\$279.34	\$35,196.84
Domestic Cold Water Coring & Fire Stopping	26 EACH		\$213.16	\$5,542.16
Gray Water Piping - 1/2"	498 LNFT		\$15.94	\$7,938.12
Gray Water Piping - 3/4"	12 LNFT		\$18.41	\$220.92
Gray Water Piping - 1"	265 LNFT		\$22.77	\$6,034.05
Gray Water Piping - 1-1/4"	98 LNFT		\$31.00	\$3,038.00
Gray Water Piping - 1-1/2"	114 LNFT		\$35.28	\$4,021.92
Gray Water Piping Insulation - 1/2"	498 LNFT		\$7.20	\$3,585.60
Gray Water Piping Insulation - 3/4"	12 LNFT		\$9.00	\$108.00
Gray Water Piping Insulation - 1"	265 LNFT		\$11.47	\$3,039.55
Gray Water Piping Insulation - 1-1/4"	98 LNFT		\$13.60	\$1,332.80
Gray Water Piping Insulation - 1-1/2"	114 LNFT		\$15.73	\$1,793.22
Gray Water Supply Fixture Connections	72 EACH		\$279.34	\$20,112.48
Gray Water Supply Coring & Fire Stopping	28 EACH		\$213.16	\$5,968.48
Booster Pump - Twin	1 EACH		\$47,618.81	\$47,618.81
Reduced Pressure Backflow Preventor w/ Indirect Waste	30 EACH		\$1,970.01	\$59,100.30
				<u>\$295,794.29</u>
A03 - Dual Distribution System **** 09 - Suburban Apartment **** 08 - Mechanical - SUBTOTAL				\$295,794.29

Figure 3: Typical detail provided for each building typology.

Figure 4 below is the summary table, showing all 22 building typologies. Estimated plumbing costs (Total Cost and Cost/SF) for the conventional systems as shown in the original drawings are indicated to provide a baseline estimate.

For each specific typology, the costs for the dual plumbing alternatives – Dual Distribution System (for 13 typologies) or Dual Distribution/Drainage System (9 typologies) – are provided in terms of Total Cost, Cost/SF, and the resulting “Premium Cost,” as compared to the Conventional System.

#	Development Type	Description	Floor Area (SF)	CONVENTIONAL SYSTEM		DUAL DISTRIBUTION SYSTEM			DUAL DISTRIBUTION/DRAINAGE SYSTEM		
				Total Cost	Cost/SF	Total Cost	Cost/SF	Premium	Total Cost	Cost/SF	Premium
1	Single Family	Garden Home	1,016	\$22,660	\$22.30				\$37,429	\$36.84	165.17%
2	Single Family	Ranch House	1,898	\$15,538	\$8.19				\$26,203	\$13.81	168.65%
3	Single Family	Estate Home	2,999	\$55,169	\$18.40				\$80,923	\$26.98	146.68%
4	Single Family	Condo/Townhouse	1,869	\$55,377	\$29.63				\$77,926	\$41.69	140.72%
5	Duplex	Side-by-Side	3,604	\$16,824	\$4.67	\$29,243	\$8.11	173.81%			
6	Duplex	Stacked	2,158	\$12,147	\$5.63	\$20,244	\$9.38	166.66%			
7	Multiplex	Fourplex	7,077	\$142,117	\$20.08				\$195,958	\$27.69	137.88%
8	Multiplex	Sixplex	8,763	\$213,199	\$24.33				\$314,885	\$35.93	147.70%
9	Apartment	Suburban Apartment	32,798	\$262,903	\$8.02	\$417,652	\$12.73	158.86%			
10	Apartment	Mid-Rise Apartments	256,822	\$5,505,803	\$21.44				\$7,691,232	\$29.95	139.69%
11	Apartment	High-Rise Apartments	221,438	\$3,629,351	\$16.39				\$4,705,413	\$21.25	129.65%
12	Mixed-Use	Mixed Use	212,053	\$1,089,886	\$5.14	\$1,812,333	\$8.55	166.29%			
13	Commercial	Hotel - Mid-Rise	93,330	\$447,611	\$4.80	\$626,959	\$6.72	140.07%			
14	Commercial	Hotel - High-Rise	112,655	\$2,463,893	\$21.87				\$2,803,458	\$24.89	113.78%
15	Commercial	Office - Mid-Rise	250,000	\$234,851	\$0.94	\$431,937	\$1.73	183.92%			
16	Commercial	Office - High-Rise	373,334	\$773,131	\$2.07	\$925,504	\$2.48	119.71%			
17	Commercial	School	98,772	\$251,759	\$2.55	\$302,210	\$3.06	120.04%			
18	Commercial	Auto Car Wash and Gas Station	10,208	\$38,897	\$3.81	\$47,315	\$4.64	121.64%			
19	Commercial	Assembly Facility	37,000	\$102,931	\$2.78	\$112,633	\$3.04	109.43%			
20	Commercial	Laundry Facility	8,576	\$95,275	\$11.11	\$115,995	\$13.53	121.75%			
21	Commercial	Data Center	172,800	\$69,559	\$0.40	\$81,505	\$0.47	117.17%			
22	Commercial	Civic Center	204,781	\$225,650	\$1.10	\$295,414	\$1.44	130.92%			

Figure 4: Conceptual Construction Cost Estimate Summary

Observations/Conclusions

To better understand any overall trends or patterns in the premium costs identified, the building typologies were grouped in the following four scenarios, with mean and median premium costs identified. With the wide range of building types, the median costs are likely to be a better predictor, since they are less sensitive to the outlier premiums that result from a wide variety of typologies reflecting unique programs and design solutions. (Note: In some categories with only one or two typologies, the mean and median values are the same.)

MEAN AND MEDIAN PREMIUM COSTS (ALL TYPOLOGIES)

Dual Plumbing System Selected	Premium Cost (%)	
	Mean	Median
Dual Distribution System <ul style="list-style-type: none"> • Duplex Side-by-Side (#5) • Duplex Stacked (#6) • Suburban Apartment (#9) • Ground Floor Retail / Restaurant (#12) • Hotel Mid-rise (#13) • Office Mid-rise (#15) • Office High-rise (#16) • School (#17) • Auto Car Wash and Gas Station (#18) • Assembly - Movie Theater (#19) • Laundry (#20) • Data Center (#21) • Civic - Library (#22) 	140.79	130.92
Dual Distribution/Drainage System <ul style="list-style-type: none"> • Garden Home/ADU (#1) • Ranch Home (#2) • Estate Home (#3) • Condo/Townhome (#4) • Multiplex Fourplex (#7) • Multiplex Sixplex (#8) • Mid-rise Apartment (#10) • High-rise Apartment (#11) • Hotel High-rise (#14) 	143.32	140.72

MEAN AND MEDIAN PREMIUM COSTS (BY DEVELOPMENT TYPE)

Development Type	Description	Premium Cost (%)			
		Dual Distribution		Dual Distribution/Drainage	
		Mean	Median	Mean	Median
Single Family	Garden Home/ADU (#1) Ranch Home (#2) Estate Home (#3) Condo/Townhome (#4)	-	-	155.30	155.92
Multi-Family	Duplex Side-by-Side (#5) Duplex Stacked (#6) Multiplex Fourplex (#7) Multiplex Sixplex (#8) Suburban Apartment (#9) Mid-rise Apartment (#10) High-rise Apartment (#11)	166.44	166.66	138.73	138.78
Mixed Use & Commercial	Ground Floor Retail / Restaurant (#12) Hotel Mid-rise (#13) Hotel High-rise (#14) Office Mid-rise (#15) Office High-rise (#16) School (#17) Auto Car Wash and Gas Station (#18) Assembly – Movie Theater (#19) Laundry (#20) Data Center (#21) Civic – Library (#22)	133.09	121.69	113.78*	113.78*

**Note: Hotel High-rise (#14) is the only Mixed Use & Commercial typology to be reviewed with the Dual Distribution/Drainage System Option.*

MEAN AND MEDIAN PREMIUM COSTS (BY FLOOR AREA)

Floor Area (SF)	Typologies in Category	Premium Cost (%)			
		Dual Distribution		Dual Distribution/Drainage	
		Mean	Median	Mean	Median
0 - 5,000	Garden Home/ADU (#1) Ranch Home (#2) Estate Home (#3) Condo/Townhome (#4) Duplex Side-by-Side (#5) Duplex Stacked (#6)	170.23	170.23	155.30	155.92
5,001 - 10,000	Multiplex Fourplex (#7) Multiplex Sixplex (#8) Laundry (#20)*	121.75	121.75	142.79	142.79
10,001 - 50,000	Suburban Apartment (#9) Auto Car Wash and Gas Station (#18) Assembly – Movie Theater (#19)	129.97	121.64	-	-
50,001 - 200,000	Hotel Mid-rise (#13) Hotel High-rise (#14)** School (#17) Data Center (#21)	125.76	120.04	113.78	113.78
>200,000	Mid-rise Apartment (#10) High-rise Apartment (#11) Ground Floor Retail / Restaurant (#12) Office Mid-rise (#15) Office High-rise (#16) Civic – Library (#22)	150.21	125.31	134.67	134.67

*Note: Laundry (#20) is the only typology in the 5,001 – 10,000 SF category with the Dual Distribution System option.

** Note: Hotel High-rise is the only typology in the 50,001 – 200,000 SF category with the Dual Distribution/Drainage System option.

MEAN AND MEDIAN PREMIUM COSTS (BY NUMBER OF FLOORS)

Number of Floors	Typologies in Category	Premium Cost (%)			
		Dual Distribution		Dual Distribution/Drainage	
		Mean	Median	Mean	Median
1	Garden Home/ADU (#1) Ranch Home (#2) Auto Car Wash and Gas Station (#18) Assembly – Movie Theater (#19) Laundry (#20) Data Center (#21)	117.49	119.40	166.91	166.91
2	Estate Home (#3) Duplex Side-by-Side (#5) Duplex Stacked (#6) Multiplex Fourplex (#7) Multiplex Sixplex (#8) School (#17)	153.50	166.66	144.08	146.68
3 - 10	Condo/Townhome (#4) Suburban Apartment (#9) Mid-rise Apartment (#10) Ground Floor Retail / Restaurant (#12) Hotel Mid-rise (#13) Office Mid-rise (#15) Civic – Library (#22)	156.02	158.86	140.20	140.20
>10	High-rise Apartment (#11) Hotel High-rise (#14) Office High-rise (#16)*	119.71	119.71	121.71	121.71

*Note: Office High-rise (#16) is the only typology in the >10 Floors category with the Dual Distribution System option.

Through the FGMA Team's review of the estimated construction cost premiums associated with the dual plumbing system options, the following observations are offered:

- The premium cost percentages (mean and median) for the single family typology and the smaller multi-family typologies, are generally higher than the percentages for the other typologies. They do not benefit from the efficiencies and redundancies of larger, repetitive-unit projects, nor do they attain significant savings from the downsizing of potable water piping, since the piping is already sized at a minimal dimension.
- As a percentage, the premium costs of utilizing a dual distribution system are typically higher than utilizing a dual distribution and dual drainage system. As the scope of work increases, the additional costs are spread over a "larger denominator," thereby reducing the percentage.
- There are instances of relatively tight premium cost ranges to be found within the groupings of the Single Family and Apartment development types; however, the wide variety of building typologies and the unique design of each building – in response to its specific program and site – means that significant trends or patterns in the premium costs for the dual plumbing systems options are not apparent.
- Not surprisingly, the cost of the additional piping (and associated piping insulation, coring, and fire stopping) in the dual plumbing scenarios is the primary driver of the increased cost. The other significant factor is the need for booster pumps and reduced pressure backflow preventers in the dual systems. As indicated above, the reduction in the sizes and quantities of potable water piping helps to offset these increased costs.
- Although the wide range of project typologies results in a number of "outlier" design solutions which makes identification of overall patterns and trends difficult, the value of the study is enhanced by the simplicity of the design and estimating process. In an actual project, the process followed in this study is one that could determine, with precision, the premium cost for a dual plumbing system; i.e. laying out the parallel system with enough detail to allow for a detailed quantity take-off, comparing it to the conventional system quantities, identifying any additional equipment requirements, and applying current unit costs.
- The piping distribution floor plans and riser diagrams prepared as a part of this study reflect one engineer's reasonable approach to incorporating a dual plumbing system into a multitude of building typologies. As with any design project, other variations or options might be possible, but it is unlikely that a significant change in the cost of the dual plumbing system would result.

TAB

2

Systems Summary
by Typology

SYSTEMS SUMMARY BY TYPOLOGY

Typology			Conventional System		Dual Distribution System		Dual Distribution / Dual Drainage System				Pump(s) w/ Electrical	RPZ(s)	Pump type	Electrical Note	Comments
			Fixture Connections		Fixture Connections		Fixture Connections								
#	Development Type	Description	CW Supply	BW Waste	CW Supply	GW Supply	CW Supply	BW Waste	GW Supply	GW Waste					
1	Single Family	Garden Home/ADU	9	8	-	-	6	3	3	5	X	1	single pump	1	
2	Single Family	Ranch Home	11	10	-	-	8	3	3	7	X	1	single pump	1	
3	Single Family	Estate Home	16	15	-	-	11	5	5	10	X	1	single pump	1	
4	Single Family	Condo/Townhome	13	12	-	-	9	4	4	8	X	1	single pump	1	
5	Duplex	Side-by-Side	22	-	14	8	-	-	-	-	-	2	-	-	
6	Duplex	Stacked	12	-	8	4	-	-	-	-	-	2	-	-	
7	Multiplex	Fourplex	45	43	-	-	31	14	14	29	X	4	single pump	1	
8	Multiplex	Sixplex	54	47	-	-	37	30	17	17	X	6	single pump	1	
9	Apartment	Suburban Apartment	198	-	126	72	-	-	-	-	-	30	twin pump	2	
10	Apartment	Mid-rise Apartment	1,733	1,552	-	-	1,165	434	568	430	X	225	tri plex pump	3	Dual Distribution/Dual Drainage System at Floors 1 - 3
11	Apartment	High-rise Apartment	1,595	1,248	-	-	1,101	497	494	751	X	221	tri plex pump	3	Dual Distribution/Dual Drainage System at Floors 1, 8 - 22
12	Mixed Use	Ground Floor Retail/Restaurant	1,017	-	686	331	-	-	-	-	X	150	twin pump	2	
13	Commercial	Hotel Mid-rise	467	-	300	167	-	-	-	-	X	3	twin pump	2	
14	Commercial	Hotel High-rise	613	613	-	-	457	457	156	156	X	1	tri plex pump	3	Dual Distribution/Dual Drainage System at All Floors
15	Commercial	Office Mid-rise	131	-	56	75	-	-	-	-	-	2			
16	Commercial	Office High-rise	241	-	65	176	-	-	-	-	X	1	tri plex pump	3	
17	Commercial	School	123	-	74	49	-	-	-	-	-	-			
18	Commercial	Auto Car Wash and Gas Station	15	-	7	8	-	-	-	-	-	2	-	-	
19	Commercial	Assembly	45	-	23	22	-	-	-	-	-	-	-	-	
20	Commercial	Laundry	91	-	4	87	-	-	-	-	-	-	-	-	
21	Commercial	Data Center	36	-	17	19	-	-	-	-	-	-	-	-	
22	Commercial	Civic	158	-	57	101	-	-	-	-	-	-	-	-	

ELECTRICAL NOTES							
NOTE:	HP	Breaker	VA	Conductors	Conduit size	FEET	Disconnect
1	1	30	1920	(3) #12	3/4"	50	30A
2	(2) 1HP	25	2760	(4) #12	3/4"	100	30A
3	(3) 5HP	125		(4) #6	1"	100	150A