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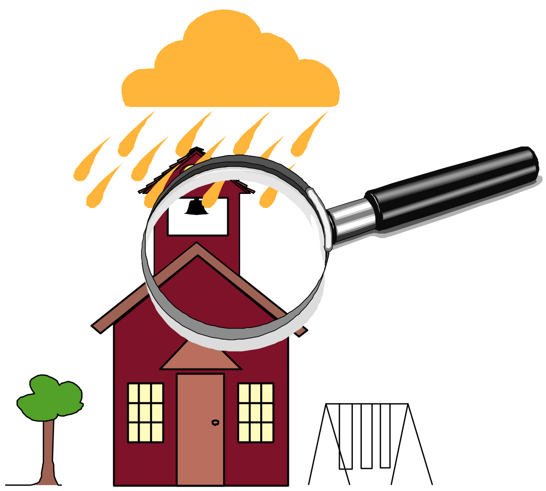
Building Research Institute

of Montana

Special Report: Water Problems at Riverside Middle School



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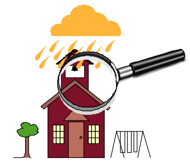

History

Water has been causing problems for many years at Riverside Middle School. With reports of leaking roofs and groundwater it is a difficult problem to solve because of the different ways water has been entering the building. The difficulties have been complicated by the "new" roof[1] that didn't work out and assumptions made about groundwater. Parts of the roof are now being repaired. Alan Anderson, Director of Facilities Services for Billings Public Schools, gave Building Research Institute of Montana (**brim**) a chance to look at the "groundwater" problem more closely and make some recommendations.

Riverside Middle School was built 35 years ago on what, by many accounts, was a swamp. The locals say truckload after truckload of gravel was hauled in to build up the area. The 14-acre site is near the Yellowstone River. It is hard to argue with anecdotes of swamp and groundwater. Solving a groundwater problem can be an expensive and difficult undertaking.

Two observations led to the idea that solving the "groundwater" problem might be much simpler and less expensive than first thought. After a particularly heavy rainstorm the night before, water was left standing on the floor of the cafeteria. Could water be coming in from the rain and not from the ground?

The cafeteria is one of the few places in the building that a roof leak hasn't been documented. But, if groundwater were a problem, one would think there would be water on the floor when the river is high in early summer. This year should be worse, when the Yellowstone River was higher for a longer time period than most years.

Secondly, a check of the plans show two drywells[2] that the entire 2-acre roof drain into. There is one on each side of the building serving approximately equal areas of roof. If these drywells are full of silt or the pipes leading to them are plugged, water could back up quickly during a rainstorm and get inside the building.

Building Research Institute of Montana put together the research team that we used for the concrete research project at Garfield Elementary School last year. We then proceeded to test our hypothesis. If we are right, a relatively inexpensive solution will be at hand (tie into the existing storm sewer). Also, a great deal of money can be saved in structural damage and damage to interior materials and finishes, not to mention ongoing labor costs for clean-up.

Problems

Water infiltration destroys buildings. At Riverside it has ruined vinyl-asbestos tile and quarry tile floors. It appears some settling has occurred and concrete floors have cracked because of water. Floors in this condition create tripping hazards. It has deteriorated wood trim and caused painting to be redone. The unseen damage within walls, ceilings and foundations can be worse and show up in the future. Water standing on floors where people walk can cause unsafe slippery conditions. It is especially dangerous in a cafeteria where people carry things while they work or eat.

Water has been found outside the cafeteria in the hallway, too. Sometimes it comes up through the cleanout in the hallway floor and in the boiler room next door. This information caused some concern because the plans show the cleanout in the hall is for the sanitary sewer not the storm sewer. Also, the sanitary sewer line runs directly below the area in the cafeteria that has a cracked concrete and quarry tile floor.

The research team decided to take a closer look at this problem while we were set up at Riverside. We ran the TV camera down the sanitary sewer line to check out what might be the cause of the back up. The line was found to be almost totally plugged with built-up grease at one point. This line carries the drains for the entire kitchen, including the sink disposals, as well as bathrooms, washing machines and mechanical room. During times of high water usage sewage can back up into the building.

The plumbers cleaned the line with high-pressure steam and then ran the cutting tool through it to remove the built-up grease. They then ran the camera down the line again to check their work. There should be no trouble with sewage back up for at least another year.

The sanitary sewer line was an unexpected additional expense and unrelated to the original research project. It does highlight the value of team research on our buildings. Many times unrelated critical problems are found that can be fixed quickly and inexpensively. It turned out to be part of our objective; solving the water problems at Riverside.

During our initial visit to gather information the research team heard about water gushing 3-feet high out of the ground. This was from the area the drywell appears on the plans to the west of the building. We were told the east side of the building used to have a geyser also (again where the plans show the drywell) but stopped sometime in the past.

We checked out the plans and there was a 5000 S.F. addition[3] built in 1979 on the east side of the building. The plans show an addition to the drywell was called for by the architects to take the additional roof water. It is possible the entire drywell was upgraded at this time if they found it full of silt. This may explain why the geyser stopped on the east side of the building.[4] No TV camera inspection was performed on the storm sewer line going to the drywell on the east side.

The research team from **brim** used the TV camera to inspect the storm sewer line on the west side of the building. This line runs from all of the roof drains on the west side of the roof to the drywell next to the new bleachers by the track. This drywell was suspected of being full of silt or the line to it being plugged. The camera revealed a pipe full of water all the way to the drywell starting at approximately the edge of the asphalt drive 24-feet from the building. The last 20-feet of pipe to the drywell was full of water. This means, as suspected, the drywell has stopped functioning. During a heavy rainstorm or sudden snowmelt water could back up the restricted pipe and come into the building.

The other possibility, due to the wet year, is that groundwater has risen into the drywell. The end of the pipe should be 10-feet below the level of the floor. Since this water problem has existed for years, even during dry years, groundwater may not be the problem. In either case the drywell has to be fixed to allow the roof drains to work properly.

From the plans, the logs of the test pits and borings show a water level at 7-feet below the ground. The drilling was done in February, which is not a great time of year to determine groundwater levels from spring run-offs. The drilling showed topsoil of 6-inches, clay of 3-feet to 4-feet, and sand and gravel 7-feet to 8-feet to the end of the boring. Many loads of structural fill must have been trucked in, as the locals say, to bring the building up to the level the architects required. The plans called for the new floor to be 3-1/2-feet above the existing ground. This would bring our groundwater in February to more than 10-1/2-feet below the building's floor.

The French Drain in the courtyard confirms that groundwater is probably not coming into the building. Dry rocks are visible in the bottom of the French Drain 5-feet below the grate. The grate is 1-1/2-feet below floor level. Therefore, there is at least 6-1/2-feet from the floor to any groundwater or it would be visible in the French Drain. This was inspected in early August.

The problem with the courtyard is rainfall. Stories were related that the French Drain fills with water and overflows. With such a large area, this courtyard could collect 38,000 gallons of water if we received our maximum rainfall.
One of the two French Drains has been covered with a greenhouse so it is unavailable to collect water. The rock voids in the usable one are probably filled with silt from many years of use.

As a side note, a concrete vault in the courtyard should be removed or filled in and buried completely. It is believed to have been used for an old rock waterfall. The manmade rock outcropping is still there but the waterfall hasn't been used for years. The vault is a safety hazard. Also, the trail to the greenhouse is a safety hazard. A request has been made to pave it with concrete. It would be better if a permeable paving was used such as Grasscrete, which allows grass to grow in between concrete pads. This will allow water to continue to enter the soil in the path area and help reduce the required size of the French Drain.

Solutions

Rainwater needs to be stopped from entering the building. We need to collect and disperse the rainwater more effectively. To do this, a number of tasks will have to be performed. The research team recommends replacing the drywells on both sides of the school with new drywells and connecting them to the city storm sewer. The storm sewer is located in Madison Avenue to the north of Riverside. It was installed after the school was built. This allows us to use the drywell to "recharge" the ground with rainwater as required and have the excess run-off go to the city storm sewer.

If we install new inlets to the south of the drywell on the west side near the track we can keep that area drained. This will allow the track to be graded slightly toward the outside. The water will runoff to the drain instead of collect at the curb on the inside of the track.

Also, the French Drain in the courtyard should be replaced to make sure we are collecting that water properly. It needs to be larger.

Obviously the roof and roof drains need to be fixed also, to stop the roof leaks. That problem is being addressed this year by others.

Strategic Planning

The reality of budgets and the priority of the project may require the construction to take place in phases. They are listed in order of what the research team feels are the most urgent.

- Phase One: The west side drywell because it is of the most immediate concern.
- Phase Two: The inlets to drain the track and field are important but not essential to the operation of the building.
- Phase Three: Replacing the east side drywell will become more important in the future. It may be causing more problems than we can see now.
- Phase Four: The replacement of the French Drain in the courtyard. It would solve an immediate problem and a worse future problem.

Decision Support System

The costs can vary greatly depending on the solution and thoroughness applied to the project. The timing of the bidding will also have an impact. The following table is provided to help make a decision on the project and phases and to correlate to the district's overall budget. The table shows a predesign estimated cost of the four phases with a running grand total.

Go To Table Now

Blueprint for Action

Solving the rainwater problem is an important step in safeguarding the building from further deterioration. Following a blueprint for action will optimize resources while providing a long-term solution to the process.

1. Replace drywells and connect to city storm sewer.
2. Replace French Drain in courtyard.
3. Restore damaged interior finishes.
4. Check for leak in sprinkler irrigation at low spot south of the bleachers.
5. Correct unsafe conditions in courtyard.
6. Check for unseen damage to the building.
7. Continue fixing roof and roof drains then check monthly.
8. Establish a yearly drain cleaning program for storm and sanitary sewers.
9. Make all trades aware of building envelope waterproofing requirements.
10. Schedule inspection programs to stay on top of maintenance.

Conclusion

Solving the water problems at Riverside will improve the quality of life at the school and protect the district's investment. It will solve not only cosmetic concerns but also safety and health issues. The Riverside rainwater problem is well past the point of having some water on the floor now and then. The continual disruption of the teaching and maintenance staff from daily routines is expensive and time consuming.

It creates other problems such as the special precautions needed when replacing vinyl-asbestos tile in the hallway. It increases contracted maintenance projects such as the replacement of the quarry tile floor in the kitchen. Sanitary sewer back ups go unrecognized because it is normal to see water on the floor. And standing water on the track and grass areas limit their use and prevents maintenance.

The morale at the school is surprisingly upbeat considering the years of water problems they have had to endure. The school and grounds are very clean and well kept. The condition of the facility is a testament to the hard work and optimism of the staff. Two inexpensive changes would take some burden off the staff and make the facility even better: Guidance on routine inspections and maintenance for the roof and drains, and yearly inspection and cleaning of the sewer lines. By working together as a team we can improve the quality of life at Riverside Middle School.

Go Cougars!

Appendix

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[1] See the report in this appendix on the existing roof problems Building Research Institute of Montana prepared last year.

[2] Drywell is the term Orr Pickering Associates, the architects of the building used. A drywell is used to collect rainfall whereas a seepage or leach pit is used for sewage effluent. They are constructed the same. A leach or drain field is used for septic tanks. A French Drain in this case is a drywell with a concrete manhole above it and a slotted metal grate for the water to enter.

[3] Learning Center Addition by architects Dana, Larson, Roubal.

[4] Water may have been the cause of the trouble with the asphalt parking area, which was in horrible shape, in the area above the drywell. We overlaid this area last year with 1-1/2 inches of asphalt over reinforced fabric. This was a stop-gap measure as we didn't have the budget to take out the unsatisfactory base. So far no signs of deterioration where it was overlaid.

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Estimated Costs

Phase	Concept	Item	Unit	Quantity	Unit Cost	Total	Grand Total
Phase 1	Replace dry well on west side and install storm drain line to storm sewer in Madison Ave.	New dry well w/slotted MH	LS	1	10000	10000	
		10" PVC pipe	LF	325	25	8125	
		Manholes	EA	2	2000	4000	
		Sidewalk/Asphalt Replacement	SF	300	3	900	
		Subtotal				23025	
		Contingency (15%)				3454	
		Subtotal				26479	
		A&E Fees (15%)				3972	
		Total				$ 30,451	
Phase 2	Extend storm drain line to south and install inlets to drain lawn and track.	10" PVC pipe	LF	255	25	6375	
		Ditch Grading	CY	40	4	160	
		Add Storm Drain Inlets	EA	2	1300	2600	
		Inlets instead of Phase1 MHs	EA	3	-700	-2100	
		Subtotal				7035	
		Contingency (15%)				1055	
		Subtotal				8090	
		A&E Fees (15%)				1214	
		Total				$ 9,304	$ 39,754
Phase 3	Install storm drain line on east side from dry well to City storm sewer in Madison Ave.	Slotted MH	EA	1	3500	3500	
		10" PVC pipe	LF	315	25	7875	
		Sidewalk/Asphalt Replacement	SF	3300	3	9900	
		Subtotal				21275	
		Contingency (15%)				3191	
		Subtotal				24466	
		A&E Fees (15%)				3670	
		Total				$ 28,136	$ 67,891
Phase 4	Replace French drain in courtyard with larger capacity.	New dry well w/slotted MH	LS	1	5000	5000	
		Contingency (15%)				750	
		Subtotal				5750	
		A&E Fees (15%)				863	
		Total				$ 6,613	$ 74,503

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Back To Decision Support System

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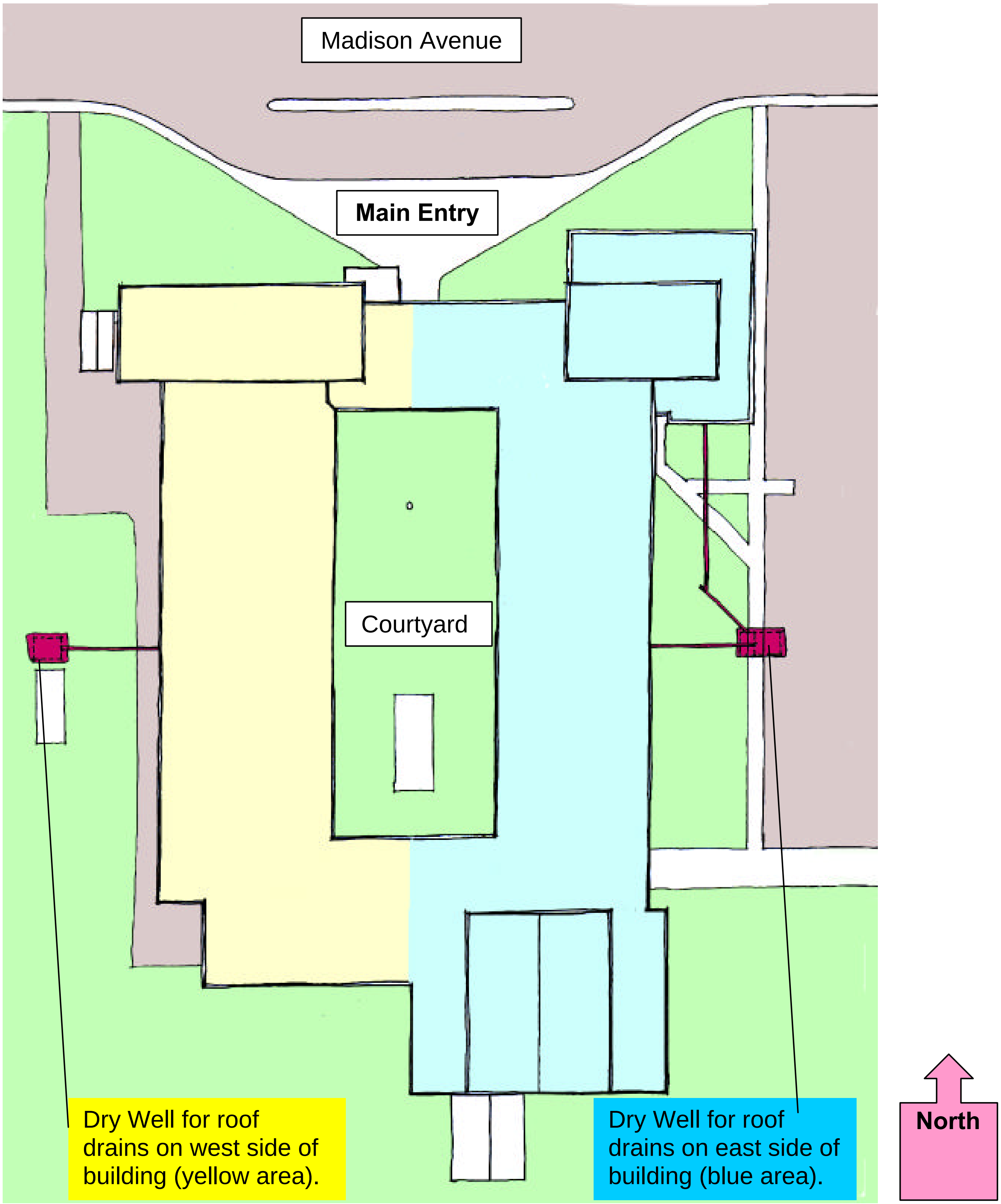
Site Plan (Not To Scale)



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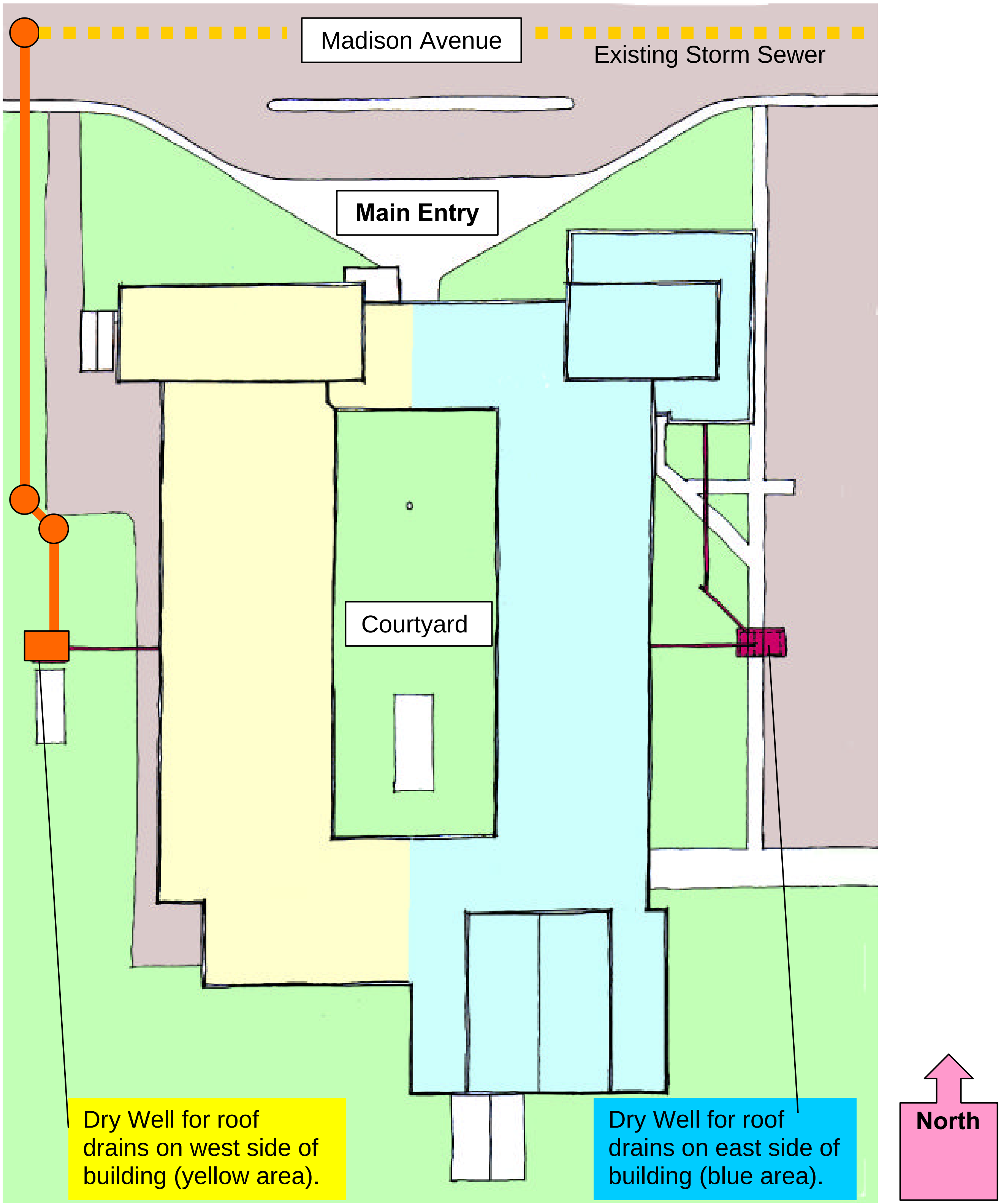

Phase 1 (orange): $30,500

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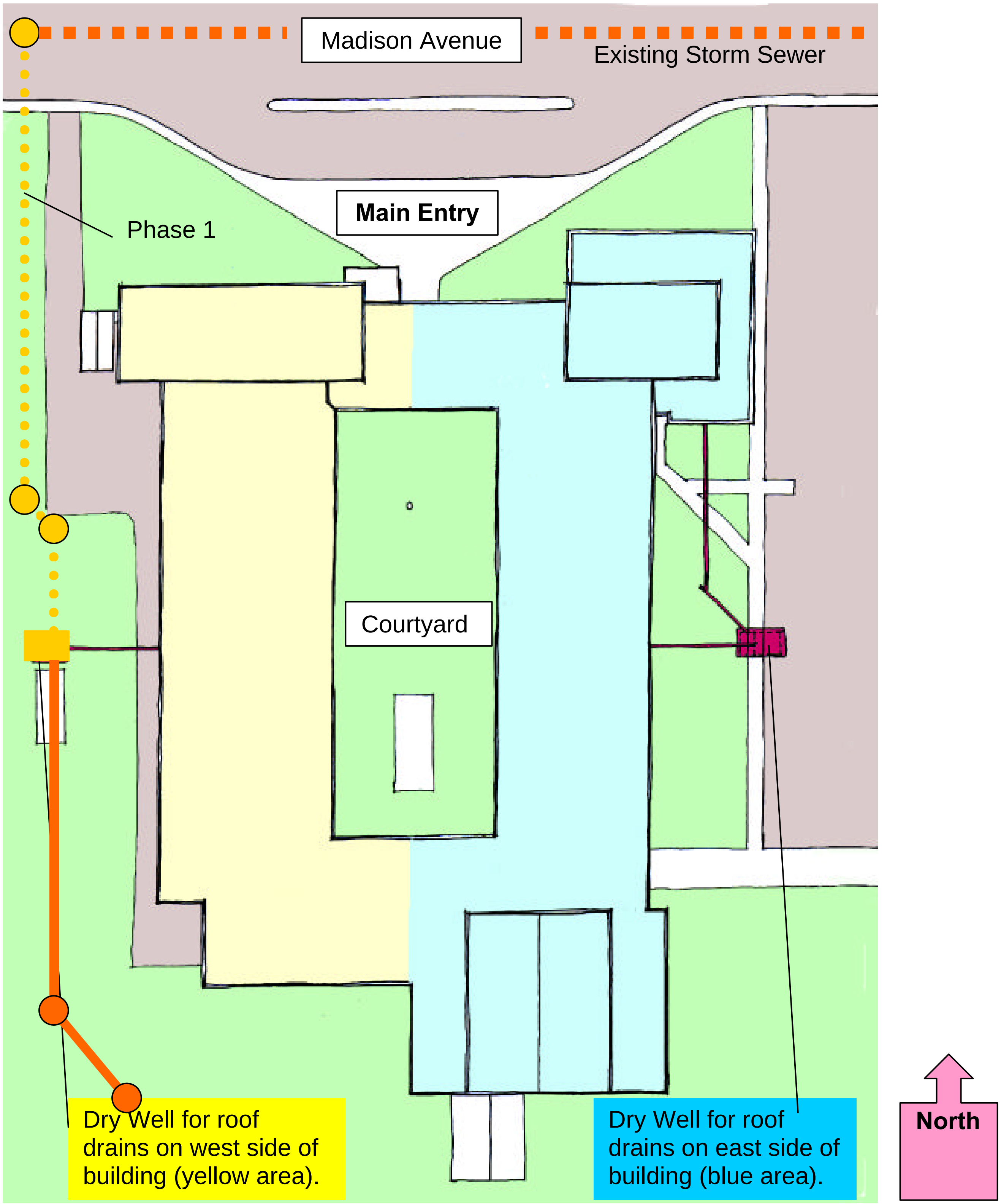

Phase 2 (orange): $9,300

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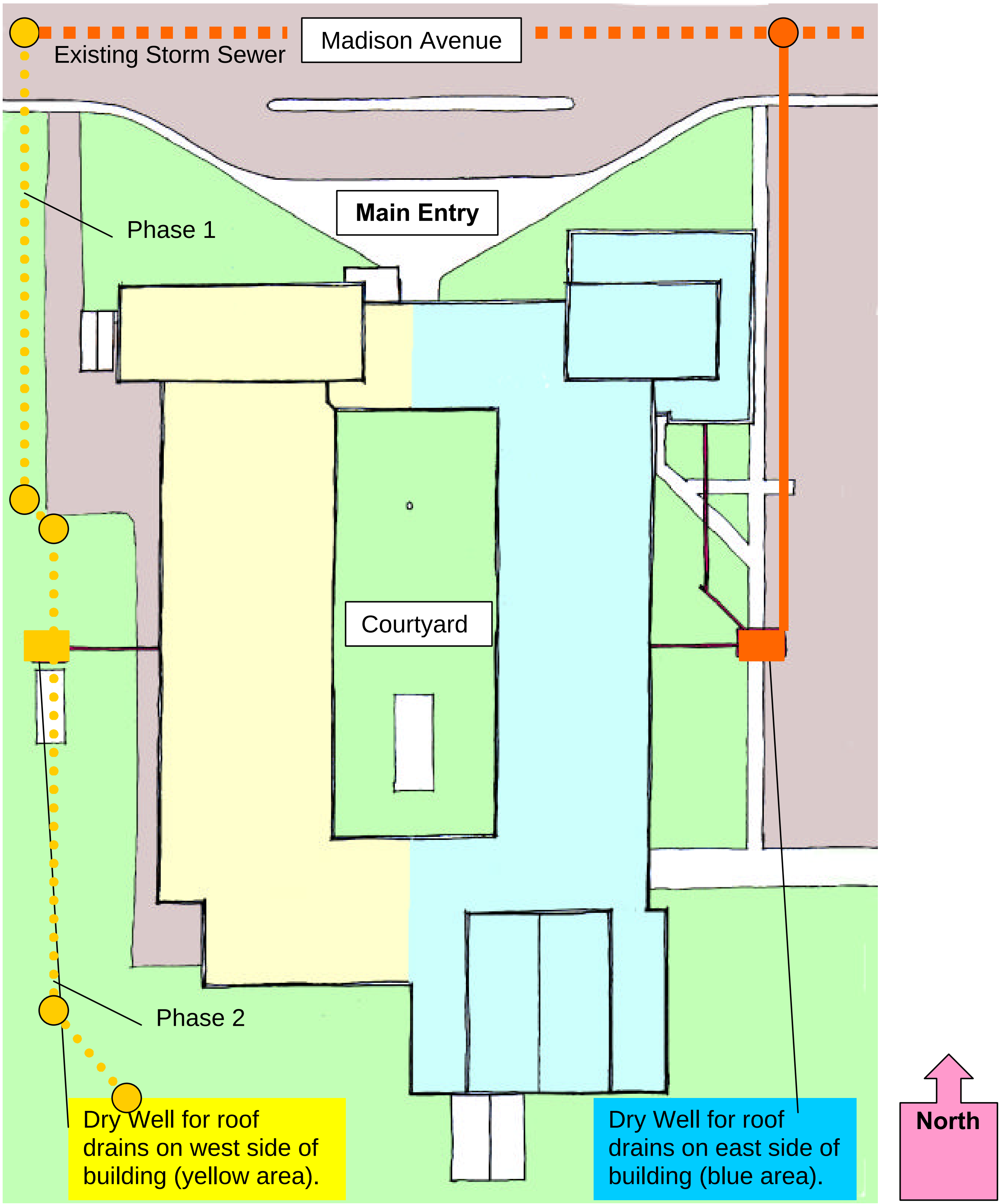

Phase 3 (orange): $28,100

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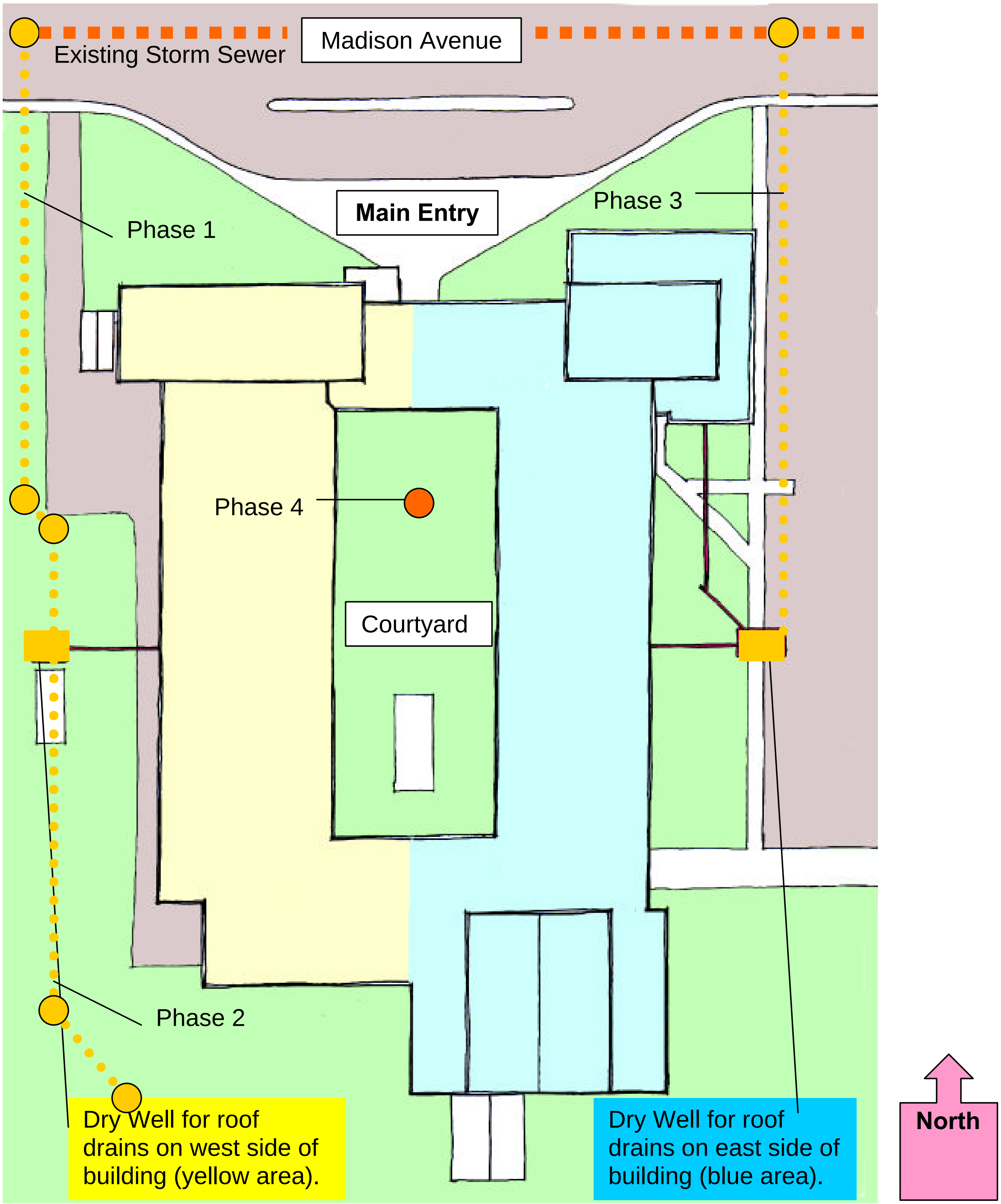

Phase 4 (orange): $6,600

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June 28, 1996

Mr. Alan Anderson
Director of Facilities Services
Billings Public Schools
101 10th Street West
Billings, MT 59102

RE: Roof - West wing of Riverside Middle School - Cursory general overview

ROOF SYSTEM:
Modified-bitumen membrane on 1/2-inch cover board over extruded polystyrene board insulation (XEPS) attached to concrete deck with hot asphalt.

HISTORY:
Installed approximately 10-years ago, done in two phases by Bradford Roofing. Architects left town shortly after installation unrelated to roof problems. Second phase tried to solve problems encountered on first phase with little success. School District tried to have warranty work done to no avail.

PROBLEMS:
Unsubstantiated information: Manufacturer claimed warranty was void. Reasons given ranged from no reflective coating used to surface the black membrane (could reduce heat gain up to 45%) to using XEPS rigid insulation in combination with no reflective coating. Extreme temperature changes caused buckling over entire roof and rupture at roof edges.

Facts: Polystyrene board is unsuitable as a substrate material for conventional built-up roof systems with felt-bitumen membranes because it is virtually impossible to bond to a deck with hot asphalt. It also has an extremely high thermal coefficient (less dimensionally stable), roughly twice that of a built-up membrane.

Thermal insulation has a secondary function; to provide horizontal shear strength to relieve concentrated stresses and distribute them over wider areas and limit membrane strain to below breaking point. Through its failure to perform these secondary functions, extruded polystyrene causes roof splits and pulls flashings from their wall anchorages.

SOLUTIONS:
Possible solutions range from complete tear-off of membrane and insulation and installation of proper roof system, to maintenance work such as attaching a rubber edge material that will allow movement in existing membrane and help keep the building weathertight. One possible in-between solution would be to cut the humps out of the existing roof, apply a slip sheet and install a vented Hypalon roof membrane system.

STRATEGIC PLANNING:
Decisions could be based on (among other things) appearance, repair vs. replacement costs, anticipated life-cycle of existing roof vs. new products, maintenance costs and risks and rewards associated with each option.

DECISION SUPPORT SYSTEM:
Compile, analyze and report the repair and cost strategies that best serve the Owner's long-term interests. Possible trial run on small area of roof to gain information on a maintenance system, if Owner deems necessary. Provides Owner with clear record of why decisions were made.

BLUEPRINT FOR ACTION:
Owner makes informed decision based on usable information provided. Owner optimizes resources while gaining long-term solution.

RELATED ACTION:
Similar systems are known to be in place at Senior High School and West High School kitchen area.

Jeffrey C. Baston, NCARB, AIA
Director