Technical and Managerial Succession Planning for Mile High Flood District

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December 9, 2021

Abstract

Organizations often fail to plan for succession resulting in replacement mentality and loss of institutional knowledge when employees retire. While literature covers succession planning from a managerial standpoint, less is available regarding technical succession planning. This study provides a systematic approach to develop a holistic succession plan that incorporates technical aspects specific to the flood warning services of a regional flood district into best practices for managerial succession. The research informs steps the organization can take to implement a succession plan that provides: 1) technical knowledge transfer to ensure smooth transitions when staff specific to flood warning services leave and 2) assurances that the program is cared for within an organization that has an effective managerial succession program. The researcher used a grounded theory approach and gathered data from eight local governments and seven staff via semi-structured interviews to develop recommendations. This research explores best managerial succession practices consisting of performance management systems, career progression clarity, systemic insight, leadership development including mentoring, development of talent pools, and active participation by management. Recommendations identify how information specific to technical aspects of MHFD's flood warning services can be used to inform these best managerial succession practices.

Keywords: Succession, public sector, flood warning, performance management, career path clarity, systemic insight, leadership development, talent pool

Introduction

This study is intended to identify steps for Mile High Flood District (MHFD), a quasi-governmental special district serving the Denver Metropolitan region, to take in developing a technical succession plan for their flood warning services while also taking steps to ensure that this technical succession plan fits within a structure that includes good managerial succession planning practices. Succession planning is "a systematic, long-term approach to meeting the present and future talent an organization must have if it is to continue to achieve its mission and meet or exceed its business objectives" (Rothwell, 2002, p. 32). Rothwell (2002) further explains that succession planning and management is a strategy that can help an organization meet its continuing need for people at all levels and in all occupational groups.

The scope of this study includes several interviews with current staff and local government partners; literature review to understand best practices for succession planning including performance management systems, career progression clarity, systemic insight, leadership development including mentoring, talent pool development, and active management participation; and recommendations to integrate program needs with these best practices.

Organizational Information and Structure

MHFD is a special district whose boundary includes 41 local governments in the Denver Metropolitan region. Their Mission and Vision is "Protect People, Property, and Our Environment through Preservation, Mitigation, and Education." Over the past several years MHFD has revised its structure to increase knowledge transfer among staff. One benefit of this is that when the time comes to fill leadership positions several candidates are prepared to make that transition. This helps mitigate the potential loss of institutional knowledge and loss of opportunity for new and different perspectives. A relatively new watershed-based structure has

helped with this, increasing the breadth of work for most of the engineering staff. However, various services related to flood warning have continued without modification and the organization wants to ensure that these services also have a good road map for succession.

The current structure is based on eight watersheds within the MHFD boundary. Rather than jurisdictional boundaries, watershed boundaries are based on stream systems and each watershed includes the land tributary to the stream system. See Appendix A for a map of the watersheds. In this relatively new structure, watershed teams led by a Watershed Manager work to provide a variety of services to the local governments and general population within the watershed. These services include master planning, capital projects, maintenance projects, and the Maintenance Eligibility Program (Mile High Flood District, 2017). Each of the eight Watershed Managers reports to one of three Engineering Services Managers (ESM). However, each ESM is responsible for a select number of services. For example, one ESM oversees watershed planning and floodplain management while other ESMs cover over services. In this way, each Watershed Manager has exposure to multiple leaders within the organization while satisfying the responsibilities of their position. Historically, efforts related to flood warning and planning for emergencies related to flood events have been provided by a separate Manager in the organization with limited overlap with the watershed teams. This individual has been with the organization for more than 40 years and has announced his retirement effective February 2022. MHFD leadership now wishes to explore ways to restructure the work of flood warning services in keeping with their model for increased knowledge transfer and wishes to implement any changes before hiring a new manager for this position.

Purpose

Public sector organizations have substantial uncertainties about leadership capabilities and there is a lack of succession planning in the public sector which continues to contribute to these uncertainties (Montlha Pila et al., 2016). This problem is relevant to all organizations as senior leaders retire and take with them institutional knowledge.

The goals of this study are two-fold: 1) collect data needed to create a succession plan for certain technical services provided by flood warning staff, and 2) identify and make recommendations to perform this work in keeping with best practices for succession. While the literature presents and reinforces common practices recommended for succession planning and what is termed vertical career progression, less has been published related to succession planning for technical positions that exist across the horizontal level of the organization chart. This exploration of technical succession planning focuses on efforts to ensure the continued performance of a department by retaining and communicating key institutional memory and lessons learned over time (Rothwell, 2004).

The research will identify steps to ensure the development of leadership skills within the organization while also ensuring a succession path for technical expertise vital to the local governments and residents who depend on this special district for holistically managing flooding throughout the Denver region. This study will be not just relevant to MHFD but will serve as a case study for other special districts and public sector organizations to develop and implement succession plans that include considerations for technical positions.

Literature Review

Succession planning requires strategic methods and planning for an organization to adjust to changing internal and external pressures over time (Murphy, 2006). While much of the literature highlights the benefits of succession planning including increased employee satisfaction and retention (Kim,2003 and Weisman et al., 2016), barriers often win as very few public organizations have formal succession plans. Barriers to succession planning include the sense that with all other demands, succession planning does not have a high enough priority and that sometimes the staff is too small to make it a worthwhile effort (Weisman et al., 2016). Frase-Blunt (2003) posits that a barrier to creating succession plans that include diverse candidates is the secrecy attached to the process and a fear of morale damage among those who do not feel they are likely to be chosen for advancement. Without an intentional plan, leaders can feel more comfortable when critical organizational roles are filled by people who are similar to the incumbent. Succession planning should allow candidates to take personal responsibility for their development, define competencies for each individual, offer a plan for continual development, and allow individuals to self-nominate for key future openings (Frase-Blunt, 2003).

While the literature collectively presents and reinforces common themes related to best practices for managerial succession planning including performance management systems, career progression clarity, systemic insight, leadership development including mentoring, development of talent pools, and active participation by management (Ahmad & Saad, 2020; Groves, 2007; Kim, 2003; Montlha Pila, et al., 2016; Murphy, S. A. 2006; Al Suwaidi, et al., 2020), less has been published regarding technical succession planning.

The themes presented in this literature review identify best practices for managerial succession planning as well as recommendations for technical succession planning. While

managerial succession practices create a framework to grow leaders at each successive level in

an organization, technical succession planning captures specific and technical information

needed to preserve and enhance specialized knowledge so that the organization can continue to

advance as people progress into new positions or exit the workforce. The literature review is

comprehensive in that the researcher found no other themes that were highly studied in the

literature.

Best Practices and Recommendations for Succession Planning

The following sections detail findings from the literature on five common themes for best

practices of succession planning as well as an approach to technical succession planning.

Performance Management Systems

Performance management includes performance planning, performance appraisal, and

performance development plans (Montlha Pila et al., 2016). When employees understand the

connection between their contributions to the objectives of the organization and their personal

growth, they will be able to envision a path ahead that empowers them to pursue growth

opportunities that interest them and are also complementary to the objectives of the organization

(Montlha Pila et al., 2016). In this way, good performance management can advance succession

planning.

Performance management systems can both serve to advance a succession planning

program but, if done poorly, could be detrimental. Olatunji (2017) showed that skill development

and performance evaluation significantly impacted employees' satisfaction for normative

commitment and that ill-conceived and ill-considered performance perceptions for succession

planning can create tensions in the organization. This speaks to the importance of not just having

a management plan but ensuring that it is an effective means to empower employees to envision their development path.

Career Progression Clarity

Employees perceive succession planning practices not just as planning for filling key positions but as a tool for general career development (Kim, 2003). In this way, succession practices provide benefits to both the organization and the individual. Proper planning and management of career paths can achieve organizational needs and also fulfill staff aspirations (Ahmad & Saad, 2020). Like good performance management systems, clear career paths can help employees to envision a path that benefits them personally and they may be more likely to remain with the organization.

Raeespoor et al. (2018) focused on an integration model for career path progression and succession planning. Career path progression planning is typically a bottom-up process (or from the individual to the organization) while succession planning has a top-down flow (or from management to individuals). Integrating the two can effectively meet the goals of both individuals and the organization. Raeespoor et al. (2018) identified seven categories for effective establishment of an integrated model, the first of which was familiarization which happens when individuals are familiar with succession training and their career advancement path. Other categories identified by Raeespoor et al. (2018) consisted of active participation by [leadership], organizational learning, making trust, futurism, autonomy, and systemic insight. Some of these are consistent with other best practices identified below.

Ahmad and Saad (2020) present four independent variables of transformational leadership to support career progression. Of these four, they identified idealized influence, embodied by exemplary and trusted leaders, as the most predictive characteristic of the career

development program as perceived by the subordinates they surveyed. Idealized influence is

defined as leaders who behave in ways that make them role models for their team. They are

admired, respected, and trusted (Breaux, 2010). An individual's clarity in understanding their

career path will help an organization fulfill succession planning needs and to have a supervisor

that models an ideal role in that path provides even stronger clarity. By both providing career

path clarity and idealized influence, the path is further clarified and reinforced narrowing any

gaps between one position and the next vertical step.

Systemic Insight

Integrating succession planning with career progression should be viewed through a

systemic lens. Raeespoor et al. (2018) found systemic insight to be effective in integrating

succession planning and career progression path. They also outline an approach to attain

systemic insight which consists of, "setting a statement of mission, writing the policy guidelines,

clarifying processes, identifying the target groups for action, determining the roles in the

successor fostering program for CEOs, senior manager, and others; and setting the priorities of

the program" (Raeespoor et al., 2018, p. 108-9). These recommendations are specific to various

organizational objectives and will allow integration of technical succession with managerial

succession planning for this research.

Leadership Development Including Mentoring

Rothwell (2002) identified establishing an in-house leadership development program to

narrow gaps, a best practice for succession planning. Since most learning is done on the job,

leadership development programs can include on-the-job work assignments, projects, task force

participation, and external training and events. According to Groves (2007), in-house leadership

training in the form of job assignments and "action learning" was also identified as a best

practice for leadership development along with 360-degree feedback, executive coaching, mentoring, and networking.

Mentoring is a method of best practice for leadership development (Groves, 2007). Mentoring significantly increases employees' satisfaction for affective commitment, the employee's positive emotional attachment to the organization (Olatunji et al., 2017). Groves (2007) describes mentoring relationships to consist of discussions related to career planning, assessment of core strengths, areas of improvement, and development of leadership competencies and recommends that organizations develop a mentoring network "by fully engaging all managers in mentoring relationships with direct reports and other high-potential employees in other work units" (p. 256). An organization's mentoring program can help expose individuals to the multiple mentors they will need at different times in their career and "develops high potentials' leadership competencies through personal coaching, group discussions, career guidance, and exposure to senior leaders" (Groves, 2007, p. 246). Mentors are rarely immediate supervisors (Rothwell, 2002). This advances the importance of purposefully creating opportunities for mentoring and not depending on one person to provide that role.

Talent Pool Development

In an effort for organizations to fill positions with the most qualified individuals and those that will model idealized influence, the literature supports developing a talent pool. "An important finding related to avoiding the replacement mentality is resisting the temptation to designate an heir apparent for key executive positions" (Groves, 2007, p. 248). Replacement mentality is when leaders are replacement-oriented and overly focused on identifying successors rather than the future leadership needs of the organization. When the succession process ends, replacement-oriented leaders pay too little attention to ongoing development for those involved

(Barnett & Davis, 2008). To avoid replacement mentality, much of the literature related to succession planning has a focus on taking a systematic approach to talent management that results in developing a pool of individuals capable of stepping into key positions. Al Suwaidi et al. (2020) posit that this approach addresses change management and the fulfillment of the organizational mission and strategy and that it can only be achieved with commitment at every level of the organization.

Talent management includes talent attraction, development, and retention, including the talent pool (Montlha Pila, 2016, p. 146). Raeespoor et al. (2018) identified talent pool development and identification of top talents within as part of a strategy for integrating succession planning and career path development. Groves (2007) suggests that avoiding the replacement mentality and keeping updated lists of "high potentials" within a diverse pool of candidates will ensure a flexible and fluid succession planning process. Armstrong (2012) presents a more expansive view of the importance of talent by suggesting that talent management includes a perspective that "every employee in the organization is regarded as actual or potential talent, given the opportunity and direction" (p. 1057). Adoption of this more expansive view maximizes the number of potential candidates and supports growth and development opportunities of all employees, an approach that has benefits beyond that of succession planning. Not everyone will advance into leadership positions. However, many best practices for succession planning focus on the growth and development of individuals and as these individuals take responsibility for their development and training, they will continue to increase skills and provide new benefits to the organization.

Active Participation by Management

The literature reinforces the importance of the leaders within the organization to be active participants in succession planning. It is not something that can be delegated to human resources. Senior leaders need to take a hands-on approach to succession planning and view their role partly as talent developers (Rothwell, 2002). Raeespoor et al., 2018 also speaks to support from senior staff as important to the integration of succession planning and career progression path. Supervisors have a direct role with performance evaluation and they are responsible for helping to chart a path for growth. However, they may not always be aware of the intent behind some of the details of the overall performance management system or other components of a succession plan developed by human resources and strong collaboration between human resources and supervisors can help reinforce those connections.

Al Suwaidi et al. (2020) found "management commitment toward leadership transition" to be one of five determinants linked to executive succession planning in the public sector. Other determinants consisted of succession planning strategy, organizational culture, leadership development opportunities, and knowledge management opportunities. The researchers also highlighted the challenge presented in striking a balance between allowing incoming leaders to assume full responsibilities to start developing strategies and the fear of compromising organizational continuity when the outgoing executive leaves too early (Al Suwaidi et al., 2020).

Technical Secession Planning

While existing literature reinforces several common themes related to succession planning, there are fewer publications specifically addressing technical (versus managerial) succession planning. Sometimes only one or two individuals within an organization need to understand certain technical processes or programs. This can create a need to outsource or look

externally to replace these key individuals when they leave. Outsourcing also refers to looking to

vendors to accomplish program tasks. Regarding the use of vendors to outsource program tasks,

Rothwell (2004) notes that the person overseeing these vendors still needs to understand past

operations and present initiatives enough to ensure the public gets value on these outsourced

operations. Technical succession planning requires isolating relevant knowledge, distilling it,

preserving it, and finding practical ways to share it in useful forms to the right people when they

can use it (Rothwell, 2004). To address this systematically, Rothwell (2004) recommends seven

steps:

1. Commit to capturing certain specialized knowledge and institutional memory.
2. Clarify what work processes are key to the agency's mission.
3. Clarify who possesses specialized knowledge about these work processes.
4. Clarify how those work processes are performed by those possessing the knowledge through planned (e.g., interviews and storyboarding the flowcharts of processes) and unplanned (e.g., shadowing).
5. Capture and distill the specialized knowledge.
6. Consider how to maintain and transmit it to ensure the efficient and effective continuity of operations; and
7. Continuously assess knowledge gaps, evaluate the action strategies taken to address them, and the results achieved. (pp. 409-410)

This research uses the recommendations identified above to help identify how MHFD's flood

warning services can be carried out in keeping with the best practices identified in the literature.

Methodology

This study attempts to identify steps MHFD should take to develop a succession plan for

their flood warning services and build that plan within a structure that incorporates best practices

for managerial succession.

Research Question and Proposition

The research question is:

What steps should MHFD take to integrate the current and future needs of flood warning services with best practices of succession planning?

The proposition associated with this research question is: Identifying goals, workflow, opportunities for knowledge sharing, and objectives related to skills and expertise will enable the organization to implement succession best practices specific to flood warning services.

Approach

This study is qualitative using data collected through a series of semi-structured interviews. Literature supports the use of semi-structured interviews when studying perceptions and opinions and to understand themes from interviewees with different perspectives (Kallio et al., 2016).

To collect information specific to MHFD's flood warning services, the researcher first identified three themes requiring specific programmatic and, in some cases, technical information that were consistent with the literature findings for general best practices of succession planning. These themes and how they relate to best practices of succession planning are detailed in this section. The themes consist of: (1) Setting a statement of mission and setting priorities, (2) Increasing opportunities for knowledge sharing and collaboration, and (3) Identifying objectives related to skills and expertise needed to perform tasks. Theme one supports systemic insight, a concept identified by Raeespoor et al. (2018) as an effective strategy for integrating succession planning with a career progression path. The findings of Groves (2007) detail the need for multiple mentors and talent pool development, both are supported by theme two. Theme three is identified as one of three theories underpinning performance management by Armstrong (2011). Theme three can also be used to help individuals become familiar with their career advancement path, a practice identified by Raeespoor et al. (2018) as

supporting succession planning. Finally, in keeping with the best practice of active participation by management, including leadership staff in the sample population to provide input, especially concerning themes one and two, will help ensure that the resulting recommendations of this study will be recommendations that the leadership team can actively support.

Sampling Plan

Two populations require representation in this study. The first is MHFD staff who have experience with flood warning services activities as well as MHFD leadership who have a specific interest in the work of the program. Seven staff interviews were used to inform all three themes listed earlier. The second population is local governments that benefit from flood warning services offered by MHFD. There are a total of 41 local governments in the service area. Based on recommendations from staff, eight local government contacts were identified as "best representing MHFD's flood warning clients" and were included in the sample. In keeping with MHFD's core value of supporting local governments, interviews with local government representatives had a stronger focus to inform the first theme, developing goals and clarifying processes related to the program. Developing goals and clarifying processes supports systemic insight as outlined by Raeespoor et al. (2018). Interview guides are provided in Appendix B.

Validity and Reliability

Internal validity is the extent to which a measure adequately captures the concept under investigation (Nishishiba et al., 2013, p. 53). Both participant bias and researcher bias, personal biases held by the interviewee and researcher, are threats to this study. To address participant bias, interview questions were open-ended as to not guide the answer and the researcher remained neutral no matter the answer. Researcher bias was mitigated by starting with simple and general questions before moving to specific questions. For this study, the researcher is also an employee

of MHFD and it was especially important to consider all data without bias. This bias was

mitigated by actively involving the interviewee in checking and confirming the data received

(member checking).

External validity is the extent to which the research results can be used to conclude the

study to the whole population of interest (Nishishiba et al., 2014). The research is specific to the

needs of MHFD and the perspectives of the current staff. In this way, applicability beyond

MHFD is limited.

The study is reliable and repeatable. Although, potential threats to reliability include

significant changes in leadership or organizational processes. These could change opportunities

for integrating flood warning services with succession best practices.

Data Analysis

The researcher recorded all fifteen interviews, reviewed each transcript, and coded each

question consistent with grounded theory methods as described by Glaser & Strass (1967) to

identify priorities for various aspects of MHFD's flood warning services, opportunities for

knowledge sharing and collaboration, and objectives related to skills and expertise needed to

perform tasks. Based on the themes identified, the researcher developed recommendations for

integrating specific information related to the program into best practices for succession planning.

MHFD can use these specific themes and recommendations to inform performance management

systems, improve career progression clarity, increase systemic insight, inform leadership

development, and increase collaboration to help develop a talent pool.

<div align="center">**Results**</div>

The Tables section of this study provides ten tables providing all topics identified through

thematic coding of the interviews. The below discussion draws from those tables to inform the

three themes identified in the Approach section: (1) Setting a statement of mission and setting priorities, (2) Increasing opportunities for knowledge sharing and collaboration, and (3) Identifying objectives related to skills and expertise needed to perform tasks.

Theme 1: Setting a Statement of Mission

Interview questions related to identifying the mission of the program were structured to address three phases: planning for floods, MHFD's role during an active flood, and post-flood activities. Review of these phases also helps identify other relevant work products that feed into theme 2, identifying opportunities for collaboration. The researcher also collected data on which flood warning services were most critical to local governments, how local governments use data, and potential areas for growth within flood warning services.

Staff and local governments identified four areas of focus related to how MHFD should support local governments to prepare for future floods. In order of what they mentioned most, these include trainings; planning and development; tools and resources; outreach to local governments, and outreach to the public. Table 1 provides a detailed summary that expands on each of these focus areas.

When asked about MHFD's role during an active flood, the most frequently mentioned area of focus was about ensuring MHFD flood warning systems remain functional. This was followed by monitoring the situation, being available to check in with local governments and provide more detailed information, providing access to important tools and resources, and anticipating the needs of local governments. Staff interviews also specifically addressed the role of the MHFD Flood Warning Manager during an active event. Table 2 provides a detailed summary that expands on each focus area. As shown in Table 3, six of seven staff mentioned an expectation for the Flood Warning Manager to provide informative communication regarding the

situation. Four of seven interviewed also mentioned that the manager should provide central coordination in managing the flood event and help communicate staff's role to them.

Table 4 provides detail regarding how MHFD should assist local governments following a flood. The most mentioned area of focus was concerning repair and recovery efforts followed by documentation and reconstruction of the event and engaging in efforts to improve future outcomes.

Local government representatives also identified the most critical flood warning services provided by MHFD. Most mentions related to notifications and tools including daily emails identifying potential threats for the day and rain and stream gage notifications. Melissa Ryder, Community Resilience Coordinator for the City of Arvada said, "I feel very empowered by the data [MHFD] provides and the warnings as they currently exist." Mentions included the organization's Flash Flood Prediction Program (F2P2) and a predictive forecasting tool that provides local governments advance time to prepare before potential flash flooding. Local governments also mentioned the technical expertise. This includes the ability to contact forecasters directly and help in identifying critical areas. Although mentioned less frequently, local governments also included MHFD provided trainings. It is worth noting that then the researcher asked local governments what services are most critical, all mentions relate in some way to the resources MHFD provides before and during a flood event. Details of these discussions are further expanded in Table 5.

Based on interviews with staff, the program collects data that requires management and a means to access these data. Local governments provided insight into how they use these data. All eight local governments mentioned disseminating data to other departments or partners. These departments and partners include Streets, Operations, active construction sites, Parks and

Recreation, 911 dispatchers, law enforcement, and fire partners. Data are also used by local governments to inform thresholds for action. This means looking at archived data to determine when a rain gauge, stream gauge, or forecast should trigger an action such as evacuation. Table 6 identifies other uses for archived data as well as how local governments use real-time data for decision support.

When the researcher asked interviewees about what MHFD is not doing now but should be, there was a large disparity between the response from staff and that of the local governments. While staff had 15 mentions on this topic, local governments had just four. Both staff and local governments identified trainings and outreach as an area where MHFD should increase offerings. This was followed by increases in coordination and collaboration, ideas related to data development, themes related to management and leadership, and lastly an idea for a new type of planning document. These responses are further detailed in Table 7.

Interview questions related to setting a statement of mission provide detailed insight into MHFD's role before, during, and after a flood. Understanding what needs to happen and when will inform opportunities for knowledge sharing and collaboration between various positions within the organization. This is further discussed in the next section. Understanding what is most critical to MHFD's local governments and how they use flood warning data allows the organization to work in concert with the organization's core value to support local governments. Lastly, the difference in response from the staff compared to local governments regarding potential areas of growth for the program may illuminate internal needs within the organization for increased understanding and collaboration between flood warning staff and other MHFD positions.

Theme 2: Increasing opportunities for knowledge sharing and collaboration

The watershed structure places value on watershed teams understanding their watershed as a system. As shown in Table 8, four of seven staff identified a need for access to flood warning information to build a watershed understanding of hydrology and hydraulics. The scope of this understanding and coordination starts before a planning study by identifying areas where the watershed team needs to collect information to inform that study and extends through the design phase to properly design streams using the best available information. Staff also noted the importance of identifying flood warning infrastructure that may be impacted by projects or projects that may allow expansion or improvements to flood warning infrastructure. Additionally, it is valuable for watershed teams to understand critical areas of flooding as identified from flood warning services and with local government emergency managers. The interviews also uncovered a desire for emergency managers to understand what planning studies and construction projects are underway. This was identified by staff (see Table 8) and by local governments (see Table 10).

Beyond identifying the importance of coordination, staff also identified where data collected through the flood warning services could improve tools used by watershed teams and also how knowledge held by watershed teams could help inform flood warning tools. Staff also identified relationship building with local governments as a focus area for sharing and collaboration between flood warning staff and watershed teams.

While Table 8 details responses provided by staff and summarized above, the organization's mission regarding flood warning and some of the themes identified as both staff and local governments spoke regarding MHFD's role before, during, and after a flood event are also valuable to inform the organization of all opportunities for collaboration. Appendix C

summarizes a list of tasks identified from the interviews that the organization could consider in developing a plan to integrate the work of flood warning services with other MHFD efforts.

Theme 3: Identifying objectives related to skills and expertise needed to perform tasks

All interviewees were asked to describe the most important skills and expertise required for someone responsible for managing flood warning services at MHFD. Based on responses by both staff and local governments, the most frequently mentioned attribute for the Flood Warning Manager to possess is that of a good communicator. This is closely followed by someone that understands hydrology and hydraulics. The ability to build relationships was the third most mentioned attribute for someone in this position.

When grouping all comments received into areas of focus, technical expertise received the most mentions. This includes knowledge of climate science and meteorology, modeling, someone who understands the requirements for the collection of accurate data, and someone that understands certain aspects of the communications structure. As part of this study, the researcher worked with MHFD to create a flow chart for flood warning communications. This flow chart is provided in Appendix D along with related definitions and various roles that MHFD vendors play in the communications network.

While the need for the Flood Warning Manager to be a good communicator was the single most mentioned attribute, communication skills, in general, was the second most mentioned area of focus. Mentions in this category included the ability to communicate risk, deliver technical information with detail catered for a public audience, and the ability to engage media.

Leadership was the third area focus. This included relationship building, providing leadership under pressure, and the ability to see the big picture. The fourth focus area was that of

understanding emergency management and the fifth focus area was related to curiosity and the manager needing to have a desire to keep learning and stay active in outside organizations.

While it did not fit well into the above-listed focus areas, it is significant that four of eight local governments identified that the manager should be local or knowledgeable of past flood events. This was not something that staff identified but is seen as valuable to MHFD's local governments. All responses are detailed in Table 9.

Recommendations

This section outlines steps MHFD should take to use the findings of this research and the information specific to MHFD flood warning services to integrate data into performance management systems, reinforce career progression clarity, attain systemic insight, increase opportunities for leadership development and mentorship connections; and develop a talent pool.

Performance Management Systems and Career Progression Clarity

To develop their performance management system with specific details related to flood warning services, MHFD should use Table 9, Objectives Related to Skills and Expertise, to inform updates to relevant job descriptions and performance evaluation forms. Understanding of skills and expertise needed to advance helps individuals become familiar with their career advancement path, a succession planning best practice identified by Raeespoor et al. (2018).

The scope of this research also includes identifying opportunities for knowledge sharing and collaboration to develop a talent pool. Recommendations related to this best practice are presented later. However, they may impact job descriptions and performance management systems beyond that of flood warning service staff. Following all study recommendations, the organization should amend the existing performance management system including job descriptions, performance evaluations, and work plans, and add new skills, tasks, and roles

where appropriate. These amendments could include not just the roles of flood warning staff, but also watershed teams, the Floodplain Manager, and others because the recommendations in this study aim to identify which flood warning service tasks can be completed through a more collaborative process.

Systemic Insight

Consistent with the approach for attaining systemic insight described by Raeespoor et al. (2018), MHFD should outline a mission statement specific to flood warning services, identify and write any related policy guidelines to perform associated tasks, document processes, identify target groups for action, determine individual assignments for various positions, and set priorities.

Based on interview questions related to setting a statement of mission, the answers to which are detailed in Tables 1 through 7, the mission of MHFD's flood warning services should include a focus on its role in providing a valued resource of information leading up to and during a flood event. This focus was reinforced throughout multiple interview questions. When asked about the program's most critical services, local governments spoke most frequently about notifications and tools. This was followed by technical expertise and trainings. All these services are types of resources. This focus was further reinforced when local governments and staff spoke most frequently of trainings including trainings related to notifications when asked how MHFD should help prepare local governance for a future flood. Continuing with this focus, when interviewees were asked how MHFD supports local governments during a flood event, they spoke most frequently about the need to ensure systems are functional.

Leadership Development Including Mentoring

Consistent with Rothwell (2002), MHFD should consider both internal opportunities such as on-the-job work assignments or stretch projects for staff and external training opportunities

that contribute to leadership development. One potential on-the-job example project collected from the interviews is the development of a flood recovery assistance plan that includes what MHFD staff should do during a flood which would require staff input and collaboration. Another idea extracted from the interviews relates to the need for an outreach effort that could involve multiple staff to help inform local governments as to how staff can assist post-flood. Both efforts would require a champion to lead the effort with the input and support of additional staff. See the list of tasks in Appendix C for additional project examples.

Leadership development also includes mentoring which is critical to career success. The literature supports having multiple mentors to provide different perspectives, knowledge, and skills (de Janasz et al., 2003). As MHFD follows the recommendations suggested in this study, including increasing opportunities for knowledge sharing and collaboration, the organization can also take this opportunity to identify and reinforce communication paths between potential mentors and staff to help facilitate relationship building. Individuals can reach their greatest potential through interactions with multiple and diverse mentors (de Janasz et al., 2003)

Talent Pool Development

The organization should review Appendix C which provides a summary of all tasks related to flood warning services that were identified throughout the interviews. For each task, MHFD should consider what role various staff might have in its execution and asses what communication is needed before, during, or after the task. Potential staff includes the watershed team, flood warning staff, and the Floodplain Manager as identified through interviews but may also include others. Following the review of this plan, MHFD could populate a work plan(s) and include in it roles for various staff.

Table 8 summarizes input from staff on how the work of flood warning services and that of watershed teams impact each other. Staff identified several areas where sharing information will benefit all parties. The recommendations provided in this study help MHFD identify connection points and specific tasks for the collaboration of watershed teams and flood warning staff operations. MHFD should also evaluate ways to increase opportunities for information sharing and coordination in general. These opportunities could include workflows, various staff meetings, and other opportunities that might promote relationship building. The most frequently mentioned area of focus when staff was asked about how flood warning services impact watershed teams and vice versa was a need for improved coordination.

Conclusion

This study provides a systematic approach to developing a holistic succession plan for MHFD. This research informs steps to implement a succession plan that provides: 1) technical knowledge transfer to ensure smooth transitions when flood warning staff leave and 2) assurances the program is cared for within the organization that has an effective managerial succession program. While MHFD prepares for the current Flood Warning Manager's retirement without having the recommendations of this study already in place, this plan captures important information regarding the mission of the program and the tasks involved with its success. The recommendations can be used to help populate a work plan for the new Flood Warning Manager and others as well as develop a plan for succession long term. The long-term plan requires continuous attention to best practices including performance management systems, career progression clarity, systemic insight, leadership development including mentoring, development of talent pools, and active participation by management. Integrating technical succession within

this plan requires a continual focus on recognizing relevant knowledge and finding practical

ways to share it in useful forms to the right people when they can use it.

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Tables

Table 1

MHFD's Role Supporting Local Governments to Prepare for Future Floods

Theme Identified by Interviewees	Staff	LG	Total
Training -notices and mapping out communication lines based on thresholds	3	5	8
Training /exercises	5		5
training and exercises - how to use tools and access information		3	3
How to interpret data received and when is it actionable?		2	2
Emergency action plans/planning for emergency response	4	1	5
Masterplanning/Floodplain Management activities	2	3	5
Identifying areas to watch		3	3
Mapping different levels of risk	2		2
Documenting evacuation thresholds	1		1
Data in forecasting - decision support (real-time information)	5	1	6
Help establish and structure notifications to trigger actions		3	3
Floodplain Brochure		2	2
Daily mapped areas of inundation based on forecast (Intent of FHIT)	1		1
Website resources		1	1
Build relationships so MHFD and LG representatives know who to contact	3	4	7
Outreach to local governments to strengthen their floodplain regulations	1		1
Inform Local Governments of how MHFD will help post event		1	1
Annual Symposium presentations related to flash flood awareness or system capacity		1	1
Work with local floodplain managers related to various permits, e.g., oil and gas intrusion		1	1
Help construct (pre-planned) public messaging for certain flood scenarios		1	1
flood awareness to the public, "turn around, don't drown"		1	1
Help with messaging to the public on terminology (e.g., 100-year storm meaning)		1	1
A handbook/online resources to show the public how they can prepare for a flood		1	1
Help Local Governments educate the population with regard to their risk	1		1

FHIT = Flood Hazard Inventory Tool

Table 2

MHFD's Role Supporting Local Governments During an Active Flood

Area	Theme Identified by Interviewees	Staff	LG	Total
Ensure systems functional	Provide additional gauge data during the event to make decisions	5	7	12
Monitor the situation	Identifying zones to keep an eye on (e.g., for evacuation)	6	3	9
Be available	Provide more detailed (consultative) information		3	3
	Check in with local governments to see how MHFD can help	2		2
Tools/Resources	Provide direct access for local governments to forecasters		2	2
	Have website resources easily discoverable	1		1
Anticipate needs	Identify locations to set up shelters if needed	1		1
	Make regional connections to share equipment between municipalities		1	1

Table 3

Flood Warning Manager's Role Supporting Staff During an Active Flood

Area	Theme Indentified by Interviewees	Staff	LG	Total
	Informative communication about the situation to staff	6	n/a	n/a
Leadership	Communicate staff's role	4	n/a	n/a
	Central coordination/managing the event	4	n/a	n/a

Table 4

MHFD's Role Supporting Local Governments After a Flood

Area	Theme Identified by Interviewees	Staff	LG	Total
Repair and Recovery	Utilize contractors (Have them on standby and utilize as requested)	4	5	9
	Engage design teams and contractors for emergency repair	4	3	7
	Access to reserves (TABOR emergency, 3% unrestricted, Property Acquisition, and Floodplain Preservation)	1		1
	Damage assessments and cost estimates for reporting to FEMA		3	3
	Damage assesments and cost estimates to work closely with FEMA (WTs)	2		2
	Managing post-event needs with FEMA (FWM - working with CMs/WTs)	1		1
Documention and reconstruction	Reconstruction to inform future activites		4	4
	documentation - high water marks, photos, etc.	6	2	8
	Compare actual event to models	4		4
	Compare actual event to studies/mapping	1		1
Improve future outcomes	Hot Wash meeting Gather lessons learned to inform future activities. Develop an action plan.	1	2	3
	Help inform future projects/allocation of funding		2	2
	Assess changes in future threats due to repair/cleanup		1	1
	Fund research and development of advanced equipment and methodologies		1	1
	Evaluate criteria	1		1
	Review priorities for future improvments	1		1
Proactive communication	Inform LGs of how MHFD can help post-event	2		2

FWM = Flood Warning Manager
LG = Local Government
WT = Watershed Team

Table 5

MHFD's Most Critical Flood Warning Services as Identified by Local Governments

Area	Theme Identified by Interviewees	LG
Notification and tools	Daily email of Heavy Rainfall Threat Analysis (QPF)	6
	F2P2 Notifications system	5
	Ability to revise notification messages	1
	Informing threshholds for action	2
	ALERT 5 resources	2
	Predictive Forcasting (GARR)	1
Technical expertise	Forcasting/direct access to meteorology consultants	3
	Informing areas to watch	2
	MHFD working with the LG Emergency Operations Center (	1
Trainings	Trainings	2
	Annual location specific meeting with MHFD	2

F2P2 = Flash Flood Prediction Program
GARR = Gauge-adjusted Radar Rainfall
QPF = Quantitative Precipitation Forecast

Table 6

How Local Governments use MHFD Flood Warning Data

Area	Theme Identified by Interviewees	LG
Dissemination of information	dissemination to other departments - streets, operations	6
	dissemination to active construction projects/Parks and Rec	2
	dissemination to 911 dispatchers, law enforcement, fire partners	2
Use of archive data	historical data to inform thresholds for action	5
	historical data to understand frequency and moisture conditions	1
	historical data to address contractor claims	1
Decision support	Work with the FP Manager to make real-time decisions	1
	accesses reservoir dashboard to monitor stage	1
	Using GARR in combination with recent events and moisture conditions to inform threat potential	1

FP = Floodplain

Table 7

Potential Areas of Growth

Area	Theme Identified by Interviewees	Staff	LG	Total
Trainings and Outreach	More training and exercises	3	1	4
	More outreach on MHFD capabilities		1	1
Coordination/ Collaboration	More coordination and collaboration in general	2		2
	Listening to needs of the Local Governments	1		1
	Engage FWM in scoping of WT work products to better inform tools used during a flood event	1		1
	Work with the USACE and model reservoirs to better understand downstream impacts		1	1
Data development	Make data more actionable	2		2
	Technology updates and connections to mapping/data collection	1		1
	Increase lead time through more forecast-based decisions versus gage-based decisions	1		1
Management/ Leadership	Ensure MHFD has a strategic vision on climate change and impacts - What's the trend?		1	1
	Need an internal lead during the flood event	1		1
	Studying events and reporting out - compare actual event to modeled event and share	1		1
Planning	Create a Flood Recovery Assistance Plan for what MHFD should do during a flood	1		1

USACE = United States Army Corps of Engineers

Table 8

Opportunities for Knowledge Sharing and Collaboration

Area	Theme Identified by Interviewees	Staff
Coordination	WT needs a better understanding of gage data to inform studies - How do we share information back and forth?	5
	WT need to communicate location-specific planning/design efforts to FWM to determine impact to instrumentation	4
	Access to information that builds WT understanding of watershed hydrology/hydraulics	4
	Emergency Managers should be aware of planning studies and maintenance on spillways	1
	WT should identify areas where MHFD needs to start collecting information 5+ years ahead of a masterplanning effort	1
	WT is responsible for post-flood action	1
	Flood Warning Manager should communicate work with staff	1
	Flood Warning Manager has the ability to help inform needed improvements	1
Tool development	Data can be used to inform hydrology methodology (CUHP updates)	3
	WT needs to communicate location-specific areas of risk to inform or update FW systems (e.g., FHIT)	2
	WTs need more information (vs. more data) in the moment	1
	WT mapping/information can come directly into situational awareness tools to keep emergency managers up-to-date	1
Common tools	Active construction event notification	1
	WT and FWM can work together to identify items to support WTs during the next event	1
Relationship building	More coordination/communication will increase understanding of local government relationships and connections	1
	LG should know WT is a technical resource	1

CUHP = Colorado Unit Hydrograph Method
FHIT = Flood Hazard Inventory Tool
FWM = Flood Warning Manager
LG = Local Government
WT = Watershed Team

Table 9

Identifying Objectives Related to Skills and Expertise

Area	Theme Identified by Interviewees	Staff	LG	Total
Technical	understand hydrology and hydraulics	5	5	10
	Climate science and meteorology	2	2	4
	modeling	2	1	3
	Understands aspects of the data communications structure	2		2
	Understand requirements for collection of accurate data	2		2
	Engineering background	1		1
	Understand the complexity of measurement	1		1
	FEMA reporting requirements	1		1
Communication	communication (and communicating risk)	6	5	11
	delivering technical information with detail catered for a public audience	2	3	5
	engaging media	3		3
	writing skills	1		1
	facilitation/stakeholder representation		1	1
	negotiation		1	1
Leadership	relationship building	4	3	7
	leadership under pressure	2	1	3
	Able to see the big picture/visionary		2	2
	trustworthy	1		1
Emergency Management	Understanding of Emergency Management		3	3
	Understanding of incident command		1	1
	Understanding of local governments, special districts, fire departments, 911 commands		1	1
Curious	wants to learn	1		1
	creative and curious		1	1
	Stays active in outside organizations	1		1
Local	Someone local (knowledgeable to the specifics of past events)		4	4

Table 10

Potential Areas for Future Work

Area	Theme Identified by Interviewees	Staff	LG	Total
Scope of services	Maintain flood warning services at the current level and look to push the program further	3	2	5
	Continue to facilitate this program	1	1	2
	Plan for long-term management of data/information	1		1
Communication/ Coordination	Increased understanding of the program and its potential would result in increased support	2		2
	Interviewee wants to be more plugged into MHFD studies		1	1
	Reorganize the websites		1	1
Equipment	Requests new gauges and improvments to existing gauges	1	2	3
	Problems with MHFD not owning equipment and it not being in the public right-of-way	1		1

Appendix A
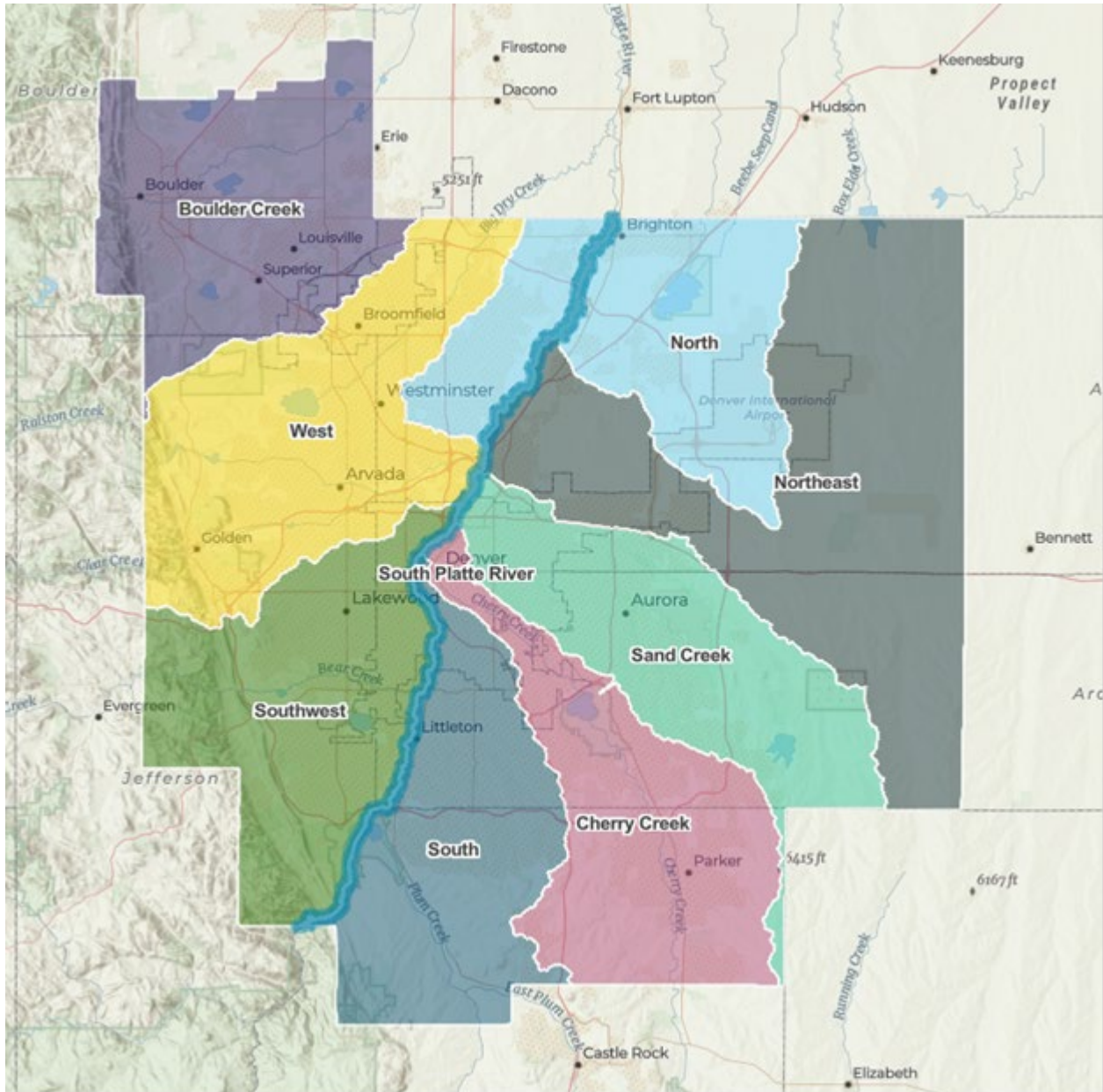
Appendix B

Interview Guide:	**LOCAL GOVERNMENT**	
Date:		
Name:		
Role:		
Key Points	Supporting Theme	Questions
Thank you		Thank you for contributing your input to this effort. This is a semi-structured interview.
self-introduction		I Introduced myself via email, but I will just remind you that, although I am part of MHFD staff, I'm interviewing you today as a MPA student at CU Denver.
Purpose		I'm asking nine open-ended questions to get your thoughts related to MHFD's flood warning program as it relates to succession planning at MHFD and specific to this program.
Opportunity for questions		Do you have any questions before we start?
Recording		Do I have your permission to record this interview?
introduction		Can you tell me your name and describe your role with (local government)
Q1	1 and 2	Can you tell what MHFD Flood Warning services (or products) are most critical to support you in your role?
Q2 - Data	1 and 2	MHFD collects, manages, and makes available data related to flood warning program. Can you tell me how you and your organization use these data?
Q3 - Education and Outreach	1 and 2	In what ways should MHFD support local governments to prepare for future flood events?
Q4 - Education and Outreach	1 and 2	What outreach and education should MHFD provide local governments to help prepare for future flood events?
Q5 - Response and Recovery	1 and 2	In what ways should MHFD support your local government during an active flood?
Q6 - Response and Recovery	1 and 2	In what ways should MHFD support your local government after a flood event?
Q7	3	What skills and expertise are most valuable for someone responsible for managing the MHFD Flood Warning program?
Q8	1 and maybe 2	Regarding the flood warning program, what is MHFD not doing now that they should be doing?
Q9	1,2,3	Is there anything else you want me to know about the flood warning program?
Follow-up		Will it be all right if I contact you to clarify anything you said?
Closing/thank you		Once again, thank you for your time and insights. This has been very helpful.

Interview Guide:	**STAFF**	
Date:		
Name:		
Role:		
Key Points	Supporting Theme	Questions
Thank you		Thank you for contributing your input to this effort. This is a semi-structured interview.
Purpose		I'm asking nine open-ended questions to get your thoughts related to MHFD's flood warning program as it relates to succession planning at MHFD and specific to this program. The questions I'm asking you today are different than those for local governments.
Q1 - Education and Outreach	1 and 2	In what ways should MHFD support local governments to prepare for future flood events?
Q2 - Response and Recovery	1 and 2	In what ways should MHFD support local governments during an active flood?
Q3 - Response and Recovery	1 and 2	In what ways should MHFD's Flood Warning Manager support MHFD staff during an active flood?
Q4 - Response and Recovery	1	How should MHFD support local governments after a flood event?
Q5	2	In what ways does the work of the Flood Warning Manager impact the work of Watershed Teams?
Q6	2	In what ways does the work of Watershed Teams impact the work of the MHFD Flood Warning Manager?
Q7	3	What skills and expertise are most valuable for someone responsible for managing the MHFD Flood Warning program?
Q8	1 and 2	Regarding the flood warning program, what is MHFD not doing now that they should be doing?
Q9	1,2,3	Is there anything else you want me to know about the flood warning program?
Closing/thank you		Once again, thank you for your time and insights. This has been very helpful.

Appendix C

This list is a comprehensive summary of tasks (current and potential) extracted from interview questions that relate in some way to flood warning services.

<u>Pre-planning and Planning studies</u>

- Conduct training and outreach efforts. Outreach audiences include local governments, the public, and staff. Review Table 1 training and outreach content.
- Share information on how notifications/forecasts can be used on active construction sites.
- Conduct trainings on how to interpret data to be actionable.
- Develop planning documents including emergency action plans and master plans.
- Identify critical areas to watch during a flood event.
- Review available information regarding evacuation thresholds.
- Map critical areas and review notifications that trigger action by the local government.
- Identify areas in need of additional data to inform hydrology or improve flood warning infrastructure.
- Identify opportunities for Flood Warning Manager to share information with MHFD staff.
- Identify key relationships between various staff members and local government contacts and establish communication paths.
- Manage website content related to flood warning services.

<u>Design, Construction, and Maintenance</u>

- Review flood warning infrastructure and coordinate with flood warning staff during design to evaluate potential impacts and opportunities.
- Determine when changes impact flood warning tools and establish a means to coordinate tool updates.

<u>Active flooding</u>

- Manage MHFD resources during active flooding ensuring all communications are functioning and local governments and staff are informed as needed.
- Monitor notifications and forecasting to understand threats and areas to watch.
- Reach out to contacts at the local government to aid and inform them of MHFD capabilities during and after the event. This includes the ability to utilize contractors and engage design teams for emergency repairs. This also includes information related to documentation required by FEMA.
- Monitor website resources to ensure information related to the threat is easily discoverable.
- Identify locations to set up shelters if necessary.
- Help facilitate communication lines to share equipment between municipalities if desired.

Following a flood event

- Coordinate documentation including damage assessments and cost estimates required by FEMA.
- Assess the need to access various reserves.
- Engage design teams and contractors for emergency repairs.
- Conduct a hotwash meeting to gather lessons learned to inform future activities and develop an action plan. Include the local government in this meeting.
- Assess damage and develop cost estimates consistent with FEMA requirements.
- Assess changes that may impact future threats including changes due to repair/clean up.
- Evaluate potential research and development of advanced equipment and methodology post-event.
- Evaluate areas where the events inform criteria.
- Assess priorities for future improvements.
- Document and reconstruct flooding to inform future events.
- Evaluate how actual events compare to models and use data to inform hydrology.

Potential Areas of Growth
- Explore how to make data more actionable.
- Evaluate technology updates and connections to mapping/data collection
- Explore strategic vision on climate change and impacts – How does it impact the region and what is the trend?
- Scope work products with both the watershed team and flood warning staff to better inform tools used during a flood.
- Work with the USACE and model reservoirs to better understand downstream impacts.
- Evaluate technology updates and connections to mapping/data collection.
- Increase lead time through more forecast-based decisions versus gauge-based decisions.
- Identify a lead during flood events.
- Create a Flood Recovery Assistance Plan that includes what MHFD staff should do during a flood.
- Plan for long-term management of data/information
- Improve understanding of the flood warning program and its potential to increase support
- Reorganize website resources.
- Entertain new gauge requests.
- Evaluate issues related to problems with MHFD not owning equipment and it not being in the public right-of-way.

Appendix D

MHFD Flood Warning Communications flow chart, definitions, and consultants
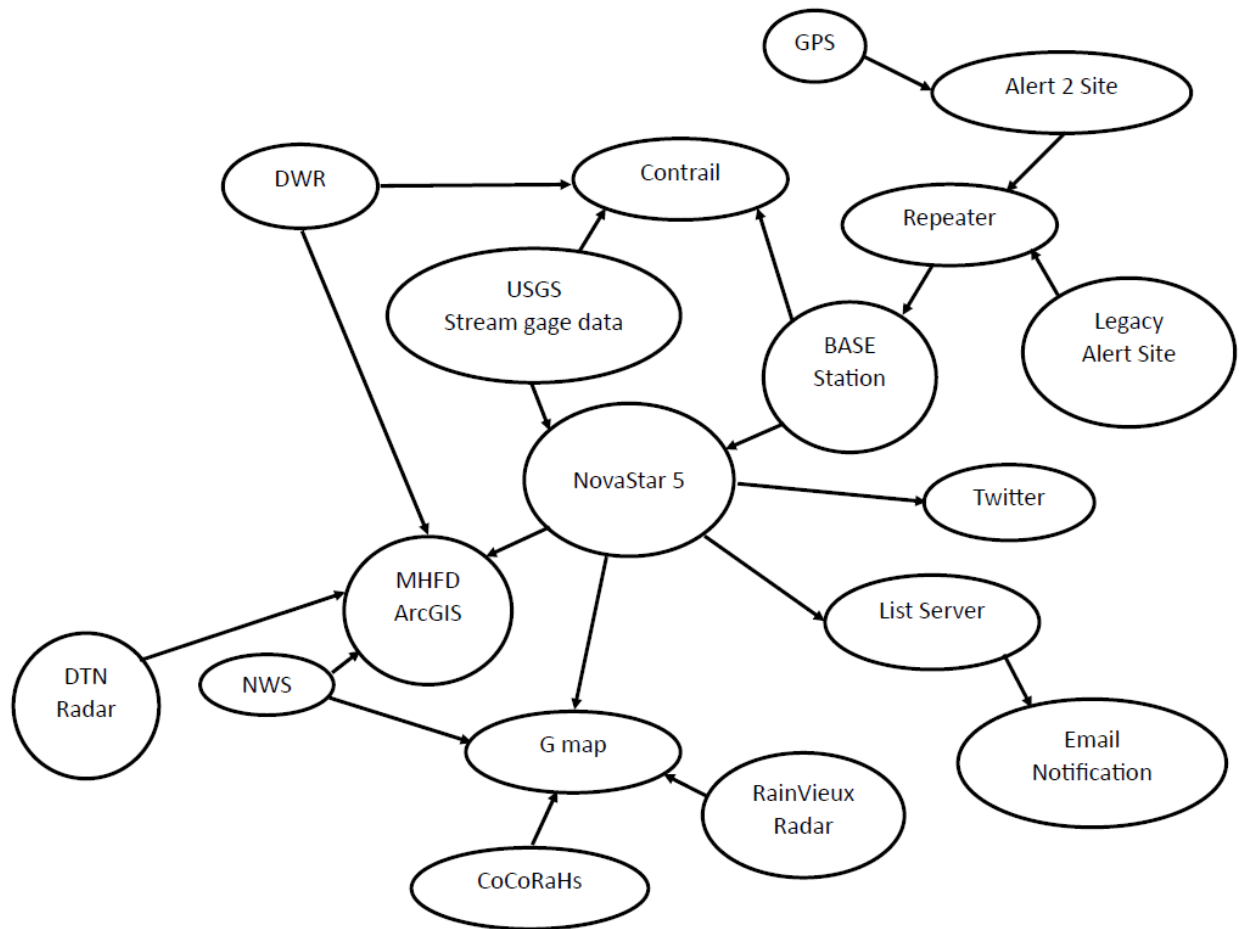
Definitions:

ALERT System – The ALERT System is a combination of sensors (tipping bucket rain gauges, anemometers, pressure transducers, temperature sensors, etc.), data loggers, RF transmitters, repeaters, receivers, and a database of data and information about various monitoring sites.

ALERT2 Site – These are upgraded versions of the Legacy ALERT site. These sites are coded with a five-digit station ID. These sites provide better data communications because of a GPS time input that follows TDMA protocol for data transmission.

ALERT5 Site - This is an internet portal for data stored in Novastar5. In addition to data access, it provides links to other Flood Warning products, resources, and helpful links.

ALERT Repeater – MHFD operates five Repeaters (Gold Hill, Louisville, Lee Hill, Smokey Hill, & Blue Mountain). These are radio frequency (RF) transceivers. They extend the distance RF

communication can be transmitted or provide a clear path due to topographic changes between ALERT System sites and Base Stations.

Base Stations – MHFD operates two Base Stations (Diamond Hill & Westminster). These sites are RF receivers and collect all ALERT data sent through the system.

CoCoRaHS – Community Collaborative Rain, Hail & Snow Network. Volunteer precipitation monitoring network. CoCoRaHS provides 24hr rainfall totals in areas the MHFD network does not. https://www.cocorahs.org/Login.aspx?ReturnUrl=%2fAdmin%2fMyDataEntry%2fListRecentPrecipReports.aspx%3fmod%3d1&mod=1

Contrail - Proprietary data collection platform by OneRain (consultant). Contrail is how OneRain monitors and performs maintenance on ALERT System sites and components. Contrail provides redundancy of Novastar5 and it is the preferred platform for use by OneRain. OneRain also uses this platform to create a dashboard and track maintenance activities.

DWR – Department of Water Resources – Data from DWR include inundation mapping for dams.

Gage-Adjusted Radar Rainfall (GARR) – Radar rainfall map providing data for display and query of near-real-time rainfall over the district boundary and upstream basin areas. The data source is from the National Weather Service. This tool is provided by Vieux & Associates.

Gmap – Provides rainfall and streamflow values throughout the MHFD region.

F2P2 – MHFD's Flash Flood Prediction Program (F2P2) Provides a series of notification messages to subscribers. F2P2 operates April through September providing local governments with heavy rain forecasts and early flood threat notifications. Messages have various coding indicating different levels of threat and various products.

Legacy ALERT Site – These are early versions of an ALERT site. The legacy sites are coded with a four-digit station ID. These sites often become troublesome with respect to data communication.

List Server – database of contacts to receive notifications

Novastar5 - Data collection platform. Once raw data is received, NovaStar5 calibrates data and adds context. It is a web host for various queries. It is used by USGS and National Weather Service. Novastar uses a PostgreSQL database format. Novastar also stores radar data, lightning data, satellite imagery, CoCoRaHS data, and other data provided by consultants.

National Weather Service (NWS) – MHFD uses radar from the NWS and provides this on the G-map and other public-facing MHFD maps

RainVieux – A data viewer derived from gauge and radar input processed and filtered to user-specific grids, catchments, or basins in model-ready format. Allows the user to display, query, and download rainfall in near-real-time products and end-of-month archival quality data

Repeater – Transceiver to receive and transmit data (used when no line of sight or long-range

USGS Stream gauge data – A portion of the stream gauges MHFD used are owned and maintained by USGS.

DTN Radar – Radar data from DTN

Consultants:

Allison House - Provides radar data used by Skyview primarily for forecasting flash flood potentials and monitoring developing threats. Skyview's storm summaries contain screen grabs from this provider. This data is also used for issuing stormtrack products.

Data Network Consultant (DTN) - DTN extracts raw data from National Weather Service and applies a proprietary algorithm to map these data and estimate rainfall. SkyView uses DNC for forecast models. WDT (Weather Decision Technologies) is now part of DTN.

Digital Data Services (DSD) - Hosts maps including the "Gmap" and "Real-Time Storm and Flood Data".

LRE-Water – Provides real-time hydrology models, notification (i.e., email and text messaging) support required for F2P2, and website development support. Notification support is accomplished through the Mailman3 list server.

OneRain - Provides field support for ALERT System sites and components. This consultant also has proprietary software, Contrail, which they use to monitor rain and stream gages. OneRain also provides website development and support.

Skyview Weather – Provides daily Heavy Precipitation Outlook (HPO) which provides a rain forecast for MHFD describing where and when storms are most likely to occur that day. When the potential for flooding exists, the service is referred to as Internal Message Status (IMS). IMS will provide individual messaging to each county in the MHFD region (Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson) when there is potential flooding. Skyview also provides "Storm Track" (ST) for storms considered to be a threat. This is a short-lead forecast available an hour or less of a storm's impact. It shows where a storm has formed, its approximate size and direction, and the estimated arrival times at points along the forecast track.

TriLynx – Provides a Novastar Operator Interface to access data stored in NovaStar5. TriLynx also owns NovaStar5.

Vieux & Associates – Provides Hydro-meteorological support and GARR. They also provide an innovative early warning product called RainVieux that forecasts rainfall intensities.

Water & Earth Technologies (WET) - WET is MHFD's consultant for mapping components of the flood warning program including Gmap and Real-time Storm and Flood Data. WET also maintains ALERT System sites and components.

HydroMet Consulting – Provides QPF-Max (Heavy Rainfall Threat Analysis).